

# New Data from Wavelet Analysis on the Dynamics of Changes in the International Currency Market

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**Abstract:** *The foreign exchange market is one of the important segments of the financial market. Such attention to the foreign exchange market is due to the fact that it provides stable economic and organizational relationships in the implementation of transactions for the purchase or sale of foreign currency. This, in turn, has a significant impact on the development of international economic relations. Thus, the analysis of the foreign exchange market plays an important role in the evaluation of various economic processes. To analyze the situation in the foreign exchange market, it is necessary to have primary data. As a source of primary data for the foreign exchange market are empirical data on the dynamics of the exchange rate. At the same time, it is necessary to know the dynamics of the exchange rate from the point of view of different countries. This increases the reliability of the results that can be obtained from the corresponding analysis. We can also evaluate the mutual influence on the dynamics of exchange rates from the point of view of individual countries. For such an analysis, we use the ideology of wavelets. This ideology allows the analysis of data presented as a time series. Among the methods of wavelet ideology, we consider wavelet coherence. This approach allows us to evaluate the mutual dynamics of exchange rates for different countries. The paper presents the results for real data. The paper presents many graphs and diagrams that allow you to better understand the progress of our study, interpret the results.*

**Keywords**—dynamics; empirical data; currency market; exchange rates; wavelet analysis; wavelet coherence.

## 1. INTRODUCTION

Primary data play an important role in the analysis of the current situation in any field of research [1]-[5]. These data are also important for forecasting, development of appropriate management decisions. At the same time, attention should be paid to the dynamics of the primary data. The analysis of such dynamics allows you to explore various relationships between data, hidden trends, and make a better analysis of the data. For such an analysis, various methods and approaches can be used [6]-[12]. The choice of such methods and approaches depends on the tasks that need to be investigated, the field of research.

One important area of research is the analysis of economic dynamics [1], [5]. Such an analysis allows assessing the functioning and development of various business entities. This is necessary for the sustainable functioning of the economy, the country, the existence of individuals, economic agents. Among such areas of research, the financial market should be singled out. The financial market provides the economy with the necessary resources, carries out and supports the movement of such resources between various business entities, individual economic agents. One of the segments of the financial market is the foreign exchange market.

The foreign exchange market is a system of stable economic and organizational relationships that arises when carrying out operations to buy or sell foreign currency [13]-[15]. Such operations are widely used in international trade.

These transactions are the basis for mutual settlements. Consequently, the foreign exchange market can also be considered as a segment of international economic relations. Then the analysis of the dynamics of the world currency market allows us to evaluate the dynamics of international economic relations. In this regard, empirical data on the dynamics of the world foreign exchange market are a source of data for the analysis of international economic relations.

Thus, the analysis of the dynamics of changes in the world currency market is one of the tasks in the study of the dynamics of international economic relations. For such a study, it is important to choose adequate analysis tools that allow you to obtain reliable results. This suggests that this study has scientific and practical value, is relevant.

## 2. RELATED WORK

The importance of considering the foreign exchange market, its relationship with various segments of economic relations makes it necessary to conduct appropriate scientific and applied research. This became the basis for many works that deal with various aspects of the functioning and development of the foreign exchange market. At the same time, special attention is paid to the analysis and evaluation of empirical data.

J. Kwapień, S. Gworek, S. Drożdż and A. Górski in their study consider the network structure of the foreign exchange market [16]. First of all, the authors analyze the structure of the global foreign exchange market [16]. This emphasizes the

importance of considering the foreign exchange market in the development of the market of international economic relations. The authors consider a number of currency pairs and single out separate groups of such pairs. Thus, separate clusters are formed, which help to better understand the dynamics of the foreign exchange market. For such an analysis, filtered correlation matrix methods are used. The authors also consider the topology of individual clusters. This allows us to assess the dynamics of the structure of the foreign exchange market.

J. Mazanec considers the issues of currency portfolio optimization [17]. At the same time, the object of analysis in this study is digital currencies. The author notes that the issue of portfolio diversification is extremely important in the cryptocurrency market for most investors [17]. This is because virtual currencies are very risky compared to traditional assets, while virtual currencies are moderately correlated. Thus, we see that the issues of the importance of the foreign exchange market are very broad.

In [18], the issues of forecasting in the foreign exchange market are considered. The authors consider the issues of forecasting based on the analysis of the dynamics of the corresponding time series. For such an analysis, the C-RNN forecasting method for time series data based on a deep recurrent neural network and a deep convolutional neural network was used [18]. The authors note that this approach improves the accuracy of forecasting.

The work [19] discusses the efficiency of the foreign exchange market in the context of the development of the COVID-19 pandemic. To do this, the authors use multifractal analysis of fluctuations without a trend (MF-DFA) [19]. This comparison is made for different time intervals. This is how the authors consider the period before the COVID-19 pandemic and in the initial period of the development of the COVID-19 pandemic. The authors also explore the internal dynamics of multifractality through seasonal and trend expansions using loess [19]. In general, the results confirm the presence of multifractality in the forex markets [19].

M. Ozturk and S. C. Cavdar analyze the relationship between the foreign exchange market and individual segments of the stock market [20]. Among such components of the stock market, the authors consider the dynamics of prices for oil, gold and Bitcoin. At the same time, such an analysis is carried out in the context of the development of the COVID-19 pandemic. To do this, the authors use the ARMA-EGARCH model to measure the impact of volatility and accompanying shocks.

K. H. Al-Yahyaee, W. Mensi and S. M. Yoon also conduct a comparative analysis of the stock market, currency and gold [21]. The authors evaluate the efficiency of the bitcoin market in comparison with the markets of gold, stocks and foreign exchange [21]. To do this, the authors use the MF-DFA approach.

H. Chung and K. S. Shin consider issues of stock market forecasting [22]. The authors explore the possibility of

applying a hybrid approach that combines a network of long-term short-term memory (LSTM) and a genetic algorithm (GA). The authors also explore the temporal property of stock market data, proposing a systematic method for determining the time window size and topology for an LSTM network using GA [22].

Z. Umar and M. Gubareva explore the volatility of the foreign exchange market and the cryptocurrency market in the context of the development of the COVID-19 pandemic [23]. For such a study, the authors use wavelet analysis. This approach has shown good results. In particular, the authors note that the results obtained may be for the development of effective cross-currency hedges that can withstand the adverse effects of global financial and economic shocks [23].

H. F. Baklaci and T. Yelkenci in their work use cross-frequency analysis of relationships to study the foreign exchange market [24]. The authors consider the possibility of identifying cross-border volatility relationships between different currencies in the foreign exchange market, taking into account different sampling frequencies [24]. Volatility relationships between these selected exchange rates were tested using the VAR-BEKK-GARCH multivariate model [24].

We see that various methods and approaches can be used to analyze empirical data on the functioning and development of the foreign exchange market. At the same time, researchers pay special attention to methods based on time-frequency analysis. Therefore, below we will consider in more detail one of the approaches of this method for the analysis of empirical data on the foreign exchange market.

### 3. WAVELET COHERENCE AS A TOOL FOR THE ANALYSIS OF EMPIRICAL DATA

Wavelet ideology has found wide application for the analysis of data, which are presented in the form of a time series. Methods and approaches of wavelet ideology are also widely used for the analysis of economic data [25]-[31]. Such an interest in the wavelet ideology is due to the fact that we can explore the dynamics of data at different time intervals. At the same time, individual results of such a study can be presented in one result window. Wavelet coherence should be singled out among such methods of analysis. This method also allows you to analyze the relationship between individual time series data and the relationship between different time series.

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 [32]-[34]:

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

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,

$A$  – smoothing operator,

$Q^2(a, b)$  – square of the wavelet coherence coefficient.

$0 \leq Q^2(a, b) \leq 1$ . If these values tend to zero, then we have a weak correlation. Otherwise we have a strong correlation [33]-[36].

#### 4. EMPIRICAL DATA AS A SOURCE FOR ANALYSIS IN THE FOREIGN EXCHANGE MARKET

For our study, we will consider some empirical data that characterize the main trends in the development of the global foreign exchange market. To this end, consider the dynamics of the values of some currency pairs. All data is taken from [www.investing.com](http://www.investing.com). The data covers the period from 01.01.2021 to 15.05.2022. In order for the data to be consistent with each other, we consider their empirical values in the context of average weekly values. Among the currency pairs we consider:

USD/JPY - US Dollar Japanese Yen;

USD/CHF - US Dollar Swiss Franc;

USD/CAD - US Dollar Canadian Dollar;

USD/GBP - US Dollar British Pound;

USD/EUR - US Dollar Euro.

On fig. 1 shows the dynamics of the values of the USD/JPY currency pair.

In general, we are seeing a positive trend in the USD/JPY currency pair. At the same time, this dynamic is not permanent. It should be noted the increase and decrease in the values in the dynamics of the USD/JPY currency pair. At the same time, it should also be noted a sharp increase in the values of the USD/JPY currency pair in the last period of time that we are studying.

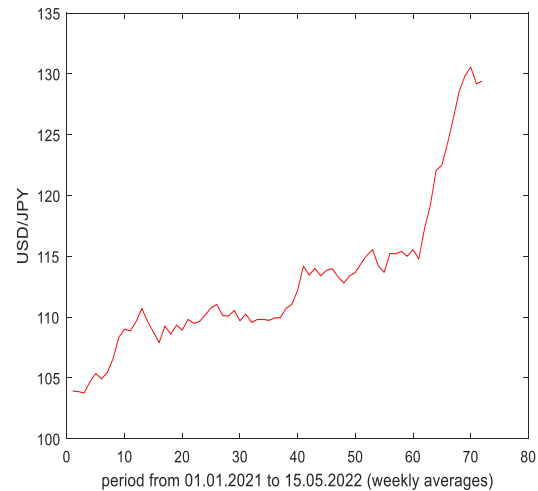


Figure 1: Dynamics of the values of the USD/JPY currency pair

On fig. 2 shows the dynamics of the values of the USD/CHF currency pair.

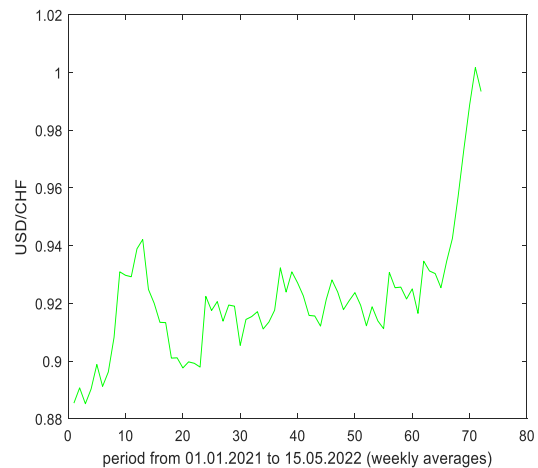
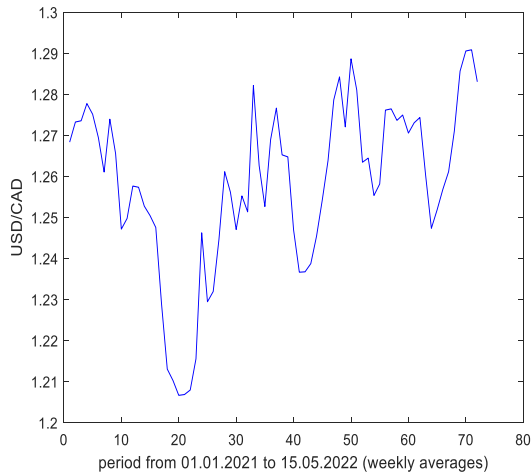


Figure 2: Dynamics of the values of the USD/CHF currency pair

We can note some similarity in the dynamics of the values of the USD/CHF currency pair in comparison with the dynamics of the values of the USD/JPY currency pair. At the same time, the dynamics of the values of the USD/CHF currency pair is more volatile than the dynamics of the values of the USD/JPY currency pair. In other words, for the USD/CHF currency pair, there are sharper changes in the dynamics of its values. This fact must be taken into account in the process of carrying out the relevant international economic activity.

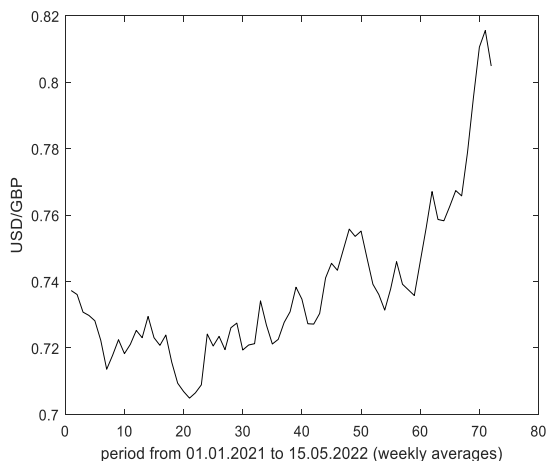
On fig. 3 shows the dynamics of the values of the USD/CAD currency pair.



**Figure 3:** Dynamics of the values of the USD/CAD currency pair

The data presented in fig. 3 differ from the data in fig. 1 and fig. 2. We observe the variable dynamics of the values of the USD/CAD currency pair. At the same time, such dynamics is characterized by several minimum values, after which there is a significant increase in values. In general, the dynamics of the values of the USD/CAD currency pair is increasing. However, this growth is insignificant.

On fig. 4 shows the dynamics of the values of the USD/GBP currency pair.

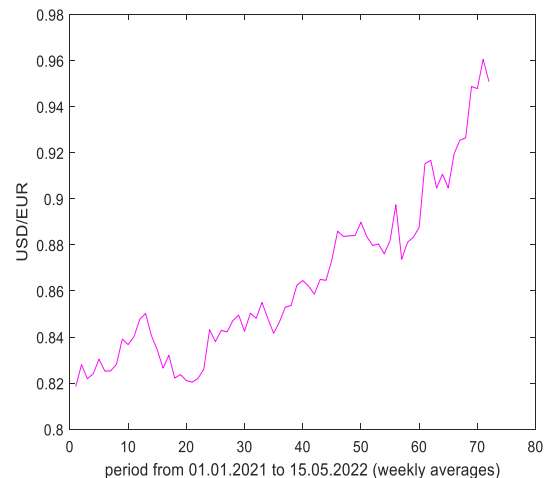


**Figure 4:** Dynamics of the values of the USD/GBP currency pair

The data of fig. 4 are somewhat similar to those in fig. 1 and fig. 2. But this similarity is characteristic only from the point of view of general dynamics. In detail, these are

completely different dynamics of the values of currency pairs. At the same time, we can note the volatility of the dynamics of the values of the USD/GBP currency pair.

On fig. 5 shows the dynamics of the values of the USD/EUR currency pair.



**Figure 5:** Dynamics of the values of the USD/EUR currency pair

We see that the dynamics of the values of the USD/EUR currency pair has some similarities with the dynamics of the values of the USD/GBP currency pair. This is due to the fact that the economies of the European Union and UK have much in common and are closely interconnected. However, we can also observe many differences in the dynamics of the values of the USD/EUR and USD/GBP currency pairs.

For a more detailed analysis of empirical data on the dynamics of the world currency market, let us consider the corresponding estimates of their mutual values of wavelet coherence.

### 5. SOME RESULTS OF WAVELET COHERENCE ESTIMATES FOR EMPIRICAL DATA OF THE WORLD CURRENCY MARKET

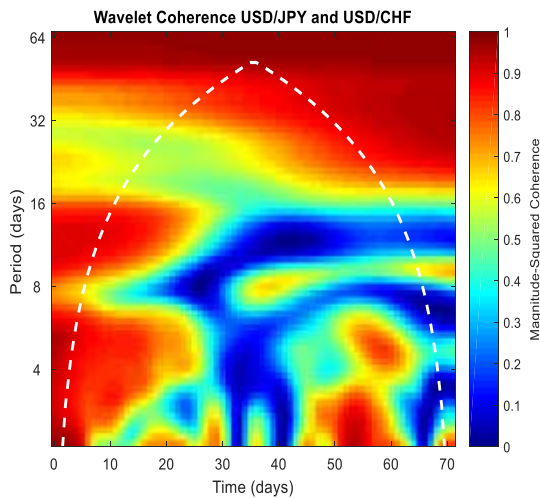
The figures below show the results of wavelet coherence estimates between different currency pairs. These estimates help to better understand the mutual dynamics of the values of various currency pairs, to make adequate decisions for activities in the market of international economic relations.

On fig. 6 shows wavelet coherence estimates for such currency pairs as USD/JPY and USD/CHF.

We can observe fragmentary consistency between the dynamics of the USD/JPY and USD/CHF currency pairs. The greatest dependence is observed at the beginning and at the end of the time period that we are studying. At the same time, at the beginning of the period, such consistency is greatest and more long-term. You should also take into account the fact that

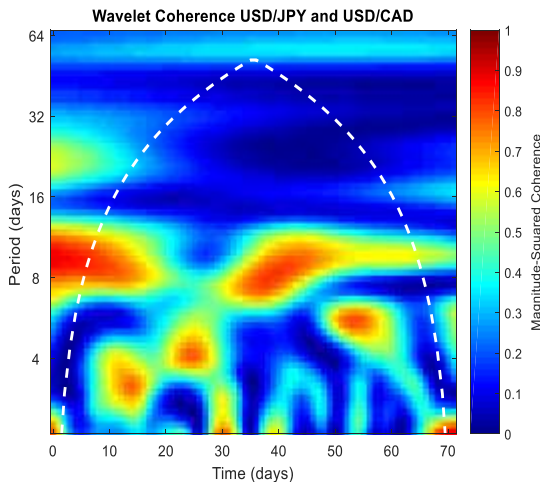


the consistency between the USD/JPY and USD/CHF currency pairs over the entire studied period of time is of a long-term nature. This must be taken into account in the implementation of international trade.



**Figure 6:** Wavelet coherence estimates for USD/JPY and USD/CHF currency pairs

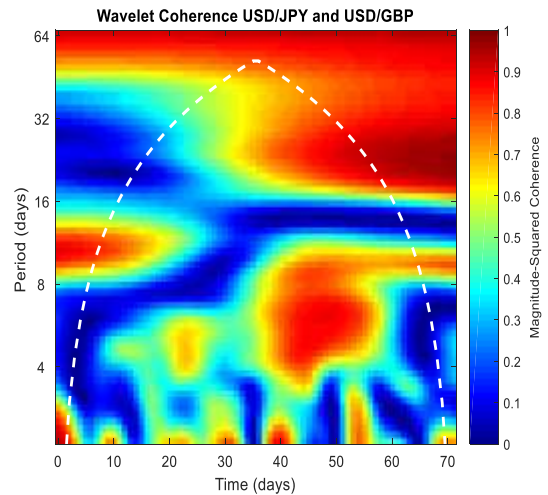
On fig. 7 shows wavelet coherence estimates for such currency pairs as USD/JPY and USD/CAD.



**Figure 7:** Wavelet coherence estimates for USD/JPY and USD/CAD currency pairs

We see even less consistency between the USD/JPY and USD/CAD currency pairs. At the same time, it should be noted that such consistency is distributed over the entire time interval that we are studying. Such coherence alternates with periods of its complete absence. It should also be noted that there is a long-term consistency between the USD/JPY and USD/CAD currency pairs.

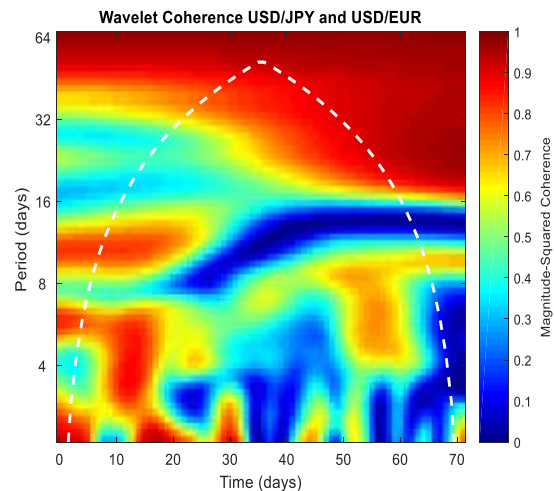
On fig. 8 shows wavelet coherence estimates for such currency pairs as USD/JPY and USD/GBP.



**Figure 8:** Wavelet coherence estimates for USD/JPY and USD/GBP currency pairs

The consistency assessment between the USD/JPY and USD/GBP currency pairs differs from those discussed above for other currency pairs. But in general, the consistency between the USD/JPY and USD/GBP pairs inherits some of the features of previous currency pairs.

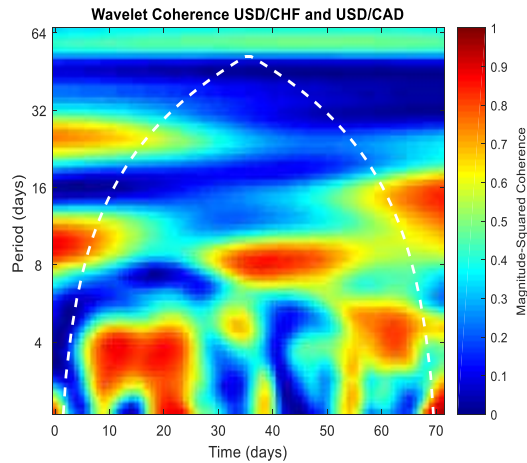
On fig. 9 shows wavelet coherence estimates for such currency pairs as USD/JPY and USD/EUR.



**Figure 9:** Wavelet coherence estimates for USD/JPY and USD/EUR currency pairs

We see that the consistency of the USD/JPY and USD/EUR currency pairs as a whole inherits the main points of the previous estimates that were discussed above. At the same time, we note that the consistency of the USD/JPY and USD/EUR currency pairs is closest to the estimates of the consistency of the USD/JPY and USD/GBP currency pairs.

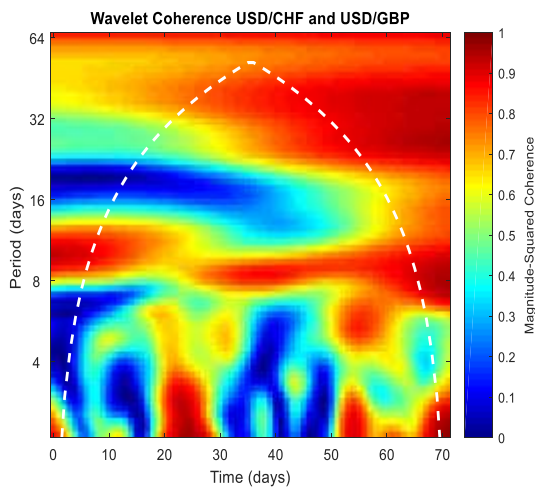
On fig. 10 shows wavelet coherence estimates for such currency pairs as USD/CHF and USD/CAD.



**Figure 10:** Wavelet coherence estimates for USD/CHF and USD/CAD currency pairs

The consistency of USD/CHF and USD/CAD currency pairs in some way copies the consistency of USD/JPY and USD/CAD currency pairs. At the same time, the consistency of the USD/CHF and USD/CAD currency pairs is more pronounced.

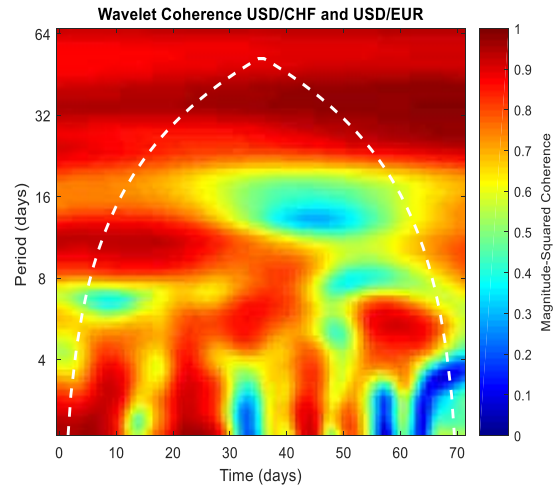
On fig. 11 shows wavelet coherence estimates for such currency pairs as USD/CHF and USD/GBP.



**Figure 11:** Wavelet coherence estimates for USD/CHF and USD/GBP currency pairs

It should be noted that, as for the estimates above, we observe fragmentary consistency between the respective currency pairs. At the same time, the degree of such consistency has been increasing in recent years.

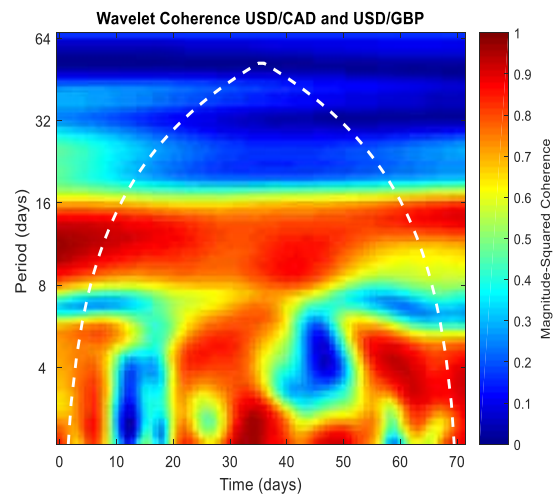
On fig. 12 shows wavelet coherence estimates for such currency pairs as USD/CHF and USD/EUR.



**Figure 12:** Wavelet coherence estimates for USD/CHF and USD/EUR currency pairs

The consistency between the USD/CHF and USD/EUR currency pairs is the greatest in comparison with what we have considered earlier. However, in recent periods this consistency has been decreasing.

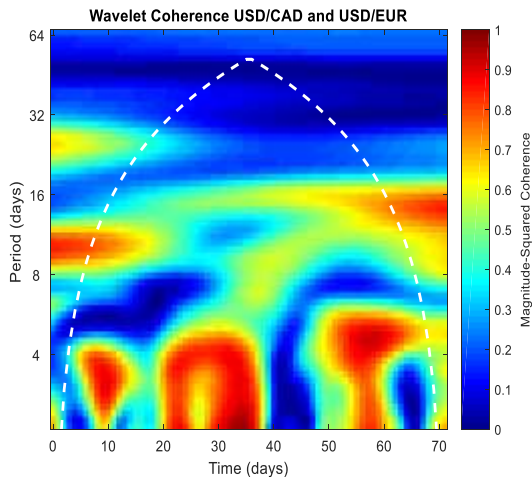
On fig. 13 shows wavelet coherence estimates for such currency pairs as USD/CAD and USD/GBP.



**Figure 13:** Wavelet coherence estimates for USD/CAD and USD/GBP currency pairs

Consistency between the USD/CAD and USD/GBP currency pairs is significant.

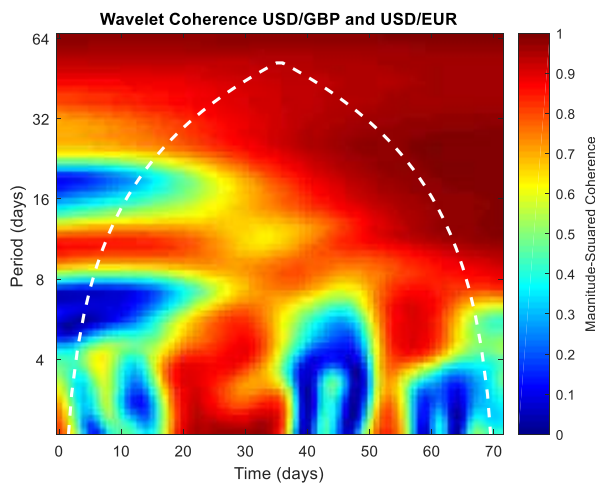
On fig. 14 shows wavelet coherence estimates for such currency pairs as USD/CAD and USD/EUR.



**Figure 14:** Wavelet coherence estimates for USD/CAD and USD/EUR currency pairs

For the USD/CAD and USD/EUR currency pair, the wavelet coherence estimate is insignificant and fragmentary in comparison with the wavelet coherence estimate for the USD/CAD and USD/GBP currency pair.

On fig. 15 shows wavelet coherence estimates for such currency pairs as USD/GBP and USD/EUR.



**Figure 15:** Wavelet coherence estimates for USD/GBP and USD/EUR currency pairs

The wavelet coherence estimate for the USD/GBP and USD/EUR currency pairs was the largest in the middle of the study period.

At the same time, it should be noted that the obtained estimates of wavelet coherence can serve as a guide when making decisions in the process of implementing international economic relations.

## 6. CONCLUSION

The paper considers the issues of analysis and research of the world currency market. A brief review of works on the topic of the study was carried out. The importance of empirical data as a source for the corresponding analysis is noted. It also shows the relationship and influence of the dynamics of the values of currency pairs on the processes of implementation of international economic relations.

For the analysis of empirical data, the ideology of wavelets is used. In particular, estimates of wavelet coherence for various currency pairs are considered. The results of calculations of such estimates are presented in the form of corresponding diagrams.

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