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Wavelet Coherence as a Digital Visualization Tool for Comparing Economic Data Dynamics

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Abstract*: Analysis is one of the tools for studying data of various nature. Among the variety of such data, we single out economic data. The analysis of economic data is an important aspect in the study of various phenomena and processes that are associated with the study of economic dynamics. At the same time, an important point of such an analysis is the comparison of the dynamics of economic data. This is important both for understanding the processes that take place and for making appropriate management decisions. At the same time, for a more complete understanding of various aspects of the analysis, it is necessary to visualize the relevant data. Such visualization helps to better analyze the comparative dynamics between the various data that we study. It also allows you to understand hidden relationships .To implement the stated task, we propose to use the methodology of wavelet analysis. Among the methods of wavelet analysis, we single out wavelet coherence. The paper considers various aspects of using wavelet coherence for digital visualization of economic data. Possibilities of conducting a comparative analysis with the help of wavelet coherence are shown. Various graphs and examples for real data are given. This allows you to better understand the consideration of the issues raised.*

Keywords—analysis; comparison; dynamics; economic data; digital visualization; time series; wavelet analysis; wavelet coherence

1. INTRODUCTION

Analysis of primary data is one of the tools for studying phenomena, events, objects. This research tool is applied in various scientific fields. The analysis allows you to explore the main relationships between the factors that need to be studied [1]-[4]. The analysis also provides additional information. Thus, analysis as a research tool expands the primary data, allows you to obtain new information about the object, phenomenon, event.

One area of scientific research where analysis is widely used is the analysis of economic data [5]-[8]. First of all, such an analysis is aimed at studying the dynamics of economic data.

The modern development of economic processes is faced with a constant increase in information that requires fast and objective processing. Such information is diverse and covers both the factor conditions for the development of economic processes, phenomena, events, and directly characterizes the development of such processes. Therefore, we have a significant amount of information, which in modern information technologies is defined by the terminology "Big Data". Consequently, there is a need to apply the latest methods for processing significant amounts of information.

Thus, the analysis of economic data is an important element of analysis, which allows you to reveal the relationship between various factor variables. These factor variables reflect some of the processes that are the object of research. The comparative aspect of the analysis allows [5], [7], [8]:

assess the functioning and development of various business entities,

to study the dynamics of relationships between various business entities,

make a forecast regarding the further development of the phenomena, events that are being studied.

It should also be noted that the latest methods of economic data analysis should [8]-[11]:

take into account and disclose the economic essence of the processes under study,

determine the reliable results of processing primary information,

provide additional information in the process of processing primary information,

meaningfully reflect the research process and be able to visualize the results of information processing.

At the same time, the use of certain methods of information processing is determined by the content of the processes under study. All this determines the importance of considering the chosen research topic, its relevance, and practical significance.

2. RELATED WORK

The issues of data analysis are in the focus of attention of various authors. At the same time, among such data, a special place is occupied by data that reflect economic dynamics.

For example, X. Wei, W. Chen and X. Li analyze economic indicators based on the machine learning method [12]. The authors consider the idea of improving the efficiency of pattern recognition of economic data. For this, a statistical model is created on the basis of machine learning technology by creating a multiple regression model [12]. To build such models, various empirical data are used, which reflect the financing of trade of various companies and firms.

F. Lebaron uses geometry methods to analyze economic data [13]. To do this, the author uses the so-called Geometric Data Analysis (GDA) [13]. F. Lebaron shows that such a methodology of analysis can satisfy the growing need to search for more solid empirical foundations and adopt a multidimensional approach in social economics [13]. At the same time, the author operates with the concepts of economic space and economic field. This approach helps to formalize the configuration and dynamics of economic institutions [13].

M. B. Shrestha and G. R. Bhatta consider the issues of choosing an analysis methodology for economic data, which are presented in the form of time series [14]. This is because time series data can have specific properties such as trend and structural discontinuity [14]. Therefore, some methods may be suitable for some time series and not suitable for other time series. Thus, the authors consider the methodological basis for the analysis of data, which are presented in the form of time series.

The study of E. Ghysels and M. Marcellino is devoted to the problems of analyzing economic data in the form of time series [15]. The authors consider various methods of time series analysis for forecasting economic data. Also, attention is paid to various models for presenting initial data in the form of time series.

Q. Wang and L. Wang consider the issues of researching economic data based on non-linear analysis of panel data [16]. To conduct such an analysis, the authors consider data on energy sources and their impact on the economy in OECD countries. For this analysis, the authors use a fixed effect model and a non-linear threshold model. At the same time, on the basis of three threshold variables, three panel threshold models are developed and compared with each other [16].

C. W. Carpenter, A. Van Sandt and S. Loveridge say that an important aspect of the analysis is to take into account the errors that are possible when measuring primary data [17]. Such errors distort the statistical estimates and the corresponding conclusions. The authors evaluate measurement errors in Suppressed Cell Estimated Datasets (SCED) versus unsuppressed federal administrative data [17]. This improves the efficiency of general statistical inference.

A. Grané, S. Salini and E. Verdolini use multivariate mixed-type data analysis to study economic data [18]. To do this, the authors use a hierarchical approach, which is based on a direct search for relevant data. Various distance measures are also used to generalize data of the same type. At the same time, the key feature of the proposed approach is the rejection of redundant data. This allows you to create similarity indexes and perform efficient data clustering. The practical usefulness of the proposed approach is illustrated by two applications of great importance for empirical economic research [18].

In [19], the authors conduct an analysis of economic data that helps to understand the relationship between renewable energy sources and economic growth. Fixed effect test and panel vector error correction model (PVECM) [19] are used for data analysis. The analysis was carried out for a large amount of empirical data.

B. Hassan, E. Osabuohien, F. Ayadi, J. Ejemeyovwi, and V. Okafor conduct an economic analysis of growth financing and liquid liabilities using data from Nigeria as an example [20]. The data used by the authors are presented in the form of various time series. Various statistical models are used for the analysis, which allow us to consider the relationship between the variables of such models.

N. Mose in his study considers various determinants of regional economic growth in Kenya [21]. To do this, the author uses the abridged Solow-Swan growth theory. As separate methods of analysis, the approaches of descriptive and logical statistics are used in the article. Various regression models were built to analyze the relationships between variables. In particular, the result of the short-term regression equation identified human capital and budget utilization as key sources of growth [21].

B. S. Bagepally, N. Chaiyakunapruk, J. Attia and A. Thakkinstian use meta-analysis to obtain various economic estimates [22]. At the same time, the authors also consider methodological issues and harmonization of primary data. In particular, the authors use cost utility analysis (CUA). At the same time, data harmonization methods include the analysis of conflicting reports, economic parameters, heterogeneity [22]. The incremental net benefit (INB) and its variance were estimated and pooled across studies using the baseline COMER meta-analysis [22].

Thus, we can say that various classical approaches are used to analyze economic data. At the same time, we can note the use of artificial intelligence methods. This allows you to evaluate the hidden relationships between the variables under study, to better understand the processes and phenomena that are being studied.

It should also be noted that the methodology and various approaches of wavelet theory are used to analyze economic data. Wavelet coherence occupies a special place among such approaches [23]-[27]. Before considering some theoretical issues of wavelet coherence, let's pay attention to the form of presentation of economic data.

3. A FEW WORDS ABOUT THE FORM OF ECONOMIC DATA PRESENTATION

Economic data of a different nature, as a rule, can be represented in the form of data:

on a certain date or at the end of a certain period of time. Then we have some set of data that characterizes the object, process or phenomenon that we are studying at a certain point in time;

for some time interval. Then we have some sequence of data that characterizes the dynamics of the object, process or phenomenon that we are studying.

The choice of a certain presentation of economic data is determined by the task that needs to be solved in the process of research.

If we talk about the direct presentation of economic data, then we should highlight:

a tabular form of data presentation, which allows you to consider some of the relationships between data and approach the description of such relationships in a comprehensive manner;

a form of data presentation in the form of graphs and diagrams, which allows us to visualize the processes and phenomena that we study. Also, this form of presentation allows you to visualize some of the relationships between the variables under study;

presentation of data in the form of a time series. This allows you to evaluate the dynamics of the process or phenomenon under study. It is also possible to evaluate the dynamics of relationships between the studied variables.

The choice of the form of presentation of economic data is determined by the task that needs to be solved in the process of research.

4. Wavelet Coherence as a Visualization and Comparison Tool for Data Dynamics

With the help of wavelet analysis, you can find the critical points for the time series that is being investigated [28], [29]. Thus, we get a set of new characteristics for the time series. An analysis of such points and their characteristics allows us to draw a conclusion about the possibility of developing the processes that we are studying.

We can also explore the mutual dynamics of different time series. Such an analysis allows us to talk about the consistency or imbalance of various relevant aspects. For this analysis we use wavelet coherence [30]-[32].

So if we have two series of data ($f(t)$ and $g(t)$), each of which reflects the dynamics of an indicator over time t, then we can determine the value of wavelet coherence between the following series of data using the following formula [30]-[32]:

$$Q^2(a,b)=\frac{\left|\Lambda(a^{-1}W_{f(t)g(t)}(a,b))\right|^2}{\Lambda(a^{-1}\left|W_{f(t)}(a,b)\right|^2)\Lambda(a^{-1}\left|W_{g(t)}(a,b)\right|^2)}$$

where:

$W(a,b)$ – values of transverse wavelet spectra,

a,b – the scale and center of time localization that determine the scale of the wavelet transform,

$f(t)$, $g(t)$ – series of data that we study,

Λ – smoothing operator,

$Q^2(a,b)$ – square of the wavelet coherence coefficient. $0 \le Q^2(a,b) \le 1$. If these values tend to zero, then we have a weak correlation. Otherwise we have a strong correlation.

Therefore, it allows to visualize the mutual dynamics of the data and to investigate in more detail the relevant economic processes.

5. Some Examples of Using Wavelet Coherence for Digital Visualization of Economic Data

On fig. 1 shows an estimate of the wavelet coherence between the volumes of loans issued and the volumes of attracted deposits in the period 2006-2008 in the context of individual months (own calculations according to https://bank.gov.ua/).

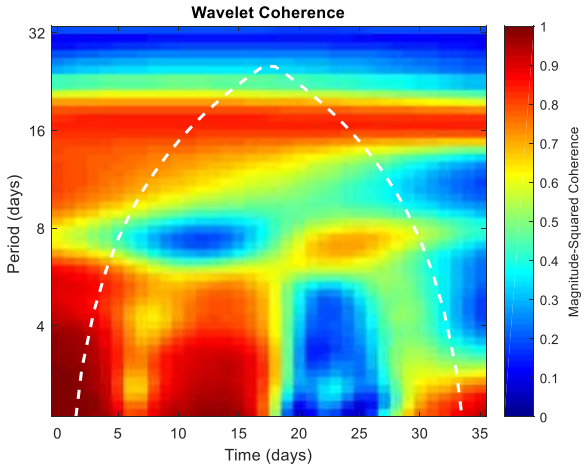

Figure 1: Evaluation of the wavelet coherence between the volumes of loans issued and the volumes of attracted deposits in the period 2006-2008

On fig. 2 shows an estimate of the wavelet coherence between the volumes of loans issued and the volumes of attracted deposits in the period 2019-2021 in the context of individual months (own calculations according to https://bank.gov.ua/).

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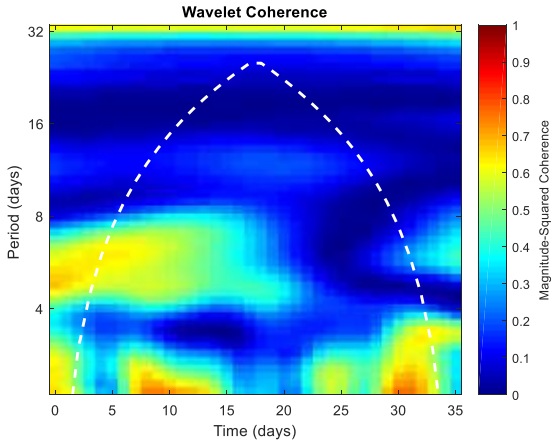

Figure 2: Evaluation of the wavelet coherence between the volumes of loans issued and the volumes of attracted deposits in the period 2006-2008

We see different mutual dynamics of the data that we study. At the same time, the dynamics of the data that we study is more significant for the period 2006-2008. The correlation of the relevant data is also high. At the same time, the correlation is higher for the first half of the period 2006-2008. For the period 2019-2021, such dynamics is less significant. Correlations for the period 2019-2021 between the studied data are insignificant.

On fig. 3 shows an estimate of the wavelet coherence between the price dynamics of Bitcoin and Ethereum in the period from 08.01.2020 to 22.12.2020.

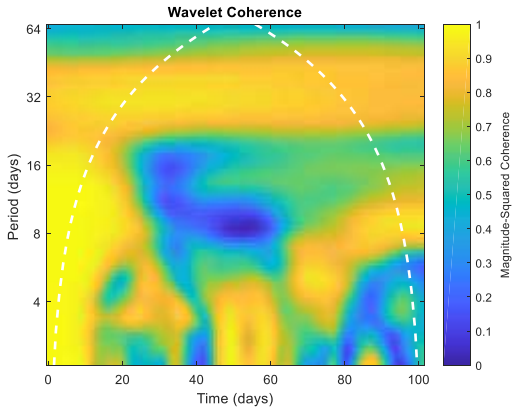

Figure 3: Evaluation of wavelet coherence between Bitcoin and Ethereum price dynamics in the period from 08.01.2020 to 22.12.2020

On fig. 4 shows an estimate of the wavelet coherence between the price dynamics of Bitcoin and Binance Coin in the period from 08.01.2020 to 22.12.2020.

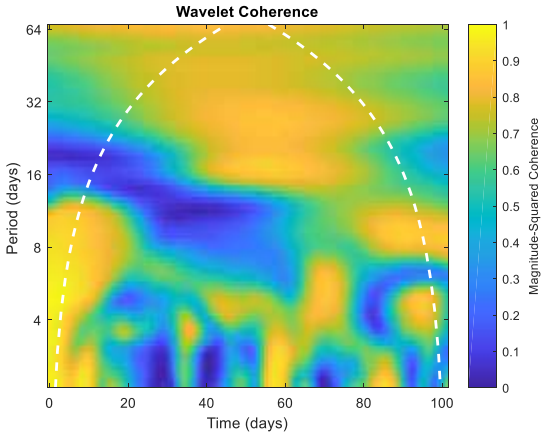

Figure 4: Evaluation of wavelet coherence between Bitcoin and Binance Coin price dynamics in the period from 08.01.2020 to 22.12.2020

We can see that the significance of mutual consistency differs for the different data pairs we are examining. The values of the corresponding correlation values between the studied data also differ.

We see that the method of constructing estimates of wavelet coherence allows us to conduct a comparative analysis regarding the mutual influence of price dynamics on the studied cryptocurrencies. At the same time, periods of more stable mutual influence and the duration of such periods can be distinguished. This fact is important from the point of view of determining investment strategies and choosing the appropriate behavior in the financial markets. Therefore, wavelet coherence should be used as a comparison and market research tool for cryptocurrencies. This conclusion also applies to data about banks. Thus, in general, wavelet coherence is a good tool for digital visualization when comparing the dynamics of economic data.

6. CONCLUSION

The article deals with the analysis of economic data. We conducted a brief review of related papers that examined different approaches to economic data analysis. Particular attention is paid to the visualization of the processes of data analysis and presentation of the results.

To solve the questions raised, it is proposed to use the methods of wavelet analysis. Among such methods, we use wavelet coherence. The paper presents various empirical data to which we apply wavelet coherence. Based on the estimates of wavelet coherence, we can clearly observe the change in the interdependence for the studied data for different time intervals and draw appropriate conclusions. Therefore, the wavelet coherence methodology should be used as a digital visualization tool for comparing economic data.

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