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RESEARCH OF STOCK INDICES BASED ON ADAPTIVE WAVELET ANALYSIS METHODOLOGY FOR IMPLEMENTATION OF DIAGNOSTIC METHODS OF GLOBAL OIL MARKET

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ABSTRACT

The stock market plays an important role in the development of individual segments of the economy and society as a whole. However, among the individual areas of the stock market, a special place is occupied by the global oil market. This is due to its role not only in the energy sector, but also in the chemical industry, the production of various goods, which provides significant employment and economic stability. A comprehensive study of the dynamics of stock indices is important, which allows us to assess the functioning of the oil market, the directions of its development. In this aspect, it is also necessary to properly consider the possible conditions affecting the dynamics of quotations of such indices, which can be characterized as adaptive factors. Among such factors, the time horizon of data analysis stands out. Based on this, for the purposes of the study, the feasibility of using the adaptive wavelet methodology for the implementation of diagnostic methods for the global oil market is considered.

Keywords: Analysis, Futures, Diagnostics, Quotes, Dynamics, Methodology, Stock Market, Oil Market, Wavelet Coherence.

Introduction

Stock markets play an important role in the modern formation of pricing policy for a number of different goods, products, services, and raw materials. Such formation occurs under the influence of the balance of supply and demand, which is reflected in the dynamics of quotations for individual securities that are traded on the stock market [1]-[5].

Among the individual goods, products, services and raw materials that are quoted on the stock market, the energy group attracts special attention. In this group, the oil market should be singled out, the derivatives of which affect not only the provision of various types of energy resources, but also the development of the chemical industry [6]-[8]. This explains the increased interest in this area of research, its relevance and significance. At the same time, new studies expand the horizons of knowledge, understanding of the processes that occur on the stock market. This is also the basis for the development of improved methods for diagnosing the global oil market.

For the purposes of the corresponding analysis, it is advisable to use various stock market indicators, where stock indices should be singled out. Such indices are a reflection of quotations for individual securities and the trading directions for which they are responsible. By considering various horizons of stock index quotation dynamics or factors of their generalization, separate data sets are formed in the reflection of the adaptive conditions of their change. This expands the scope of the study, allowing to obtain new results for decision-making. For the purposes of analysis, various methods and approaches can be used here [9]-[27], among which the wavelet methodology should be especially highlighted [28]-[34].

Thus, the main objective of this article is to analyze stock indices for the implementation of diagnostic methods for the global oil market, where it is advisable to use adaptive data sets using wavelet methodology. For this purpose, it is advisable to consider related works, data sets of the global oil market regarding the conditions for conducting the corresponding analysis.

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Related work

Many different works are devoted to the study of the oil market and the dynamics of quotations for the corresponding securities. This is due to the importance that the global oil market occupies in the system of economic relations, the development of the economy as a whole, and its influence on human civilization.

F. Khan, S. Muhammadullah, A. Sharif and C. C. Lee analyze the dynamics of the green energy stock market to forecast the Chinese crude oil market [35]. For this purpose, the IIS approach and sparse regression models are used in the work. This allows us to estimate the profitability of the oil market in the context of green energy development using China as an example. It is shown that the IIS approach and sparse regression models are more effective than the standard model without changes, since they allow adaptive change of the data set to any time horizon [35]. However, this approach limits the mutual analysis of data taking into account the dynamics of change in the time horizon of the studied data set. Therefore, it is advisable to have various analysis tools to conduct appropriate adaptive studies.

P. Esmaeili, M. Rafei, M. Salari and D. Balsalobre-Lorente consider the issues of oil price shocks in the context of the dynamic impact of demand and supply shocks in the world market and clean energy development trends [36]. For this purpose, data are considered on the example of the recession caused by the US. The work uses structural VAR and time-varying VAR models. This allows us to separate the study of shocks in the world oil market, complementing and expanding previous studies of the relationship between oil prices and renewable energy consumption [36].

A. Escribano, M. W. Koczar, F. Jareño and C. Esparcia study the transmission of shocks between crude oil prices and stock markets [37]. The paper considers data from 01.2000 to 02.2023 using the Dynamic Conditional Correlation Skew Student Copula model and the Diebold and Yilmaz connectivity index [37]. The authors state that before the global financial crisis, stock markets were less dependent on crude oil prices than after the crisis. This is justified in terms of returns and volatility between crude oil prices and stock markets. The authors also note that the side effect of shocks and crises on the correlation between stock markets and crude oil prices is insignificant. This helps to choose the most effective trading strategy in the markets. However, in this aspect, it is also necessary to take into account the adaptive change of data sets.

Y. Zhang and M. Umair study the relationship of green finance based on dynamic spillovers between green bonds, renewable energy, and carbon markets [38]. The study examined data from 01.2010 to 12.2020. The analysis is based on vector autoregressive models and time-varying models, which allows for adaptive data changes. The paper notes spillovers between carbon markets and renewable energy stocks. This allows for the interdependence of green financial instruments and their role in promoting sustainable development [38].

R. K. Soni, T. Nandan and N. N. Chatnani analyze the relationships between oil prices, stock market shares and gold [39]. The paper uses a wavelet-based approach for the analysis. For this purpose, the relevant data from India covering the period from 11.2005 to 03.2022 are considered. The originality of this work lies in the study of the impact of EPU on such components of the economy as oil, stocks and gold. At the same time, the authors note that Indian buyers of crude oil do not need to take into account the Indian EPU in transactions in the short and medium term. It is also noted that gold is an indicator of economic imbalances and an accurate observer of inflation [39].

Thus, the topic under consideration is reflected in a number of different studies concerning the assessment of the oil market development, its interaction with the stock market. This allows determining the conditions of its functioning, the ability to withstand the crisis and shocks. Ensuring the proper profitability and liquidity of the relevant securities is also important. In general, it becomes possible to determine the time of entering the stock market in order to obtain the most effective result. At the same time, various methods and approaches are used to consider such research topics, where the key aspect is the consideration of adaptive data sets reflecting various conditions of the global oil market development.

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Wavelet coherence as a tool for adaptive data analysis

The need for adaptive data analysis is primarily due to the possibility of expanding research to different time horizons in order to consider possible situations and make the most effective decisions. This is fully facilitated by the use of wavelet ideology, where an approach based on the construction and study of wavelet coherence estimates is distinguished [40]-[43]. Such estimates allow direct analysis of data dynamics on different time horizons. At the same time, adaptive data transformation allows studying their dynamics in implicit conditions of development, and giving appropriate estimates for making the necessary decisions.

Let's consider two time series ($k(t)$ and $d(t)$), 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 [44]-[46]:

$$S^2(a,h)=\frac{\left|\Psi(a^{-1}W_{k(t)d(t)}(a,h))\right|^2}{\Psi(a^{-1}\left|W_{k(t)}(a,h)\right|^2)\Psi(a^{-1}\left|W_{d(t)}(a,h)\right|^2)}, \quad (1)$$

where:

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

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

$k(t)$, $d(t)$ – series of data that we study,

Ψ – smoothing operator,

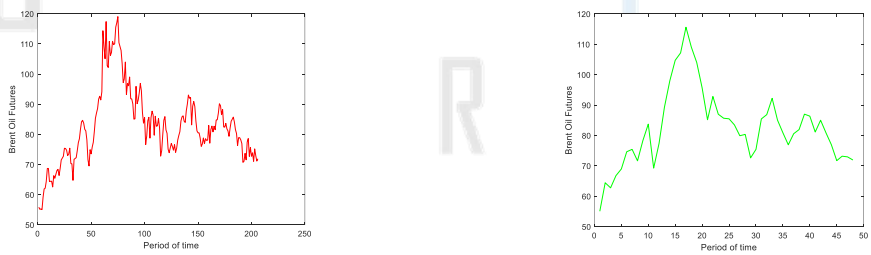
$S^2(a,h)$ – square of the wavelet coherence coefficient. $0 \le S^2(a,h) \le 1$. If these values tend to zero, then we have a weak correlation. Otherwise we have a strong correlation [45].

If we apply adaptive change to the time series ($k(t)$ and $d(t)$), we will get some new estimate of wavelet coherence ($\widehat{S}^2(a,h)$).

In general, we can have a whole set of such estimates ($\left\{\widehat{S}^2(a,h)\right\}$). By comparing the estimates, we can make more effective decisions and confirm their validity or invalidity.

Some examples of data on global oil market quotes

Fig. 1 shows Brent oil futures quotes. All data from https://www.investing.com for the period from January 2021 to December 2024.



a) weekly averaging b) monthly averaging

Figure 1: Dynamics of Brent oil futures quotes in weekly and monthly averaging in the period 01.2021-12.2024

It should be noted that the data dynamics shown in Fig. 1 are inherited. This is due to the data displayed in Fig. 1a and Fig. 1b. It is worth noting the surge in Brent oil futures quotes at the beginning

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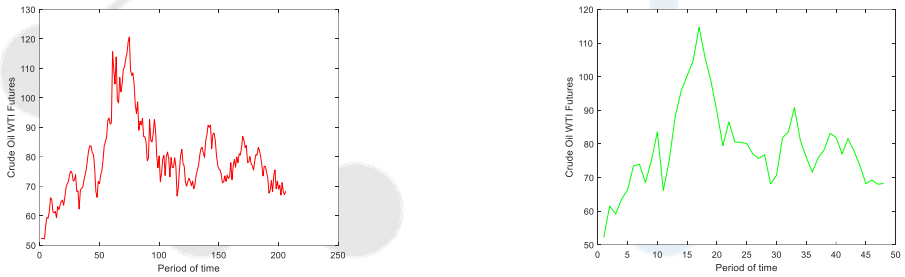
of the study period. The maximum values of Brent oil futures quotes fall on June 2022. Moreover, in the case of weekly averaging, such values are higher than in the monthly averaging of data. Then, a decrease in Brent oil futures quotes is observed.

However, such a decrease is not constant, since episodic surges in values for Brent oil futures can also be observed. At the same time, an important aspect of the analysis is to take into account all the features of the presented data, which is manifested in specific details.

Therefore, it is necessary to evaluate the data of the joint dynamics, and understand what information specific details of the data presentation contribute to such an assessment.

This is the general methodology of adaptive data analysis. For such an analysis, it is necessary to consider the corresponding dynamics of other data. Based on the logic of the study, such data also represent global oil market data.

Fig. 2, similar to the data in Fig. 1, shows the dynamics of crude oil WTI futures quotes.



a) weekly averaging b) monthly averaging

Figure 2: Dynamics of crude oil WTI futures quotes in weekly and monthly averaging in the period 01.2021-12.2024

The data in Fig. 2 also generally indicate the inheritance of the dynamics, which is reflected in the weekly and monthly display of crude oil WTI futures quotes. At the same time, the quote values presented in Fig. 2a are higher than the quote values presented in Fig. 2b. Here, too, the logical explanation is the same as in the previous case. This is either weekly averaging with a smaller amount of data, and therefore their variations or monthly averaging of data with a larger amount of data and possible variations. At the same time, given the inheritance of data memory for such a short period, the data cannot change sharply.

At the same time, we can talk about the identity of the dynamics of the data in Fig. 1 and Fig. 2. Thus, the maximum values of weekly quotes for Brent oil futures and crude oil WTI fall in May-June 2022. Then there is a decrease in such quotes with a slight increase in September 2023 and in March-April 2024. Then there is again a decrease in weekly quotes with minor variations. Similar mutual dynamics are observed in the monthly values of Brent oil futures and crude oil WTI quotes. This is explained by the fact that these are two types of crude oil.

Nevertheless, as noted earlier, it should be borne in mind that the dynamics of such reciprocity is fully manifested in the details. As can be seen from the data in Fig. 1 and Fig. 2, the corresponding figures differ in detail.

Therefore, to conduct the appropriate analysis, we will also consider a derivative product that is obtained from oil and is also traded in this segment of the stock market. In particular, for these purposes, we will consider the dynamics of gasoline RBOB futures quotes. Fig. 3 shows the dynamics of gasoline RBOB futures quotes on a weekly and monthly basis for the period 01.2021-12.2024.

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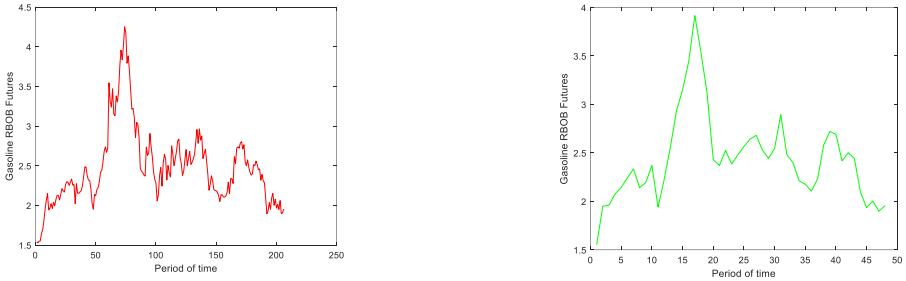


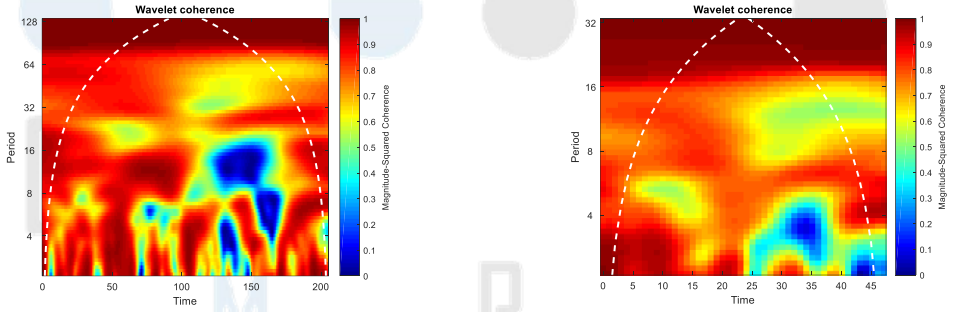
a) weekly averaging b) monthly averaging

Figure 3: Dynamics of gasoline RBOB futures quotes on a weekly and monthly basis in the period 01.2021-12.2024

As in the two cases presented above (Fig. 1 and Fig. 2), it is clear that the data in Fig. 3a and Fig. 3b display approximately the same dynamics of the corresponding gasoline RBOB futures quotes. This is also explainable, as in the previous examples. It is also worth noting the correlation between the general dynamics of gasoline RBOB futures quotes and quotes for futures of various grades of oil. In this case, gasoline RBOB is a derivative product of crude oil and this explains the close relationship in the dynamics of quotes for the corresponding futures. However, when comparing the data in all the figures, it is necessary to note significant differences in detail. A comparative assessment of the mutual dynamics of the data under consideration allows us to clarify such a detailed difference.

Comparative assessment of the mutual dynamics of the studied data

To conduct a comparative assessment of the mutual dynamics of the data under consideration, we will use the approach for determining wavelet coherence estimates, which was considered earlier and presented in the form of formula (1). First, we will consider the assessment of the mutual dynamics of Brent oil futures quotes and gasoline RBOB futures quotes (Fig. 4).



a) weekly averaging b) monthly averaging

Figure 4: Wavelet coherence estimates in the dynamics of Brent oil futures and gasoline RBOB futures quotes

First of all, it is necessary to note the differences in the presented estimates of the dynamics of Brent oil futures quotes and gasoline RBOB futures quotes in their weekly and monthly calculation. In general, such estimates are significant. At the same time, some coincidences can be observed among insignificant estimates (highlighted in blue and light blue). These coincidences correlate with their transformation from weekly data to monthly data.

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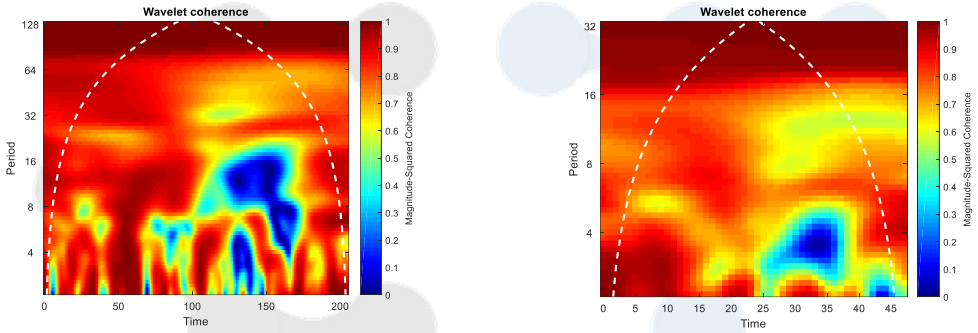
However, it should be noted that calculating the mutual dynamics of such data based on their monthly values is less expensive and faster. This allows for a general assessment of the development of the corresponding stock market segment. Estimating weekly values of mutual dynamics allows for a more detailed market diagnosis and an examination of the possibilities of entering and exiting with investments. In general, this allows for the implementation of a new methodology for the corresponding analysis.

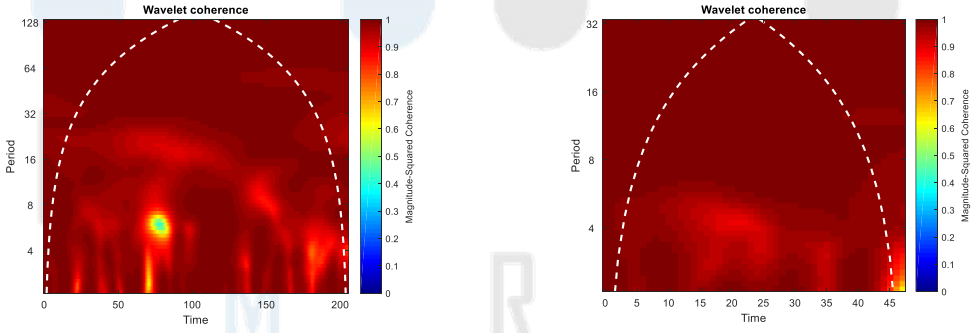
In a comparative aspect, Fig. 5 presents an assessment of the mutual dynamics of crude oil WTI futures quotes and gasoline RBOB futures quotes.



a) weekly averaging b) monthly averaging

Figure 5: Wavelet coherence estimates in the dynamics of crude oil WTI futures and gasoline RBOB futures quotes

In general, the data in Fig. 5 correlate with the data in Fig. 4 with minor variations. This is explained by the fact that there is a strong correlation in the dynamics of Brent oil futures and crude oil WTI futures quotes (Fig. 6).



a) weekly averaging b) monthly averaging

Figure 6: Wavelet coherence estimates in the dynamics of Brent oil futures and crude oil WTI futures quotes

However, the data in Fig. 5 also allow the implementation of a new approach for the purposes of studying individual segments of the stock market based on the adaptive wavelet analysis methodology, where such adaptation is specified by different data sets taking into account individual time horizons.

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It is also necessary to take into account the fact of strong mutual correlation in the study of the data group. Then it is possible to select certain parameters for entry and exit to the stock market, providing maximum efficiency to potential investors.

Conclusion

The article considers the issues of stock index analysis for the study and diagnostics of the global oil market. The importance and significance of studying this issue in the context of the transition to green energy is shown. Attention is paid to the time factor as an adaptive characteristic of the operating conditions of the stock market segment under consideration.

The dynamics of individual stock indices of the oil market such as: Brent oil futures, crude oil WTI futures and gasoline RBOB futures are considered. The corresponding data series are presented on different time horizons, which reflect the general ideology of the adaptive analysis.

For a detailed study of the possibility of implementing diagnostic methods for the global oil market, an adaptive wavelet methodology is used, which is based on wavelet coherence estimates for different time horizons of the data under consideration.

The feasibility of using wavelet coherence estimates for the analysis and diagnostics of the oil stock market based on the dynamics of individual stock indices is shown.

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