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Model for Predictive Analysis of International Trade Based on the Dynamics of Stock Indices (Example of Data from the USA, Canada and UK)

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Abstract: *Forecasting is one of the tools for assessing the functioning and development of processes, phenomena, objects. This tool has found its application in all areas of research. Among these areas of research, one should single out the direction that is associated with the economy. This is important because such studies help to assess the level of economic development, the welfare of mankind, to find ways for the further functioning and development of various processes, phenomena, objects. To solve the tasks set, various models are used that help to implement a certain forecast scheme. At the same time, the construction of such models involves the implementation of the corresponding stages of modeling. Such modeling steps help determine the type of the final model and implement the required predictive model. Therefore, we pay special attention to the individual stages of predictive modeling. The efficiency of building a predictive model is also determined by the applied problem that needs to be solved in the modeling process. In this paper, we consider the elements of a predictive model for the analysis of international trade. To do this, we use data on the dynamics of stock indices. In particular, we use the dynamics of stock indices, which describe the activities of banking institutions. To build individual elements of the predictive model, we use the apparatus of wavelet theory. Among the tools of wavelet theory, we use wavelet coherence. We also propose an approach for comparing different estimates of wavelet coherence. This approach is based on comparing the corresponding wavelet coherence estimates and visualizing the results. This allows you to better understand the mutual dynamics of stock indices and evaluate the dynamics of international trade. The paper presents various graphs and diagrams that help to understand the logic of the study and the results obtained.*

Keywords—model; forecast; dynamics; grade; international trade; stock market; stock indices; wavelet analysis; wavelet coherence

1. INTRODUCTION

Modeling is one of the tools that help to explore the process, phenomenon or object that we are studying. For such a study, some adequate model is used, which contains various factors and describes the relationship between these factors [1]-[5]. In this case, the modeling process may contain several stages. In this case, it is important to describe each of the stages of modeling and indicate the possible relationship between such stages. Ultimately, this allows us to speak about the importance of considering the individual stages of the overall modeling process. In order to single out such stages of the general modeling process, we need to know the general problem that is solved in the modeling process. This is an important point in the study.

One of the areas of modeling is forecasting [6]-[9]. The main task of such modeling is to justify the actions that must be taken in order for the process, phenomenon or object to function (develop) in the required direction. Thus, we should talk about predictive modeling. At the same time, the specification of tasks for such modeling depends on the subject area that we are studying. We will also talk about the individual stages of predictive modeling, which are determined by the subject area of the study. At the same time, it should be noted that for such modeling, it is possible to use various methods, algorithms and approaches that are used in various areas of research [10]-[23]. Therefore, it is important to select the necessary and adequate tools for the appropriate modeling.

Among the subject areas of research, one can indicate various areas in science, the spheres of production and people's lives, the functioning of various business entities [24]-[27]. One of these subject areas is the sphere of international trade, which allows assessing the dynamics of relationships between countries, economic entities, and the development of the economy as a whole. It should also be noted that it is necessary to choose the dynamics of stock indices as data for such predictive modeling. This is based on the fact that stock indices reflect the dynamics of the value of the relevant business entities (companies, firms, enterprises, various institutions). In this case, we can also talk about the impact of trade on such companies, firms, and, consequently, the development of trade. Thus, the topic of this work is relevant and has a practical focus.

2. Brief Review of Relevant Literature

Currently, you can find many works that consider various models for analyzing data on the dynamics of stock indices. There are also many works that consider various predictive models.

For example, J. Wang and J. Wang, in their study, consider a number of issues related to forecasting stock market indices [28]. First of all, the authors note that such studies are constantly in the spotlight. For their analysis, the authors use a stochastic neural network with an effective time function [28]. Also in such an analysis, the theory of principal components is used. This is necessary for training the neural network. This approach allows us to take into account the time factor and the features of its influence on the entire time horizon that is being studied. The authors note the higher performance of their approach in comparison with existing approaches. At the same time, we see that the authors consider several stages in the construction of the corresponding predictive model.

M. V. Subha and S. T. Nambi build a model for classifying the dynamics of stock indices for the corresponding analysis [29]. This is necessary in order to predict the direction of the stock market. We see that the authors single out a certain segment for building a predictive model. Such an analysis is carried out on the example of the Indian stock market. To do this, the authors use the k-nearest neighbor's algorithm.

M. Hiransha, E. A. Gopalakrishnan, V. K. Menon and K. P. Soman consider stock market analysis based on deep learning models [30]. At the same time, the authors note that the analysis of stock market data plays an important role in the modern economy. This confirms the importance of the research topic that we consider in our work. For the appropriate analysis, the authors consider four types of deep learning: multilayer perceptron (MLP), recurrent neural networks (RNN), long-term short-term memory (LSTM) and convolutional neural network (CNN) [30]. The results obtained were compared to classical statistical data analysis models.

D. Shah, H. Isah and F. Zulkernine in their study conduct a broad review and offer a classification of various methods of stock market analysis [31]. At the same time, the authors pay special attention to forecasting methods. First, the authors present a brief overview of stock markets and a classification of stock market forecasting methods. Then, the paper considers the features of the methods that are used to predict stocks [31]. The paper also discusses the technical, fundamental, short-term and long-term approaches used to analyze stocks [31].

K. P. Prabheesh, R. Padhan and B. Garg focus on the analysis of interrelations in the development of the stock market [32]. The paper considers the relationship between the return on stock prices and the return on oil prices. Thus, we see that one of the main directions in building predictive models for analyzing the stock market is to conduct a mutual analysis of various financial flows. This makes it possible to understand the main patterns of development of such flows and the stock market as a whole, which is important in the context of the analysis of international trade. For such an analysis, the authors use the DCC-GARCH model [32].

D. T. Tran, A. Iosifidis, J. Kanniainen and M. Gabbouj analyze the stock market, where time series are considered as data [33]. Such time series represent the dynamics of some indicator. Then, for the appropriate analysis, the authors use classical methods and approaches that are combined with the methods of the theory of neural networks. At the same time, such a network includes the idea of a bilinear projection, as well as an attention mechanism that allows the neural network layer to detect important temporal information and focus on it [33].

The study by the authors B. M. Henrique, V. A. Sobreiro and H. Kimura presents an overview of various models for forecasting in financial markets [34]. Among the various methods, the authors distinguish machine learning models. This is due to the fact that the prices of financial assets are non-linear, dynamic and chaotic, and such models are one of the analysis tools [34]. The authors also note that prices are financial time series that are difficult to predict. Therefore, in our opinion, it is important to break the forecasting task into several stages. Also in their work, the authors proposed a classification for markets, assets, methods and variables. This helps in choosing a specific predictive model, justifying such a choice.

X. Zhou, Z. Pan, G. Hu, S. Tang and C. Zhao in their study consider predictive models for the stock market, which are based on the analysis of generative competitive networks [35]. The authors consider a general framework that uses long-term short-term memory (LSTM) and convolutional neural network (CNN) for adversarial learning in high-frequency stock market forecasting [35]. We see that the authors consider several stages for building a predictive model. It is noted in the work that this approach allows increasing the accuracy of the forecast and reducing the forecast error. At the same time, this model uses publicly available stock indices.

S. M. Idrees, M. A. Alam and P. Agarwal study the volatility of the stock market, where time series of a series of stock market indicators are considered as input data [36]. Such an analysis includes, first of all, the identification of market trends over time. At the same time, the authors note that new innovative approaches are needed to predict the stock market.

Thus, we see that various methods and approaches can be used to build predictive models based on stock market data. At the same time, when building predictive models, it is important to single out their individual stages and focus on the most significant stages. It is also important to take into account the mutual analysis of data, which can be one of the components of the forecast. These points must be taken into account when considering a general model for predictive analysis of international trade based on the dynamics of stock indices.

3. Main Points of Building a Generalized Predictive Model

First of all, we note that we consider the problem of constructing a predictive model as one that consists of several stages (see fig. 1). In what follows, we will consider only some of these stages. It should also be noted that our predictive model is focused on estimating international trade. Therefore, we consider such a model in the framework of international trade between individual countries. Then the corresponding model is focused, first of all, on assessing the dynamics of the state of trade between countries. At the same time, based on the retrospective of such an assessment, we can draw a conclusion about further cooperation between countries in the field of trade.

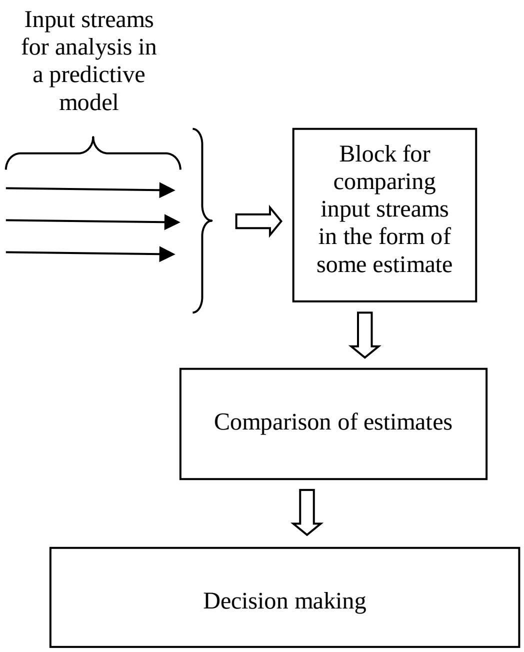

Figure 1: Some selected steps in a predictive model for international trade analysis

The first step in our predictive model is to evaluate the relationship between different input data streams. Such data streams are time series that represent certain economic indicators. To obtain a certain predictive estimate, we propose to use the wavelet ideology. We propose to use wavelet coherence, which has found wide application for the corresponding analysis [37]-[40].

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 [41]-[44]:

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

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 [44]-[47].

Thus, we can get a whole set of estimates $\{Q_n^2\}$, where n is the number of such estimates. Then the next step in our predictive model is to compare such estimates with each other.

Each score Q_n^2 is a matrix of numbers. Then, if we have two estimates (Q_1^2 and Q_2^2) we can compare them using the expression:

$$QSR = (Q_1^2 - Q_1^2)^2, \quad (2)$$

where:

QSR – is the comparison score between different wavelet coherence scores. Such an estimate is made for each element of the wavelet coherence estimation matrix. Then, the smaller the corresponding estimate QSR the more similar are the estimates corresponding to the wavelet coherence estimates for a certain time horizon.

4. Data for Analysis

We consider a model for predictive analysis of international trade between individual countries. As such countries, we have chosen the USA, Canada and the UK. At the same time, our model is based on the dynamics of individual stock indices for these countries. Among these stock indices, we have chosen stock indices that characterize the functioning and development of banking institutions in the respective countries. This choice is based on the fact that it is banking institutions that play a leading role in the financial support of international trade. Among such stock indices we consider:

Dow Jones Banks (DJUSBK) – an index that is designed to measure the performance of US companies in the banking sector;

S&P/TSX EqlWgt Diversified Banks (GSPTXDE) – an index that is designed to measure the performance of Canadian companies in the banking sector;

S&P/TSX Canadian Financials (SPTTFS) – an index that is designed to measure the performance of Canadian companies in the financial sector, taking into account the banking sector of the economy;

FTSE 350 Banks (FTNMX301010) – an index that is designed to measure the performance of UK companies in the banking sector based on buy/sell signals based on moving averages;

FTSE All Share Banks (FTASX301010) is an extended index that measures the performance of UK companies in the banking sector.

All data is taken from the site https://investing.com and reflects the dynamics of such indices in the period from 04.01.21 to 31.12.21.

On fig. 2 shows the dynamics of the stock index DJUSBK.

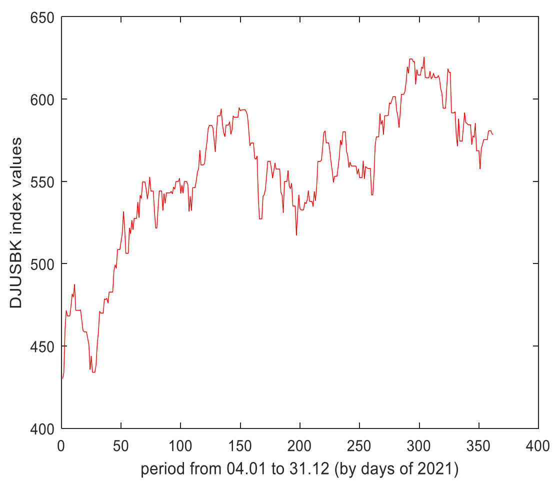

Figure 2: Dynamics of the stock index DJUSBK

On fig. 3 shows the dynamics of the stock index GSPTXDE.

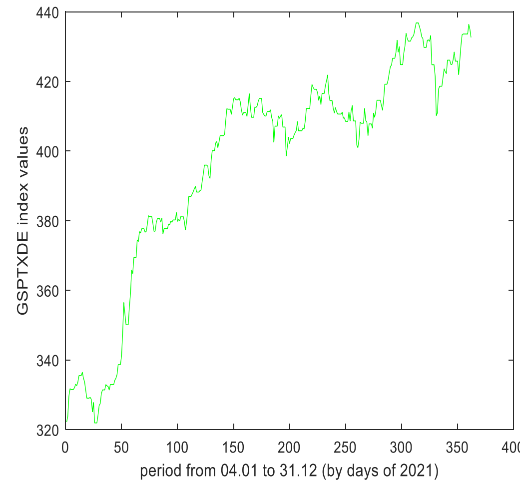

Figure 3: Dynamics of the stock index GSPTXDE

On fig. 4 shows the dynamics of the stock index SPTTFS.

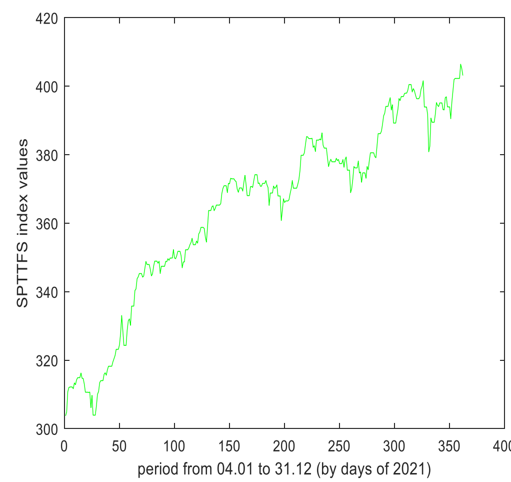

Figure 4: Dynamics of the stock index SPTTFS

We can observe approximately the same dynamics of the data for fig. 3 and fig. 4. Therefore, comparing the data in fig. 2 with the data of fig. 3 and fig. 4, we can get approximately the same wavelet coherence estimates. At the same time, it is possible to single out time intervals where the dynamics of the data is still different. This makes it necessary to compare wavelet coherence estimates in order to make correct decisions.

On fig. 5 shows the dynamics of the stock index FTNMX301010.

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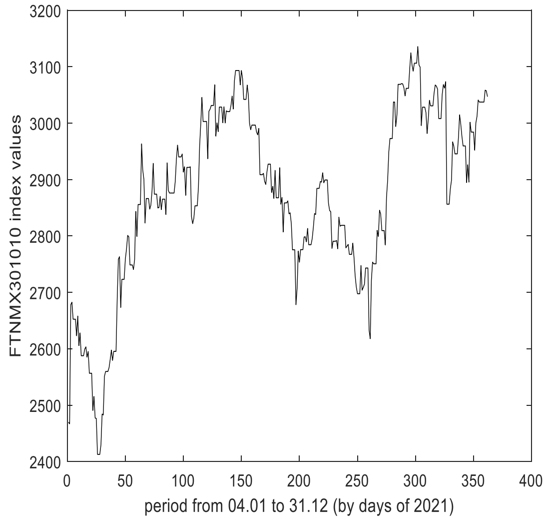

Figure 5: Dynamics of the stock index FTNMX301010

On fig. 6 shows the dynamics of the stock index FTASX301010.

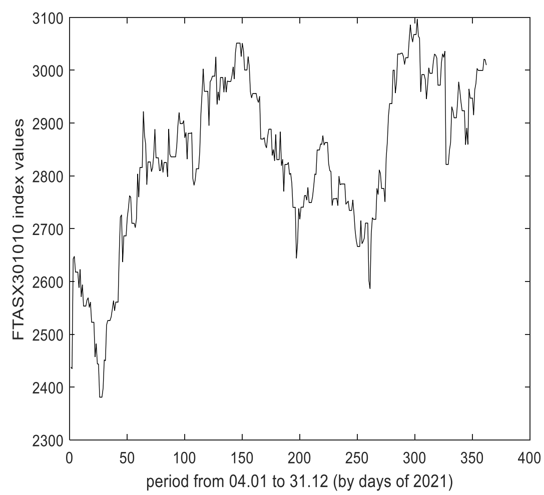

Figure 6: Dynamics of the stock index FTASX301010

We see that the data in fig. 5 and fig. 6 are even more similar to each other. This makes it difficult to use wavelet coherence estimation in predictive models for the analysis of international trade. Therefore, we will consider this issue in more detail below.

5. Results and Discussion

On fig. 7 shows an estimate of the wavelet coherence between DJUSBK and GSPTXDE data values.

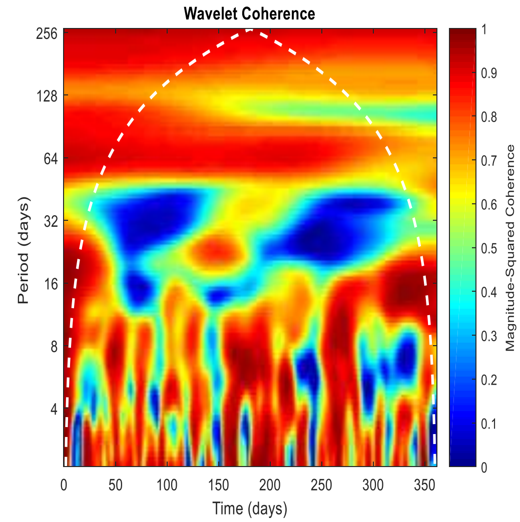

Figure 7: Evaluation of wavelet coherence between DJUSBK and GSPTXDE data values

On fig. 8 shows an estimate of the wavelet coherence between DJUSBK and SPTTFS data values.

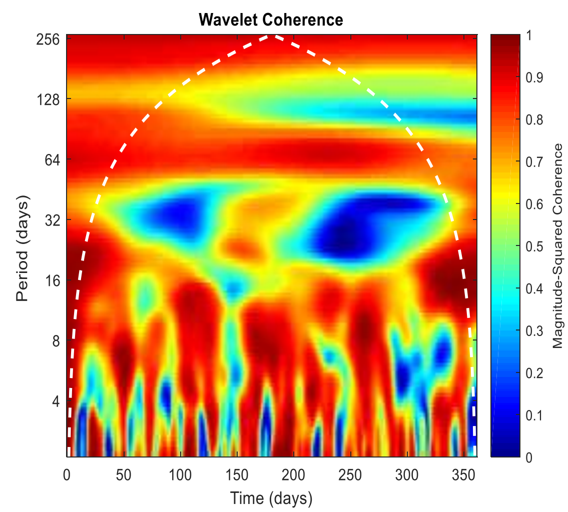

Figure 8: Evaluation of wavelet coherence between DJUSBK and SPTTFS data values

We can see approximately the same estimates of the wavelet coherence. At the same time, one can observe differences in such estimates. A comparison of wavelet coherence estimates with each other will help answer this question in more detail. For this, we use expression 2.

On fig. 9 shows a comparison of the wavelet coherence estimates for the data in fig. 7 and fig. 8.

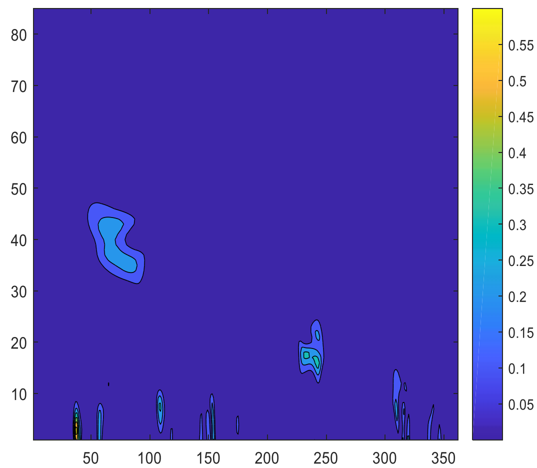

Figure 9: Comparison of wavelet coherence estimates for the data of fig. 7 and fig. 8

We see that the corresponding wavelet coherence estimates are comparable. At the same time, we can also note periods when such estimates differ from each other. At the same time, from the point of view of the predictive model, it should be noted that in the short term one of the wavelet coherence estimates can be used (either for the data in fig. 7 or for the data in fig. 8). When constructing a forecast for longer periods, it is advisable to choose specific wavelet coherence estimates, depending on the problem to be solved.

On fig. 10 shows an estimate of the wavelet coherence between DJUSBK and FTNMX301010 data values.

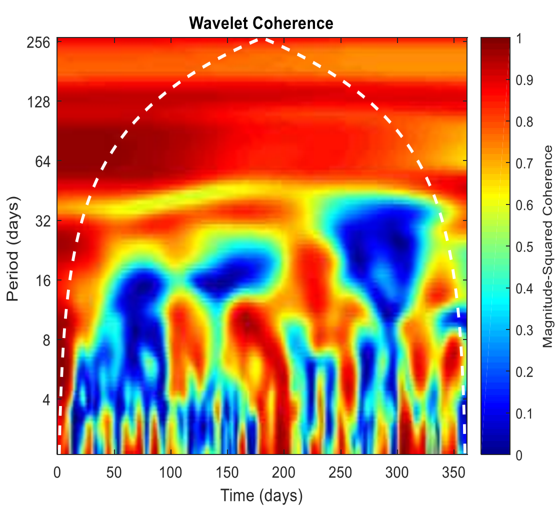

Figure 10: Evaluation of wavelet coherence between DJUSBK and FTNMX301010 data values

On fig. 11 shows an estimate of the wavelet coherence between DJUSBK and FTASX301010 data values.

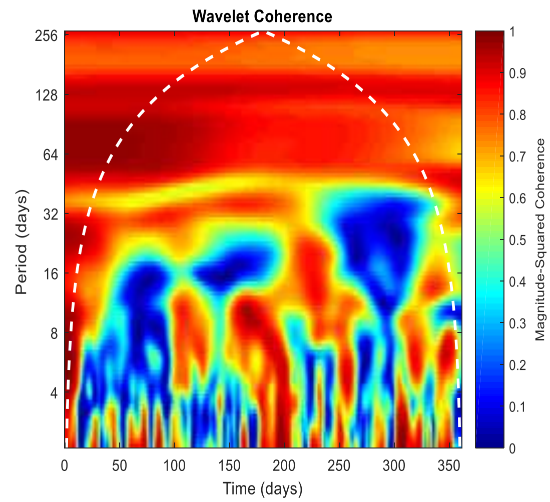

Figure 11: Evaluation of wavelet coherence between DJUSBK and FTASX301010 data values

We see that the data in fig. 10 and fig. 11 are almost completely comparable.

On fig. 12 shows a comparison of the wavelet coherence estimates for the data in fig. 10 and fig. 11.

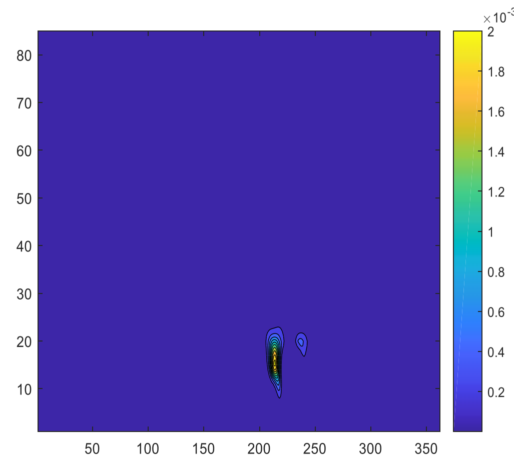

Figure 12: Comparison of wavelet coherence estimates for the data of fig. 10 and fig. 11.

The data of fig. 12 show that the corresponding coherence estimates are practically comparable. This suggests that for the predictive model, it is possible to use both wavelet coherence estimates for fig. 10 as well as for fig. 11. If we are talking about the medium term, then it is necessary to take into account specific estimates of wavelet coherence. But in this case, it is also necessary to take into account the importance and significance of the task to be solved.

6. CONCLUSION

The paper considers the issues of building a predictive model for the analysis of international trade. A brief survey of literary sources on the topic of the study was carried out. It is proposed to make an appropriate analysis based on the data of the main stock indices. The possibility of highlighting individual stages for building an appropriate predictive model is also considered.

For the analysis, stock indices of banking institutions in the USA, Canada and the UK were selected. For the analysis, the wavelet ideology was chosen, which allows you to work with data presented in the form of time series.

The paper presents a number of graphs and charts that allow you to understand the logic of the study, the results obtained.

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