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**WAVELET TRANSFORMATION OF TIME SERIES OF DATA IN DISCLOSURE OF INWARD AND OUTWARD FLOW DYNAMICS OF BANKING SYSTEM OF UKRAINE**

**Abstract.** The importance of the study of the dynamics of the movement of financial flows of the banking system using wavelet analysis methodology is emphasized. The expediency of simultaneous wavelet analysis in terms of the overall dynamics of incoming and outgoing cash flows of the banking system and individual components of such flows is shown. It is noted that it can more fully develop signs of reciprocity between the studied data rows. The analysis of the stability of the domestic banking system based on wavelet analysis is conducted. The presence of a significant correlation between the analyzed data rows during the economic crisis in Ukraine is found. Lack of effectiveness of the stable functioning of the banking system is specified.

**Keywords:** loans, deposits, banking, financial flows, time series, wavelet analysis.

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**Introduction.** The modern banking system is an open, multifaceted and ambiguous set of separate institutional units of a single monetary market. The effectiveness of such a system is largely determined by continuous mobility of certain financial flows. This is related to the fact that:

- the banking system is a leader in the processes of accumulation and redistribution of available financial resources between the various actors of economic relations,

- the banking system is able to generate new financial resources, especially through the creation of conditions for a rapid and continuous rotation of attracted resources with the possibility of augmenting that is acceptable to all participants in this process.

Among the existing set of various financial flows of the banking system we should highlight so-called input and output streams that represent means of bank customers involved in their deposit accounts and lines of further accommodation, particularly in the form of credit resources.

Key conditions to achieve the most acceptable impact on the banking system on all participants of economic cooperation should include the stability of its functioning and sustainability [Vasyurenko 2014; Lyaschenko 2014]. As a manifestation of achievement of such impact we can consider consistency between input and output flows of banking system. That is, these flows should be interdependent in terms of movement dynamics as of a period of time and its individual intervals. This defines appropriate to conduct more in-depth analysis of incoming and outgoing financial flows of the banking system mobility, which...
ultimately determines the relevance of the chosen direction of research and its practical orientation.

**Literature review and the problem statement.** Traditionally, in order to analyze mobility of various financial flows different statistical methods were used, among which are:

- General descriptive statistics methodology which allows to calculate the main parameters of the time series data, determining certain financial flows. As an example, on the application of the general methodology of descriptive statistics works of O. I. Vorobyov, O. Malakhova, D. Gladkyh can be mentioned, defining issue of uniformity of volumes of loans and the dynamics of their growth on the basis of a specified period of time that is selected for study [Vorobyova 2010; Malakhova 2008, Gladkyh 2014];

- Methodology of correlation and regression analysis reveals existing impacts on mobility of the analyzed data. An example of such research are works M. I. Krupka та N. B. Demshichak [Krupka, Demshichak 2012], V. V. Kovalenko [Kovalenko 2010];

- Methodology for the analysis of stochastic boundary that allows movement studied to determine the effectiveness of financial flows of banks under the influence of factors internal and external environment they (banks) functioning [Vasyurenko 2014; Lyashenko 2014];

- Methodology of structural analysis of available statistical data with which to emphasize the characteristics studied structuring financial flows [Rogozhnikova 2012; Malyutin 2010];

- Methodology of correlation and regression analysis applied to the transformed data for mobility of financial flows in another space, thus extending the boundaries of the studied processes and emphasizing their reciprocity in terms of new general indicators [Dobrovolskaya, Lyashenko 2013; Kots, Lyashenko 2012];

- Mutual data analysis methodology based on statistical methods of treatment in combination with the methods of probability theory [Vozhzhov 2002].

However, despite the diversity of individual approaches to the analysis of mobility flows of individual financial banking system, unfortunately, outside usually remains the possibility of benchmarking for individual intervals of the time period studied against the background of the estimates for selected for this analysis period as a whole.

That is, the classical methods of analysis used for mutual disclosure of efficiency of financial flows may not be sufficient for simultaneous consideration of possible motion parameters of such flows for the entire study period of time, and its individual intervals. This imposes a certain uncertainty about the results and their further use at least in terms of the manifestation of various financial and economic crisis, which is characteristic of modern economic development in Ukraine.

So, as the main purpose of this study we choose analysis of mobility of certain existing financial flows of the banking system in terms of both a selected period of time for such a study, and separate intervals of the selected period of time.

**Research results.** In order to analyze the dynamics of mobility of incoming and outgoing cash flows of the banking system we will consider the following time series:
the total amount of loans granted to residents by sectors (excluding deposit-taking corporations);
the total amount of deposits of the banking system in terms of resident sectors (excluding deposit-taking corporations).

These financial flows are chosen according to what determines the total deposits, the most common variety, incoming financial flows of the banking system, while total loans - outgoing financial flows of the domestic banking system. For a more complete understanding of the dynamics marked by financial flows we will also consider their individual components, namely:
the volume of loans granted to non-financial corporations;
the volume of loans to households;
deposits of non-financial corporations;
deposits of households.

For this study we have selected a time period from 01.2007 to 05.2015 on a monthly basis. Choosing a specified period for this study is based the fact that this period includes the most volatile and challenging period of economic and social development of Ukraine.

On fig. 1 (calculations based on the official data of National Bank of Ukraine – http://www.bank.gov.ua) the dynamics of deposits of residents by sectors (excluding deposit-taking corporations) and the volume of loans granted to residents by sectors (excluding deposit-taking corporations) are reflected. As seen from fig. 1, dynamics of resident deposits and of loans granted to residents are mostly interconnected on the basis of analyzed period.

Figure 1 - Dynamics of resident deposits by sectors (excluding deposit-taking corporations) and the volume of loans by sectors (excluding deposit-taking corporations) from 01.2007 till 05.2015 monthly

Source: built by author on the basis of own research

So the question arises as manifestations of such reciprocity in dynamics of the analyzed time series data and for certain intervals of the selected period of time for general review. To clarify this issue we use the methodology of wavelet...
analysis based on wavelet transformation of time series [Lyashenko, Deineko, Ahmad 2015; Delbeke, Abry 2008; Abry, Baraniuk, Flandrin 2002; Fan, Gençay 2010; Jammazi, Lahiani, Nguyen 2015; Naccache 2011]. Feasibility of using wavelet analysis methodology is defined by the following:

- wavelet transform, as part of wavelet analysis to determine the hierarchical structure of the input researched time series that expands the possibility of a more detailed analysis of time series that analyzed;
- wavelet transform input range can be considered as time-frequency data set where the wavelet coefficients locate possible irregularity sites and changes in the input time series, and special techniques can determine the content of the studied;
- constructing estimates based on wavelet coherency in the form of time-frequency mapping section for the studied series data, we can determine the variability of correlation values between selected time series for the selected period of time in general.

On fig. 2 (calculated and built according to fig. 1 according to the methodology for determining the cross estimates of wavelet transform data [Abry, Baraniuk, Flandrin 2002; Benhmad 2012]) shows the wavelet coherence between the rows of data - total resident deposits (D), the total volume of loans to residents (K).

![Wavelet Coherence Diagram](image)

**Figure 2** - Wavelet coherence of data rows - total deposits, total loans

Source: built by author on the basis of own research

On fig. 2:

1) on the horizontal axis we show the timeline that corresponds with the analyzed sequence, beginning and ending with 01.2007 05.2015 correspondingly,
2) the vertical axis shows weighted characteristics of wavelet coefficients of analyzed input series in time-frequency space of their measurement by results of grouping time periods, which is studied,
3) the figure presented separate columns as the scale of significance of the displayed in fig. 2. According to this scale of values its smallest values correspond to non-essential displayed in fig. 2, and the biggest ones correspond to significant values displayed in fig. 2. Separate lines are a manifestation of localization for individual irregularities of studied time series according the significance of such irregularities,
4) the right arrow indicates the uniformity of cause-effect relationships of lead lag in the studied ranks;
5) the left arrow indicates the presence of reversible cause-effect relationship of lead lag in the studied ranks;
6) slope of arrows - the imbalances of cause-effect relationships of lead lag in the studied ranks.

Fig. 2 shows that level of coherence between the studied data is mostly higher for the first and last stages of the overall time period that is analyzed than in its middle. At the same time for the initial stages characteristic is greater imbalances of cause-effect relationships of lead lag in the studied ranks. For the latter stages of the overall time period that is analyzes such imbalances are more moderate. That is, we can specify that for the initial stages although there is considerable coherence between the studied data, an imbalance in cause-effect relationships reveals that a lack of coherence of dynamics of data series (total deposits and total loans of the banking system) exists. For the latter stages of the overall time period that is analyzed the imbalance between the rows of data is more moderate. However, such moderation occurs on the background of either minor (fairly modest) growth or permanent reduction of the volume of total deposits, as well as the total volume of loans. In this case, imitation of dynamics of deposits and loans is quite akin, what determines a significant level of coherence between the analyzed series. However, it is also not a manifestation of the efficiency of the banking system stable functionning, because in this case we observe the decline in the provision of banking services. Therefore, the overall stability of the domestic banking system in terms of the analysis of its key financial flows on the basis of wavelet analysis is not very effective.

Fig. 3 (calculated and built in accordance with data in Fig. 1 according to the methodology of determining the cross evaluation of wavelet transformation of data [Abry, Baraniuk, Flandrin 2002; Benhmad 2012]) displayes the wavelet coherence of analyzed data rows:

- **D** – financial flow of the banking system that determines the volume of resident deposits by sectors of the economy (excluding deposit-taking corporations) from 01.2007 till 05.2015 in monthly calculation;
- **D1** – financial flow of the banking system that determines deposits of non-financial corporations in the period from 01.2007 till 05.2015 in monthly calculation;
- **D2** – financial flow of the banking system that determines the deposits of households in the period from 01.2007 till 05.2015 in monthly calculation.
As seen on the Fig. 3, the correlation value between the data rows – the volume of resident deposits by sectors of the economy (excluding deposit-taking corporations) and data rows – deposits of non-financial corporations as well as between the data rows – the volume of resident deposits by sectors of the economy (excluding deposit-taking corporations) and data rows – deposits of households is approximately the same. Additionally it can be observed that the greatest correlation between the rows of data volumes of deposits from non-financial corporations and deposits of households occur in the initial and the last intervals of the studied period.

Fig. 4 (calculated and built in accordance with data in Fig. 2 according to the methodology of determining the cross evaluation of wavelet transformation of data [Abry, Baraniuk, Flandrin 2002; Benhmad 2012]) displayes the wavelet coherence of analyzed data rows:

**Figure 3** – Wavelet coherence of data rows under analysis 
(D, D1, D2)

Source: built by author on the basis of own research
K – financial flow of the banking system that determines the volume of loans granted to residents by sectors of the economy (excluding deposit-taking corporations) from 01.2007 till 05.2015 in monthly calculation;

K1 – financial flow of the banking system that determines the volume of loans granted to non-financial corporations from 01.2007 till 05.2015 in monthly calculation;

K2 – financial flow of the banking system that determines the volume of loans granted to households from 01.2007 till 05.2015 in monthly calculation.

**Figure 4** – Wavelet coherence of data rows under analysis (K, K1, K2)

Source: built by author on the basis of own research

Fig. 4 shows that mutual coherence between the rows of data of the total loans granted to residents and loans granted to non-financial corporations is identical both in general and in terms of individual time intervals of the studied period. It can be also pointed out that dynamics of loans granted to residents is entirely determined by the dynamics of the loans granted to non-financial corporations. Consistency between the rows of data on the volume of total loans granted to residents and loans granted to to households is not solid. Moreover,
the period of 03.2011 to 11.2012 allows to observe a significant reduction of coherence between the rows of data on the volume of total loans granted to residents and loans granted to households.

Also, according to the data displayed on Fig. 4, the consistency between the rows of data on the volume loans granted to non-financial corporations and loans granted to households is not solid. Moreover, according to the data on Fig. 4 it can be concluded that coherence between the rows of data regarding overall loans granted to residents and loans granted to households inherits the coherence between the rows of data on the volume loans granted to non-financial corporations and loans granted to households.

Therefore, it should be generally defined that in particular peculiarities of dynamics of loans granted to Ukrainian banking system to residents is a manifestation of the peculiarities of the corresponding dynamics in terms of individual structural elements of financial flows under study, which consider certain sectors of the economy.

**Conclusions.** Thus, the paper reveals the appropriateness and possibility of introducing a common methodology of wavelet analysis for the study of time series of indicators of banking activities and determining the conditions of the banking system stability.

Suggested approach allows distinguishing different levels of correlation between the studied rows of data according to certain periods of the banking system development in Ukraine. It is separately shown that dynamics of total loans granted to residents and manifestations of its peculiarities completely corresponds to the dynamics of loans granted in terms of individual economical sectors. However it is also pointed out that stability of the domestic banking system functioning is insufficiently effective.

It is also noted that the use of of wavelet analysis allows specifying the periods of coherence and imbalance between the individual rows of data under analysis. This way it becomes possible to make conclusions regarding reasonable adjustment of dynamics of the components of data rows under study and form a balanced policy of impact on the banking system. So development of suggestions on banking regulation on the basis of wavelet analysis should be indicated as the direction of further researches.

**References**


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