

# Empirical Estimates of Data on the Dynamics of Changes in the World Foreign Exchange Market

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**Abstract:** Empirical assessments are generalized characteristics of the data, processes and phenomena that are being investigated. Such estimates are based on real data, which are considered from some historical perspective. Particular attention is paid to such assessments in the study of processes, events, phenomena that occur in different spheres of the economy. This allows you to assess the situation from different points of view, justify and make the necessary decisions. Among the different spheres of the economy and areas of economic activity, the need for foreign exchange transactions should be highlighted. In a market economy, during the period of globalization, such a need arises for many business entities (access to raw materials markets, sales markets, implementation of cooperation, and provision of conditions for the division of labor). This is due to the fact that the conduct of economic activities requires the establishment of a correspondence between the monetary units of different countries. In this regard, the paper considers an approach to assessing data on the dynamics of changes in the world foreign exchange market. This approach is based on methods of wavelet analysis, where an approach to data estimation based on wavelet coherence is chosen. At the same time, the ideology of the formation of cross-rates of currencies is also taken into account. We considered different currency pairs and constructed estimates of their wavelet coherence. Conclusions are drawn about the dynamics of each of the currency pairs that we are considering. The results of the analysis of estimates of wavelet coherence for the currency pairs that we are studying are generalized. Research results are based on real data. All results are presented in the form of visual graphs, which allows the continuation of similar studies. It is shown that the results of the study are in agreement with the results of other authors.

**Keywords**—assessment; time series; currency pair; foreign exchange market; cross-rate; wavelet analysis; wavelet coherence.

## 1. INTRODUCTION

The modern functioning and development of individual business entities, various sectors and branches of economies, economies in general is associated with the international division of labor, the need to enter the markets for raw materials and sales of products. This requires the development of international cooperation in the context of the formation of new conditions for access to markets and division of labor, spheres of influence. The implementation of such activities is based on the mutual movement of commodity and financial resources [1]-[3]. At the same time, an important aspect is the establishment of parity prices for the corresponding goods and services, the establishment of correspondence between the monetary units of different countries.

The establishment of a correspondence between the monetary units of different countries is displayed in the concept of the exchange rate. The mechanism of formation of the exchange rate is associated with the possibility of converting different currencies and is formed in one of the segments of the financial market – in the foreign exchange market [4], [5]. At the same time, there is no single exchange rate in a market economy. This makes it necessary to conduct various empirical estimates on the dynamics of data in the change in the correspondence between the monetary units of different countries. Such an analysis allows us to understand the dynamics of changes in the exchange rate, to choose the

right strategy for the development of international economic relations.

We can also note that you can establish a direct quote between the currencies of different countries or use a cross rate, when such a quote is established, indirectly, through the currency of a third country. This expands the need for various empirical assessments. At the same time, it is also important to choose a method for constructing empirical estimates, justify such a choice and reveal the general methodology of analysis. Thus, the main goal of this study is to analyze and establish estimates for data that characterize the dynamics of changes in the world foreign exchange market.

The solution to this problem involves: conducting a brief review of existing publications on this topic; substantiation of the methodology for constructing the corresponding estimates; consideration of the data that we will investigate; conducting experiments and discussing the results obtained.

## 2. MATERIALS AND METHODS

### 2.1 Selecting a Template Related Work

Study [6] looks at the predictability of the exchange rate. The authors investigate the dynamics of the yen-dollar pair. At the same time, various changes in the dynamics of such an exchange are analyzed: the growth of the exchange rate and its decline. The authors build their own model, which is based on the theory of random walk and reflects the probabilistic structure of the conditions for changing the corresponding currency pair [6]. Methods of the theory of probability and

statistical analysis are used in this work for the research and construction of models.

P. Aniūnas, J. Nedzvedskas and R. Krušinskas study the development of the foreign exchange market, the possible development of various associated risks [7]. At the same time, such risks are considered in the context of fluctuations in the exchange rate of different currency pairs. The authors note that this is an important point in managing foreign exchange risk, choosing investment decisions, and methods of management. For this study, the authors use the VaR model. The issues of conditions and assumptions of application of the VaR [7] method are also considered. This allows us to speak about the reliability of the model, the conditions for its use in real practice.

G. Panayotov analyzes the occurrence, development and possible prediction of risks in the foreign exchange market in order to minimize their impact [8]. For this, the author analyzes the influence of various factors on the development of the foreign exchange market. The paper shows that the main factor in the formation of currency risks in modern conditions is the dynamics of asset prices. Moreover, the formation of such prices is influenced by the stock market. This allows us to build adequate models for predicting currency risks.

J. Mazanec considers the optimization of a portfolio of currencies taking into account the presence of digital currencies in such a portfolio [9]. The purpose of this study is to optimize a portfolio of currencies depending on the types of digital currencies that are in this portfolio. In his research, the author uses the classical portfolio theory.

S. Avdjiev, V. Bruno, C. Koch and H. S. Shin investigate fluctuations in the dollar as a factor in the emergence of risks when investing [10]. The authors note the importance and necessity of considering exchange rate fluctuations in the context of the development of economic activity of various business entities, changes in their business activity. Such research is carried out at the macro (at the country level) and micro (at the level of an individual company) levels. For this analysis, the authors use various statistical methods.

The article by the authors J. Ha, M. M. Stocker and H. Yilmazkuday examines the relationship between inflation and changes in the exchange rate [11]. In particular, the authors investigate the impact of the exchange rate on consumer prices. At the same time, periods of significant fluctuations in exchange rates are especially analyzed. The paper also discusses the issues of stabilizing consumer prices by regulating the exchange rate. For such a study, various methods of statistical analysis are used. At the same time, in our opinion, to identify the relationship between inflation and changes in the exchange rate, it is advisable to use the methods of wavelet ideology.

Authors D. C. Mallqui and R. A. Fernandes analyze the dynamics of the high, low and closing prices for the bitcoin exchange rate [12]. This also takes into account the change in directional dynamics for that exchange rate. This allows the

authors to propose an appropriate predictive model that would be practically useful to investors. To build such a model, the authors use methods of the theory of fuzzy logic, machine learning methods. Nevertheless, in our opinion, it is difficult to build a universal model for such forecasting. This lies in the specifics of the behavior of the dynamics of various cryptocurrencies. Therefore, it is important to have different methods and approaches to analyze the dynamics of changes in currency pairs. This makes it possible to build more adequate predictive models.

P. K. Narayan, S. S. Sharma, D. H. B. Phan and G. Liu consider the issues of forecasting profitability for different exchange rates [13]. This analysis is done for 16 different currency pairs. For this, the authors use the time series predictability test, which is based on the methods of the theory of statistical analysis. This approach allows you to build an adequate forecasting model that helps to determine and reasonably choose different trading strategies.

S. Qureshi and M. Aftab investigate the relationship of exchange rates [14]. This relationship is analyzed for exchange rates of countries such as Indonesia, Malaysia, the Philippines, Singapore, and Thailand. The authors note the importance of analyzing the mutual dynamics of exchange rates of different countries. This is due to the possibility of predicting sharp fluctuations in currencies, preventing the negative consequences of such fluctuations for the economies of different countries. The authors also note the expediency of using wavelet analysis to reveal the mutual dynamics of currencies of different countries.

S. Afshan, A. Sharif, N. Loganathan and R. Jammazi investigate the relationship between stock prices and the exchange rate [15]. This analysis is based on the wavelet coherence methodology. The authors emphasize that such analysis is important in understanding the mutual dynamics of the data being researched.

The brief review that we carried out above shows that various methods and approaches are used to analyze data on the dynamics of changes in the foreign exchange market: methods of statistical analysis, fuzzy set theory, machine learning methods, and wavelet ideology. It is important to note that it is advisable to use wavelet coherence in the analysis of the mutual dynamics of exchange rates. It is this method that forms the basis of the generalized methodology for assessing data on the dynamics of changes in the foreign exchange market, which is discussed below.

## **2.2 Generalized Methodology for Assessing Data on the Dynamics of Changes in the Foreign Exchange Market**

Traditionally, the exchange rate is set against the US dollar. Then, in order to compare the mutual dynamics of the exchange rate of different currencies, you need to use the cross-rate technique. This requires a certain amount of time. Nevertheless, we can use the wavelet analysis methodology and compare the mutual dynamics of different currencies in

relation to the dollar. For example, if we have two time series  $g_1, g_2$ , one of which describes the dynamics of the rate of the first currency against the dollar, and the second series describes the dynamics of the rate of the second currency against the dollar, we can implement the following analysis scheme:

$$\left. \begin{matrix} g_1 \\ g_2 \end{matrix} \right\} \rightarrow R(W), \quad (1)$$

where:

$R(W)$  – is some wavelet method of data analysis. In this case, it is advisable to use wavelet coherence to analyze mutual dynamics [16]-[18].

Wavelet coherence allows cross-referencing analysis of two data series for different time intervals. As a result, we get many results as an analogue of multiple correlation. In this case, by analyzing the mutual dynamics of the exchange rate, which is presented as dependence on the dollar, we actually compare the mutual behavior of such currencies. To implement wavelet coherence as an assessment of the mutual dynamics of different exchange rates, the following expression can be used [19]-[21]:

$$R^2(a, b) = \frac{|\Theta(a^{-1}W_{g_1g_2}(a, b))|^2}{\Theta(a^{-1}|W_{g_1}(a, b)|^2)\Theta(a^{-1}|W_{g_2}(a, b)|^2)}, \quad (2)$$

where:

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

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

$g_1, g_2$  – is a data series that we explore;

$\Theta$  – is a smoothing operator;

$R^2(a, b)$  – is a squared wavelet coherency coefficient.

$0 \leq R^2(a, b) \leq 1$ . If these values tend to zero, then we have a weak correlation. Otherwise, we have a strong correlation.

### 2.3 Data for Analysis

For the analysis, consider the following currency quotes:

Australian dollar against the US dollar (AUD / USD);

US dollar to Swiss franc (USD / CHF);

US dollar against the Japanese yen (USD / JPY);

euro to US dollar (EUR / USD);

British pound against the US dollar (GBP / USD).

These currencies are the most used for the implementation of economic activities of various economic entities and are among the main ones in the conduct of economic activities

between countries. The data cover the period from 05.01.2020 to 14.11.2021 and are presented in averaged weekly values. Data from the site – <https://investing.com>.

In fig. 1 shows the dynamics of the values of AUD/USD.

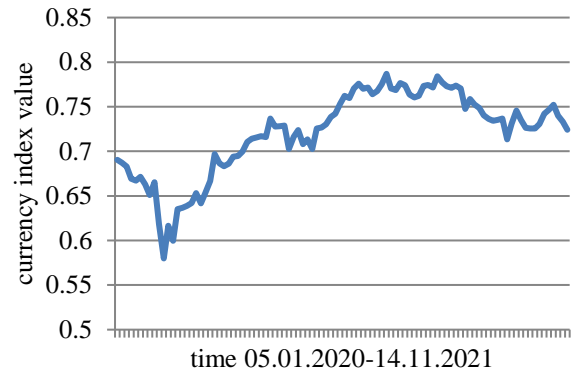


Figure 1: Dynamics of AUD/USD values

In fig. 2 shows the dynamics of the values of USD/CHF

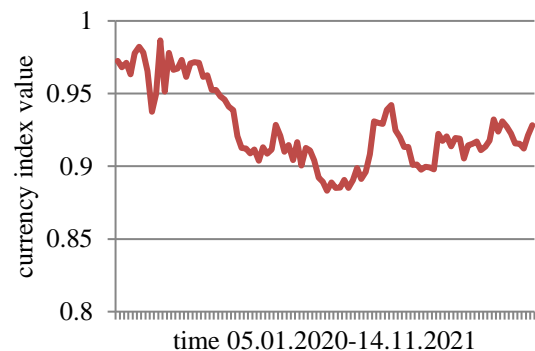


Figure 2: Dynamics of USD/CHF values

In fig. 3 shows the dynamics of the values of USD/JPY.

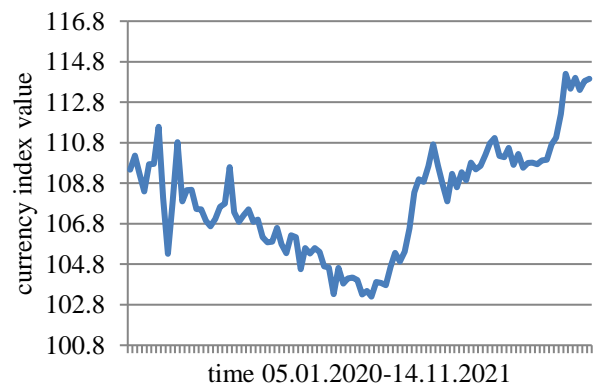
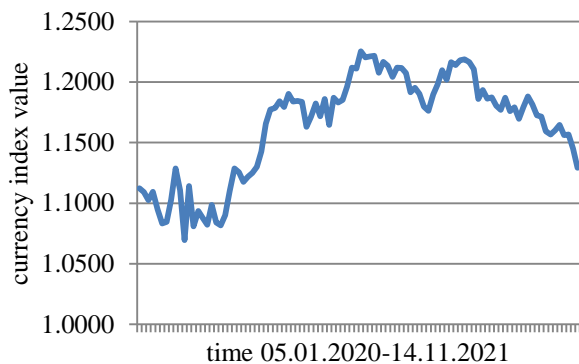


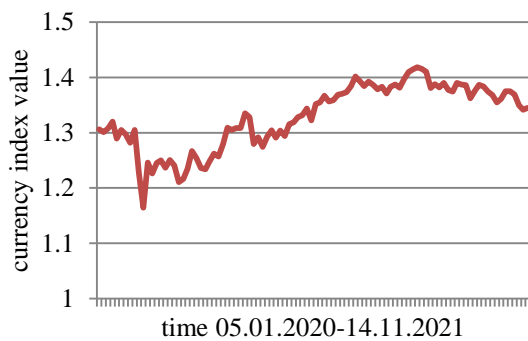
Figure 3: Dynamics of USD/JPY values

In fig. 4 shows the dynamics of the values of EUR/USD.



**Figure 4:** Dynamics of EUR / USD values

In fig. 5 shows the dynamics of the values of GBP/USD.



**Figure 5:** Dynamics of GBP/USD values

Fig. 1-fig. 5 shows that the dynamics of the values of exchange rates, which we are studying, are different. At the same time, some values of exchange rates have the same trends in dynamics for some time intervals. Therefore, we will take a closer look at the relationship for some currency pairs using the wavelet coherence methodology.

### 3. RESULTS AND DISCUSSION

The figures below show the results of evaluating the mutual dynamics of various currency pairs based on wavelet coherence for the empirical data that we are studying. We consider, first of all, the degree of relationship between data series. At the same time, we do not consider which time series of data is the main one, but which one inherits the behavior of another series of data. Each figure below shows:

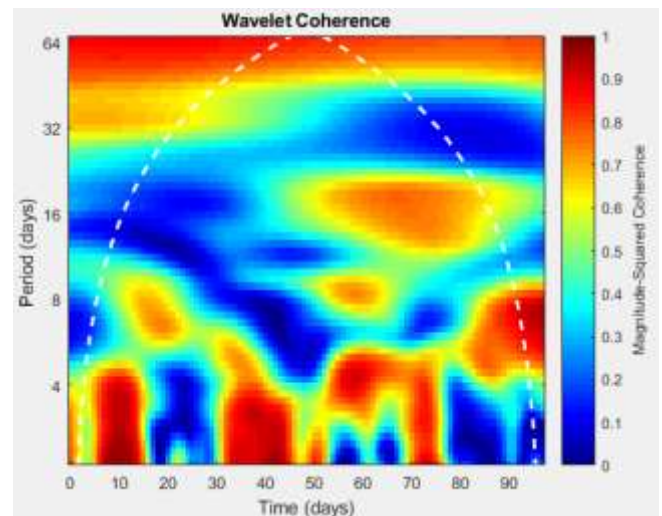
- the abscissa is the time period that we are analyzing. These are the ordinal values of the data that we are examining from the interval 05.01.2020-14.11.2021;

- the ordinate is the depth of cross-references between time series. This allows you to understand the relationship of currency pairs at different time intervals;

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

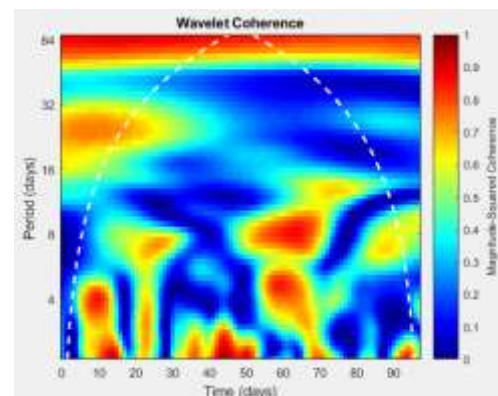
- the column on the right, which allows you to visualize the values of the wavelet coherence from 0 to 1 and have the corresponding color characteristic.

In fig. 6 shows an estimate of the wavelet coherence between AUD/USD and USD/CHF.



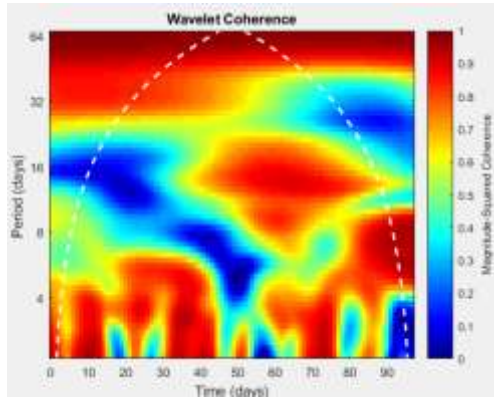
**Figure 6:** Assessment of Wavelet Coherence between AUD/USD and USD/CHF

In fig. 7 shows an estimate of the wavelet coherence between AUD/USD and USD/JPY.



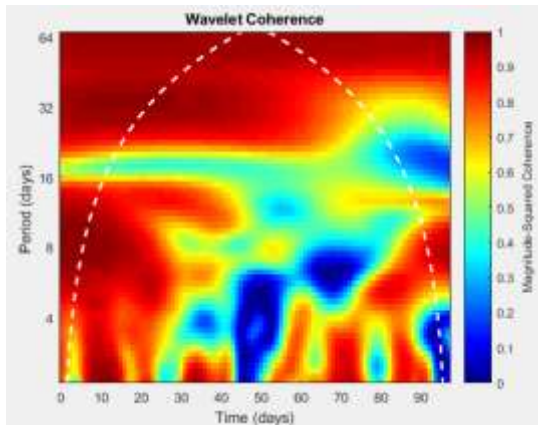
**Figure 7:** Assessment of Wavelet Coherence between AUD/USD and USD/JPY

In fig. 8 shows an estimate of the wavelet coherence between AUD/USD and EUR/USD.



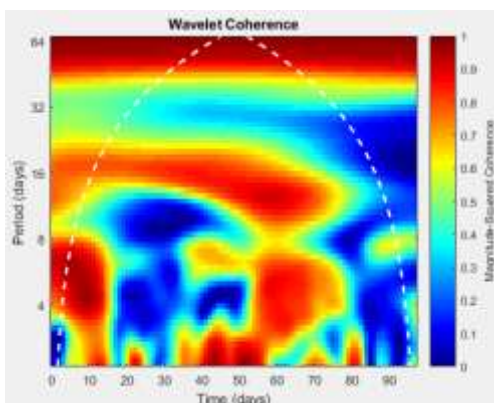
**Figure 8:** Assessment of Wavelet Coherence between AUD/USD and EUR/USD

In fig. 9 shows an estimate of the wavelet coherence between AUD/USD and GBP/USD.



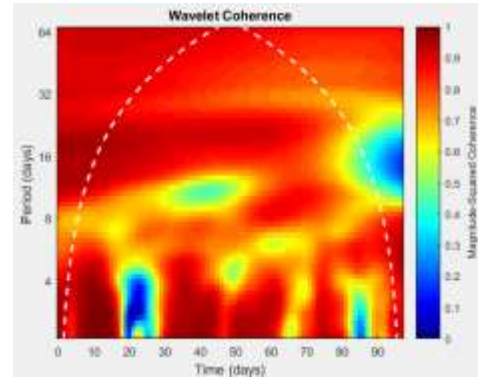
**Figure 9:** Assessment of Wavelet Coherence between AUD/USD and GBP/USD

In fig. 10 shows an estimate of the wavelet coherence between USD/CHF and USD/JPY.



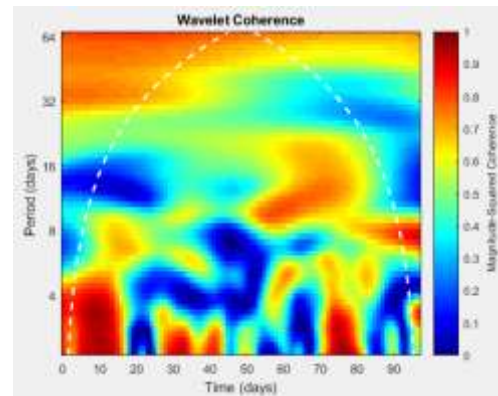
**Figure 10:** Assessment of Wavelet Coherence between USD/CHF and USD/JPY

In fig. 11 shows an estimate of the wavelet coherence between USD/CHF and EUR/USD.



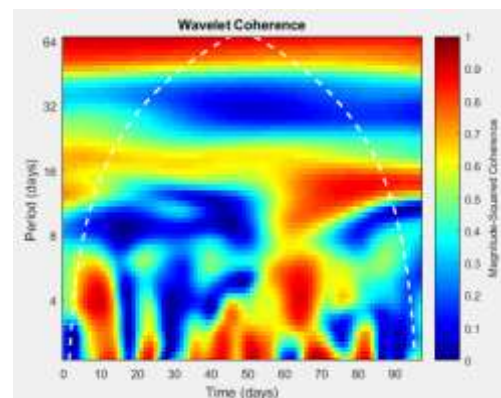
**Figure 11:** Assessment of Wavelet Coherence between USD/CHF and EUR/USD

In fig. 12 shows an estimate of the wavelet coherence between USD/CHF and GBP/USD.



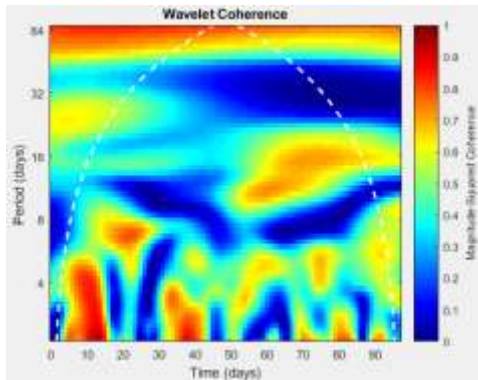
**Figure 12:** Assessment of Wavelet Coherence between USD/CHF and GBP/USD

In fig. 13 shows an estimate of the wavelet coherence between USD/JPY and EUR/USD.



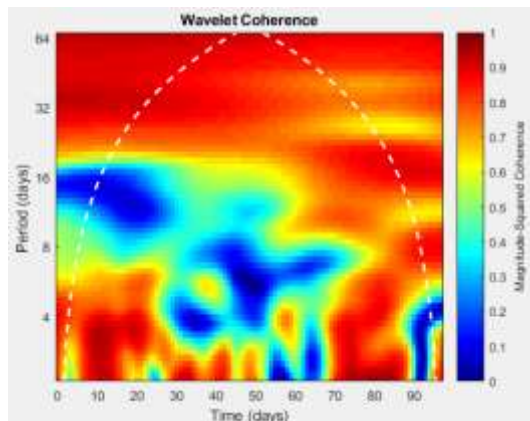
**Figure 13:** Assessment of Wavelet Coherence between USD/JPY and EUR/USD

In fig. 14 shows an estimate of the wavelet coherence between USD/JPY and GBP/USD.



**Figure 14:** Assessment of Wavelet Coherence between USD/JPY and GBP/USD

In fig. 15 shows an estimate of the wavelet coherence between EUR/USD and GBP/USD.



**Figure 15:** Assessment of Wavelet Coherence between EUR/USD and GBP/USD

Data analysis fig. 10 - fig. 15 shows that the estimates of wavelet coherence for different currency pairs differ from each other. At the same time, for most currency pairs, there is a stable relationship at the same time intervals. This is a reflection of the influence of the same factors that occur in the world foreign exchange market. This fact is confirmed by the same depth of cross-referencing, where we can also observe stable and significant estimates of wavelet coherence for different currency pairs.

It should also be noted that for a number of currency pairs, estimates of the stability of the wavelet coherence are observed for most parts of the time interval that we are analyzing (see fig. 11, fig. 15). This is because the countries with the respective currency pairs have close economic relationships. Thus, these remarks confirm the reliability of the results

obtained and the expediency of using the wavelet coherence methodology for the appropriate analysis.

#### 4. CONCLUSION

The paper deals with the analysis of the dynamics of changes in the foreign exchange market. To do this, we gave a brief overview of publications on the research topic and analyzed the dynamics of a number of currency pairs. It was also shown that to analyze the mutual dynamics of currency pairs, it is advisable to use the wavelet coherence methodology. This approach allows one to take into account cross-rates of currency pairs and analyze the reciprocity of joint dynamics.

The paper shows a number of assessments of the dynamics of changes in various currency pairs based on real data. A conclusion is made about the periods of consistency in the dynamics of the currency pairs that we are studying. It is shown that the results obtained are reliable and can be used in practice.

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