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ANALYSIS OF THE DYNAMICS OF EUROPE STOCK MARKETS DEVELOPMENT

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ABSTRACT

The article proposes a complex of economic and mathematical models of assessment, analysis, and forecasting of the world stock indices development state for effective management of investment flows. The modern concept and strategy of European countries' stock market development were considered, and the existing methods of diagnosing the stock market development level were analyzed. ARIMA models were built and spectral analysis of the main world indices was carried out. The possible trends in the stock indices development for the future period were analyzed using predictive models. It makes it possible to determine directions for improving the stock market efficiency and investment strategies in modern conditions.The proposed set of models for evaluation, analysis, and forecasting of the world stock indices state can be used to test various trading strategies and to test various hypotheses in relation to the entire stock portfolio of a particular company or to one stock index. The results of the research can be used in the development of theoretical provisions and methodological tools for evaluating the global stock market effectiveness in modern conditions and development trends in local markets.

Keywords: stock market, stock index, modeling, spectral analysis, ARIMA model, forecasting

JEL Classification: D53, E44, G15

INTRODUCTION

In today's world, money plays a greater role, the accumulation of funds is one of the most important factors that affect the development of the economy. As an organizer of the securities market, the stock exchange is engaged in creating the necessary conditions for effective trading, its development, and popularization. The main task is not so much the organization of trade as its service. All market participants are interested in their markets being recognized as high-quality and well-organized markets from a legal point of view. In this case, they can make decisions based on the data they provide without the risk of being defrauded or abusing the trust of other investors.

That is why stock markets are the most unstable element of the economy, reacting to any changes in society very quickly. At the first stages of the formation of the securities market in the country, the state must be an active creative participant in this market in order to ensure the country's financial security.

In addition, even citizens who decide to invest money can also consider the purchase of stocks and bonds to multiply savings, along with the growth of securities of successfully developing enterprises. Of course, there is also a risk that the company shares were overvalued in the market and will subsequently fall in price, or the company will not develop effectively, which will lead to the same result with the price level of its shares.

LITERATURE REVIEW

In modern economic literature, the issues of the content of the stock market are widely covered, as well as the growth of its role in the process of ensuring the country's investment attractiveness is proved. Among the modern foreign economists who deal with

issues of the securities market development, the following should be singled out: L. J. Gitman, M. D. Jong, G. Bierman, S. Schmidt, A. Davidson, R. Dornbuch, D. Lindsay, R. Dornbusch, etc.

Features of the development and functioning of the Ukrainian stock market in modern conditions are considered in the papers of such researchers as O. Tymoshenko and L. Gudym, O. Shuba, O. Tretyakova, V. Kharabary and R. Greshko, Levkovich O. and Finko A., Rakhman M., Kolupaev Y., and Zalyubovska M. and many others (Kolupaev et al., 2018, Levkovich and Finko, 2019, Rakhman and Shevtsova, 2019, Tymoshenko and Gudyma, 2020, Tretyakova, et al., 2020).

Many issues still remain unresolved, as well as controversial points. From the point of view of the national stock market development, the recommendations of scientists concern only certain aspects of this problem. However, the stock market as an economic system consists of many interconnected elements. In this system, the production of goods and services is financed and significantly expands the circle of investors, and the cash flow increases, which ensures the inflow and redistribution of investments between industries and enterprises. Therefore, the research of such a multifaceted economic category as the stock market requires the use of a complex, systematic approach and modern methods of analysis.

The modern economic literature on the outlined subject research offers many approaches and methods of analysis and forecasting of the dynamics of world stock indices. For example, (Slepecký et al., 2022) examine the impact of traditional stock market indices on the country's net international investment position. For this, the authors suggest the use of such methods as ANOVA analysis, multiple regression analysis, correlation analysis, VAR analysis, and R/S analysis, as well as a test of causal relationships. Traditional indexes of Finland, Sweden, France, Spain, and Ukraine for the period 2005–2021 are studied in the paper.

(Marszk and Lechman, 2020) analyze the differences between ETFs and stock index futures. They examined the development of ETF markets using descriptive statistics and diffusion models.

(Rudra et al., 2020) investigate the inter-relationships between the reforms undertaken in the financial sector (banking sector, stock market, and insurance industries) and economic growth in Europe. More specifically, this study examines whether there are Granger causal relationships between banking competition, stock-market development, insurance market development, and economic growth, using a panel dataset covering European countries over the period from 1996 to 2016. Utilizing a multivariate framework, the study’s results show that all the variables are cointegrated. The findings reveal a network of Granger causal associates between the variables, including short-run bidirectional causality between stock market development and insurance market development. In the long run, there is compelling evidence of Granger causality from banking competition, insurance market development, and stock market development to economic growth. The results provide valuable insights into the types of financial sector reforms that will enhance sustainable economic growth in Europe.

(Kedong Yin et al., 2017) use the 51 most representative stock indices to analyze dynamic changes in global stock market linkage. After transforming the 51 indices' closing price into log return, the dynamic coefficient correlations are calculated through the DCC-MVGARCH model. Then, the authors construct the volatility network and analyze their topological features, such as the network density, average path length, and clustering coefficient. Further, by the algorithm of minimum spanning tree and low pass filter, the authors analyze the variable periodicity of the co-movement. Finally, using the index of average weighted degree, the authors investigate the stability of the network and confirm the cluster structures of global stock markets with core nodes for every cluster.

The authors conduct a critical analysis of the models used to analyze the dynamics and forecast of stock indices. They say that the univariate GARCH model is widely used in the field of market volatility and risk description due to the heterogeneity of financial time series. However, the univariate GARCH model cannot satisfy the research on different market or assets with distinguishing influencing factors. Then, the multivariate GARCH models, as a tool that can both reflect the fluctuation characteristics of the univariate GARCH model and describe the interaction and correlation between different variables and different factors, were introduced into the financial market analysis. Dynamic conditional correlation multivariate generalized autoregressive conditional heteroskedasticity (DCC-MVGARCH) is the improved model of CCC-MVGARCH and BEKK-MVGARCH. Compared to other GARCH models, DCC-MVGARCH is intuitive, concise, and stable. The biggest characteristic of the DCC model is that the correlation coefficient is the dynamic correlation coefficient which changes over time. There are many scholars who apply the model to analyze the dynamic relationship between economic indicators and financial assets to explore the internal mechanism of economic phenomena.

The authors (Razzaq et. al., 2021) investigate whether nonlinear models can outperform linear models in providing accurate predictions of future earnings. In this study, the analysis was conducted on an emerging market, namely the Amman Stock Exchange.

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The study (Shkolnyk et. al., 2021) analyzed Ukraine's stock market, the world stock market, and regional markets and assessed their mutual influence. On the basis of paired correlation coefficients, the existence of a significant dependence of the development of the world stock market on the development of the American stock market was determined. Forecasts of stock market activity are built using triple exponential smoothing.

The paper "Lessons for Euro markets from the first wave of COVID-19" evaluates the volatility observed on European stock exchanges, for which a VAR panel model is built, and the generalized impulse characteristic function and variance decomposition methods are used (Siriopoulos et. al., 2021).

The scientific paper "Modeling the segment interactions of Ukraine's financial market" is devoted to the evaluation of the level of interconnection of individual segments of Ukraine's financial market and their dynamics in uncertain conditions, based on the methodology of the system approach and the evaluation of time series (Prymostka et. al., 2020).

Despite a large number of publications, existing scientific research does not provide a sufficiently complete toolkit for complex analysis and forecasting of the dynamics of world stock indices, namely, in our opinion, the issue of applying high-precision modeling and forecasting methods of stock indices in combination with other evaluation methods is not sufficiently covered.

That is why the development of research tools in the direction of improving the processes of evaluation, analysis, and forecasting of the world stock indices state for proactive management actions in the modern turbulent market is relevant.

AIMS AND OBJECTIVES

The article's purpose is a set of economic-mathematical models building for the assessment, analysis, and forecasting of the world stock indices state for effective management of investments in modern conditions adapted to selected vectors of development.

METHODS

To build a complex of models, it is necessary to decide on which algorithm to build and process them, which results to present in the report and take for further development.

The algorithm is a set of procedures for organizing a full cycle of research, modeling, and forecasting of the main world stock indices:

- data collection;
- data compression;
- construction of the model and its evaluation;
- extrapolation of the selected model (actual forecast);
- evaluation of the received forecast; comparison of initial data with forecast data (Guryanova et. al., 2016).

The algorithm of the full research cycle of the problem of modeling and forecasting world stock indices, which will ensure the practical suitability of the developed methodologies and their high efficiency, is presented in Figure 1.

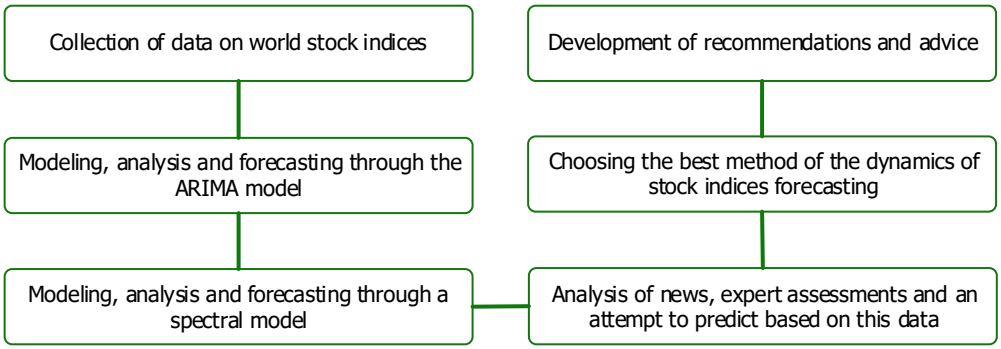

Figure 1. Algorithm of the full research cycle of the problem of modeling and forecasting of world stock indices.

Such complex of systems can be used to test various trading strategies and to test various hypotheses in relation to all shares of a particular company or to one stock index.

RESULTS

We will consider in more detail the proposed methods of modeling the dynamics of the stock market. Let's start with the stage of modeling the dynamics of world stock markets based on the ARIMA model.

The algorithm of the process of modeling and forecasting world stock indices according to the ARIMA model is presented in Figure 2.

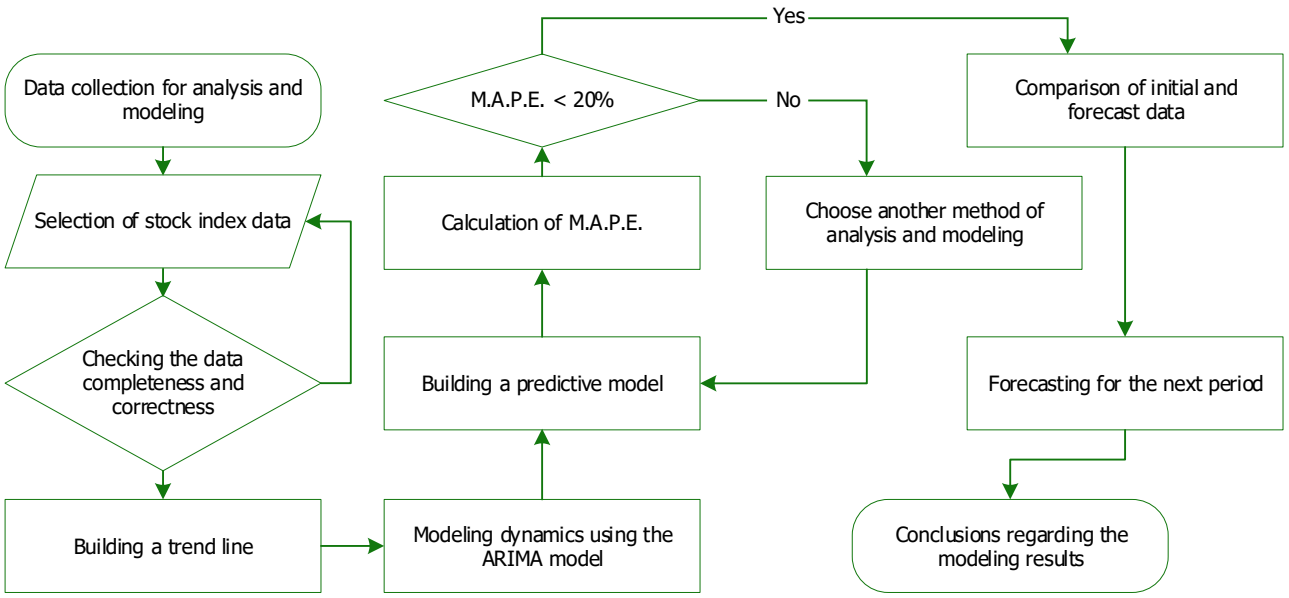

Figure 2. Algorithm for modeling and forecasting world stock indices according to the ARIMA model. *(Source: built by the authors based on Marszk, Lechman, 2020, Razzaq, et. al., 2021)*

Time series analysis, proposed by Box and Jenkins, has a very powerful tool for accurate forecasting for small time intervals (Klebanova, et al., 2015). At the same time, ARIMA models have a fairly wide range of characteristics that allow them to be quite flexible and versatile. In addition, the built forecasts and their prediction intervals come directly from the selected model. Therefore, it is best to use such a model first of all for simulating stock indices. Next, data research is conducted according to the built model.

We will apply the proposed algorithm for forecasting stock indices based on the ARIMA model for the European market. During data sampling for the European market, such stock indices were selected as the FTSE index and DAX index, because experts first of all closely monitor these indices and draw conclusions about the state of the economy in the European sector. The data are taken from official sources from 14.06.2021 to 5.06.2022 (52 periods) (Stock Markets Analysis & Opinion).

First, one of the indexes was studied in detail, and then others were presented in a more consolidated form. The first index was considered FTSE using an MS Excel spreadsheet. In the first stage, the series was tested for stationarity. To do this, primarily visual analysis of the graph was used to identify the trend and seasonal component. The output graph of the FTSE index is shown in Figure 3.

As can be seen from the graph, the series has a non-stationary character, constant growth, and fluctuations are observed. Therefore, it is necessary to transform the series to a stationary form, for this, we will find the difference between the next and previous values of the series (y_t-y_{t-1}), that is, the difference of the first order ($d=1$). Then we plot the resulting transformed series and draw a conclusion about its stationarity (Figure 4). It can be seen from the graph that the obtained series has a stationary character, as it does not have clearly defined regularities (trend and/or seasonal component, etc.). Thus, already after applying the difference of the first order, a stationary series was obtained.

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Figure 3. Graph "Yt" of the raw data of the FTSE index.

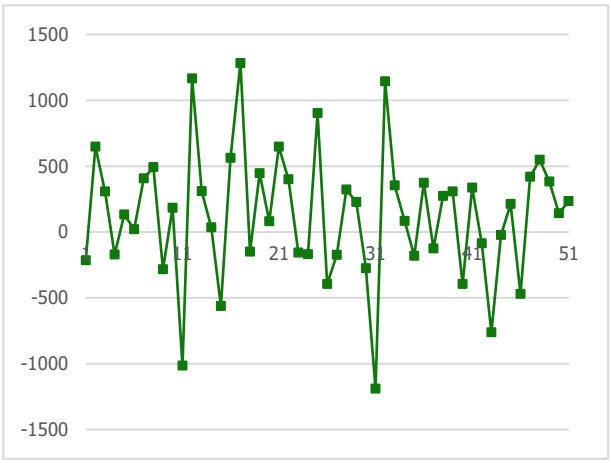

Figure 4. Graph of the transformed series.

The next stage after obtaining the stationary series is the identification of the basic set of models. Let's calculate the sample autocorrelation coefficients for the studied series. For this, we will take lag variables (k=52/6=8), moving up the stationary series by the value of the corresponding lag. Let's calculate the autocorrelation coefficients of order 1-8 between the stationary series and the corresponding lag series. The calculation results are shown in Figures 5-6. The diagram shows, the maximum value has an autocorrelation coefficient with a lag of 1 and is equal to (-0.292). Based on the calculations, we determine the parameters of the ARIMA model (*p, d, q*).

Lag	**r1**	**r2**	**r3**	**r4**
Coef.	-0.292	-0.226	-0.019	0.2312
Lag	**r5**	**r6**	**r7**	**r8**
Coef.	0.1134	-0.14	-0.097	-0.224

Figure 5. Results of calculation of autocorrelation coefficients of order 1-8.

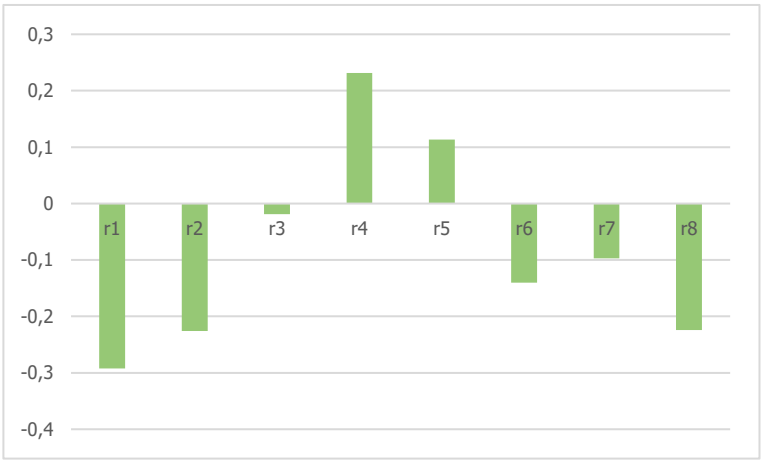

Figure 6. Diagram of autocorrelation coefficients of order r1-r8.

The results of calculating the forecast values of the stock index and checking the accuracy of the obtained forecast model are shown in Table 1.

Table 1. The results of the calculation of the forecast values of the stock index.

t	yt	Value of the differences	Predictive value	t	yt	Value of the differences	Predictive value
1	2	3	4	1	2	3	4
1	6316.4	-	-	27	7043.61	18.13674497	7061.746745
2	6351.5	-7.38529940	6344.064701	28	7018.05	5.384148681	7023.434149
3	6367.6	-3.39774327	6364.182257	29	7022.61	-0.96055234	7021.649448
4	6550.2	-38.4747557	6511.755244	30	7069.04	-9.78036087	7059.259639
5	6546.8	0.733053107	6547.483053	31	7134.06	-13.6962968	7120.363703

(continued on next page)

Table 1. Continued

t	yt	Value of the differences	Predictive value	t	yt	Value of the differences	Predictive value
1	2	3	4	1	2	3	4
6	6529.2	3.701075599	6532.881076	32	7017.47	24.55938555	7042.029386
7	6502.1	5.702226322	6507.812226	33	7136.07	-24.9827869	7111.087213
8	6460.5	8.760827216	6469.280827	34	7123.27	2.696287289	7125.966287
9	6873.3	-86.9426262	6786.317374	35	7121.88	0.292799948	7122.1728
10	6735.7	28.97455599	6764.684556	36	7008.09	23.96957271	7032.059573
11	6695.1	8.560712143	6703.630712	37	7027.58	-4.10551869	7023.474481
12	6407.5	60.58431151	6468.044312	38	7032.3	-0.99425593	7031.305744
13	6489.3	-17.2457068	6472.084294	39	7122.95	-19.0951908	7103.854809
14	6589.8	-21.1616422	6568.628358	40	7218.71	-20.1715992	7198.538401
15	6624	-7.21046202	6616.809538	41	7087.9	27.55479221	7115.454792
16	6483.4	29.61492422	6513.044924	42	7148.01	-12.6620178	7135.347982
17	6630.5	-30.9841326	6599.535867	43	7138.35	2.034854314	7140.384854
18	6761.5	-27.5842828	6733.885717	44	7029.2	22.99216856	7052.192169
19	6708.7	11.11375917	6719.823759	45	6963.64	13.81004646	6977.450046
20	6740.6	-6.71544053	6733.874559	46	7051.48	-18.5032715	7032.976728
21	6737.3	0.693030092	6737.99303	47	7027.07	5.14190412	7032.211904
22	6915.8	-37.5900364	6878.159964	48	7095.55	-14.425137	7081.124863
23	7019.5	-21.8609917	6997.669008	49	7234.03	-29.1704581	7204.859542
24	6938.6	17.05612358	6955.616124	50	7204.55	6.209886663	7210.759887
25	6969.8	-6.58273264	6963.227267	51	7237.57	-6.95557861	7230.614421
26	7129.7	-33.6825263	7096.027474	52	7249.4	-2.49195926	7246.908041

M.A.P.E. is equal to 0,25%, which indicates the high accuracy of the ARIMA model (since the error value does not exceed 10%).

The calculated value of the index for the forecast period (53rd) based on the constructed ARIMA model is equal to 7246,91 units. The graphical representation of the initial data and forecast data obtained on the basis of the ARIMA model is shown in Figure 7.

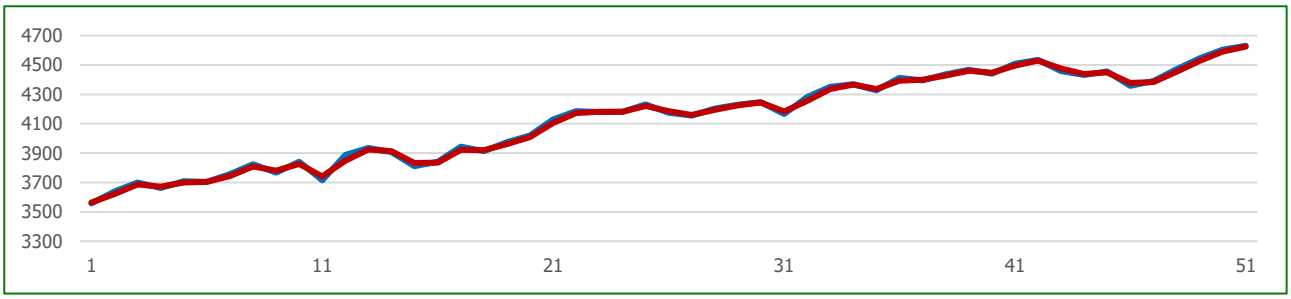

Figure 7. Actual (blue color) and predicted (red color) values of the FTSE index.

Similarly, we perform calculations based on the data of the DAX index. The general results are presented in Figure 8, Figure 9, and Table 2.

M.A.P.E. is equal to 0,14%, which indicates the high accuracy of the ARIMA model (since the error value does not exceed 10%).

The calculated forecast value of the index for the next week (53rd period) based on the ARIMA model is equal to 15970,04 units. The graphic representation of the initial data and forecast data obtained on the basis of the ARIMA model is shown in Figure 9.

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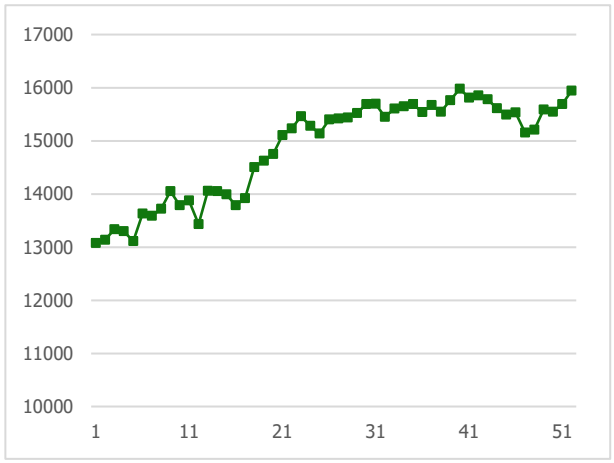

Figure 8. Graph "Yt" of output data of the DAX index.

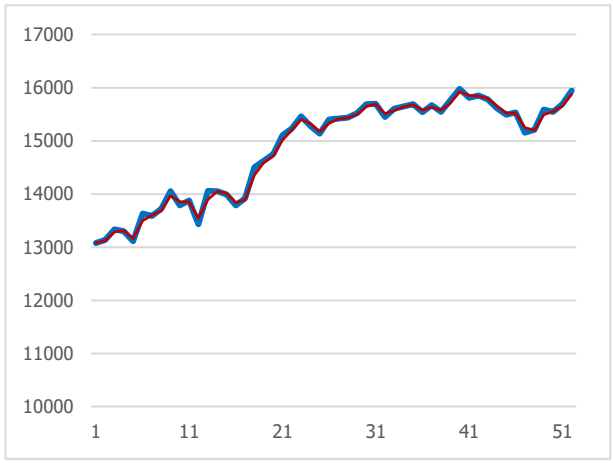

Figure 9. Actual and forecast values of the DAX index.

The results of calculating the forecast values of the stock index and checking the accuracy of the obtained forecast model are shown in Table 2.

Table 2. The results of the calculation of the forecast values of the stock index. *(Source: built by the authors based on Stock Markets Analysis & Opinion)*

t	yt	Meaning of sacristy	Predictive value	t	yt	Meaning of sacristy	Predictive value
1	2	3	4	1	2	3	4
1	13077	-	-	27	15416.6	-4.38473318	15412.25527
2	13137	-15.6214184	13121.62858	28	15437.5	-5.38607307	15432.12393
3	13336	-51.2102769	13284.46972	29	15520	-21.2836342	15498.69637
4	13299	9.476598151	13308.4366	30	15692.9	-44.6267252	15648.27327
5	13114	47.65655268	13161.95655	31	15693.3	-0.09548859	15693.17451
6	13631	-133.222078	13497.28792	32	15448	63.28829424	15511.32829
7	13587	11.16958518	13598.39959	33	15608	-41.2743012	15566.6957
8	13719	-33.9500677	13684.82993	34	15650.1	-10.8702155	15639.21978
9	14050	-85.3590642	13964.17094	35	15687.9	-9.76564471	15678.16436
10	13788	67.56463497	13855.29463	36	15540.3	38.0973698	15578.40737
11	13874	-22.2565856	13851.71341	37	15669.3	-33.2868090	15636.00319
12	13433	113.8378934	13546.70789	38	15544.4	32.23385373	15576.62385
13	14057	-161.001518	13895.71848	39	15761.5	-56.0182569	15705.43174
14	14050	1.762667902	14051.65267	40	15977.4	-55.7421142	15921.69789
15	13993	14.62265935	14007.85266	41	15808	43.71829321	15851.75829
16	13786	53.40651474	13839.69651	42	15851.8	-11.2805584	15840.46944
17	13921	-34.685588	13886.00441	43	15781.2	18.20735293	15799.40735
18	14502	-150.123560	14352.26644	44	15609.8	44.23186702	15654.04187
19	14621	-30.6105475	14590.38945	45	15490.2	30.87636718	15521.04637
20	14749	-33.0184087	14715.92159	46	15531.8	-10.7308537	15521.01915
21	15107	-92.4510282	15014.71897	47	15156.4	96.85898835	15253.29899
22	15234	-32.7732352	15201.38676	48	15206.1	-12.8238606	15193.30614
23	15460	-58.2196562	15401.53034	49	15587.4	-98.3868059	15488.97319
24	15280	46.48746255	15326.10746	50	15543	11.45347021	15554.43347
25	15136	37.08828759	15172.99829	51	15688.8	-37.6250883	15651.14491
26	15400	68.06530491	15331.5847	52	15940.2	-64.8883734	15875.31163

So, the built ARIMA model shows quite accurate models for the studied stock indices, according to all models, the accuracy of the MAPE forecast is quite high. Such an index as DAX (0,14%) has a quite high accuracy and a rapid increase in quotations (15970,04 units).

Adhering to the research methodology indicated in Figure 1, at the next stage we will use spectral analysis (Klebanova et. al., 2015, Spectral analysis, 2023) to calculate stock indices. The algorithm of the modeling and forecasting process of world stock indices using the spectral analysis methodology is presented in Figure 10.

The advantage of spectral analysis is its high reliability, informativeness, the possibility of automation, and the possibilities of spectral analysis which determine its attractiveness in research. It should be noted that the calculation system is most developed for the so-called stationary series of dynamics (Klebanova et. al., 2015).

Based on the given data on the dynamics of the main stock indices for the European market, we will perform a spectral analysis for each index. Let's find the trend model, determine the most significant periodic components using Fourier spectral analysis. Let's analyze the graphs for the time series and the obtained coefficients of the components of the Fourier series. We will build a model of the periodic component of the time series taking into account the trend and the periodic (seasonal) component based on the combined model. We compare the actual data with the modeled data and build forecast values.

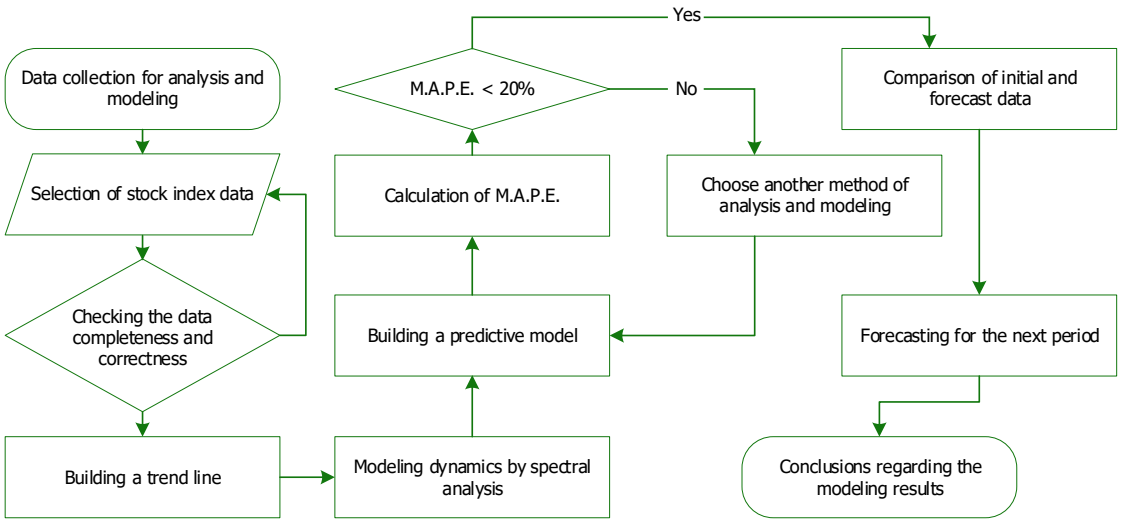

Figure 10. Modeling algorithm using spectral analysis.

The results of the performed regression analysis of the sample are presented in Figure 11. Thus, the trend model is (1):

$$y_t = 6445{,}438 + 13{,}309t \quad (1)$$

The calculation of the values of the detrended time series is possible by specifying the calculation formula in the specification area of the *Long name* variable (2):

$$P\_R = Yt + 6445{,}438 + 13{,}309t \quad (2)$$

The graph of the first residual series values for the FTSE index is shown in Figure 12.

N=52	Regression Summary for Dependent Variable: Yt (Spreadsheet 1) R=.89306673 R?=.79756818 Adjusted R?=.79351955 F(1.50)=197.00 p<.00000 Std. Error of estimate: 125.76					
	b*	Std. Err. of b*	b	Std. Err. of b	t(50)	p-value
Intercept			6445.438	35.38803	182.1361	0.000000
t	0.893067	0.063629	16.309	1.16196	14.0356	0.000000

Figure 11. The result of the regression analysis according to the FTSE index. *(Source: built by the authors in the package Statistica)*

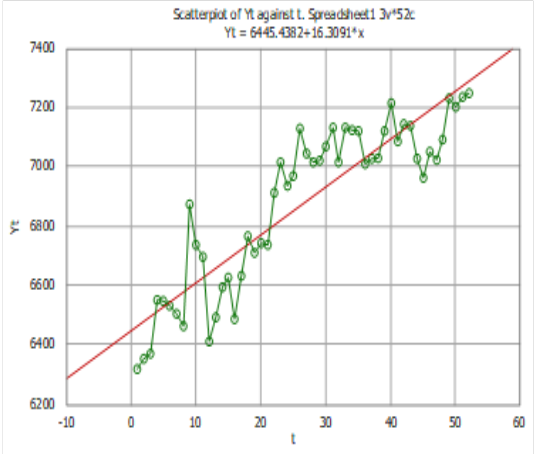

Figure 12. Graph of the detrended FTSE time series. *(Source: built by the authors in the package Statistica)*

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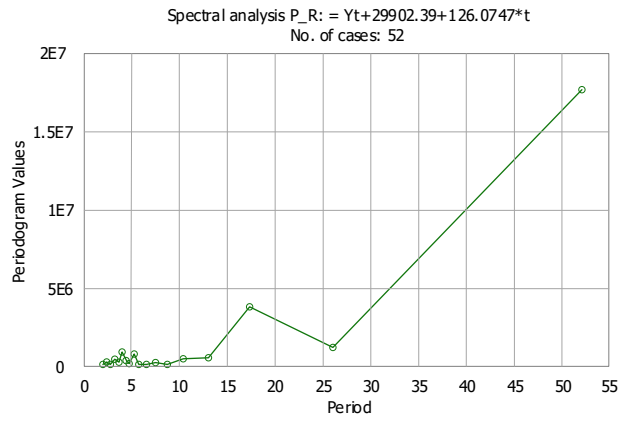

Figure 13. Periodogram of the time series from the time of the FTSE index. *(Source: built by the authors in the package Statistica)*

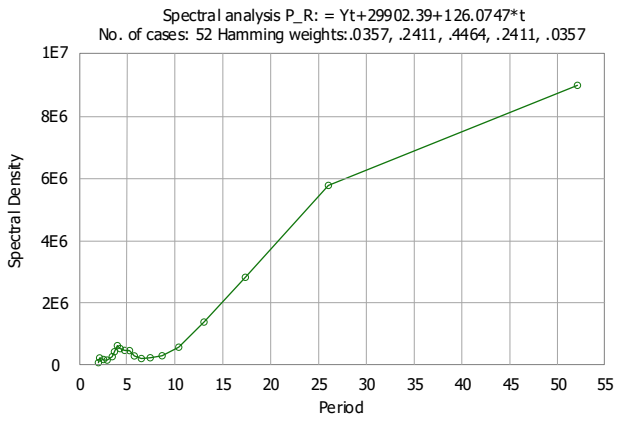

Figure 14. Spectrogram of the time series of the FTSE index. *(Source: built by the authors in the package Statistica)*

Both the periodogram and the spectrogram consider the distribution of harmonics in a time series and are used to determine and estimate the periodic components of an unknown frequency and to determine a given frequency. At this stage, the coefficients of the components of the Fourier series are calculated, which are shown in Figure 15.

	Spectral analysis: P_R: = Yt+6445.438+16.3091*t (Spreadsheet 1) No. of cases: 52						
	Frequency	Period	Cosine Coeffs	Sine Coeffs	Periodogram	Density	**Hamming Weights**
1	0,019231	52,00000	-95,4160	-12,5380	240796,8	150975,5	**0,241071**
2	0,038462	26,00000	47,9990	54,0504	135859,3	133711,5	**0,446429**
3	0,057692	17,33333	-31,9556	35,6022	59505,5	73713,2	**0,241071**
12	0,230769	4,33333	40,0749	-18,3475	50508,3	35836,1	
5	0,096154	10,40000	12,7733	-35,2175	36489,1	30744,6	
13	0,250000	4,00000	-10,8956	32,6341	30776,1	26950,6	
6	0,115385	8,66667	-3,7677	-32,9911	28667,7	29150,9	
7	0,134615	7,42857	-14,0127	28,2852	25906,6	24956,5	
9	0,173077	5,77778	-27,5475	-11,1892	22985,6	21019,8	
11	0,211538	4,72727	9,1752	-27,1060	21291,9	28318,2	
10	0,192308	5,20000	-21,1841	-17,4285	19565,5	21857,9	
4	0,076923	13,00000	-4,6306	-26,3714	18639,2	37338,6	**0,035714**
8	0,153846	6,50000	-19,8129	17,3904	18069,4	21575,8	
24	0,461538	2,166667	-11,6083	-22,2032	16321,1	11198,8	
22	0,423077	2,36364	-14,7542	16,1050	12403,5	9080,9	
18	0,346154	2,88889	-17,3736	-11,8828	11519,1	8100,7	
23	0,442308	2,26087	-9,8636	16,6647	9750,1	11484,0	
19	0,365385	2,73684	15,2794	3,8722	6459,8	7045,2	
16	0,307692	3,250000	9,6619	-12,4059	6428,7	4491,2	
20	0,384615	2,60000	-1,3338	13,6084	4861,1	5018,5	
26	0,500000	2,00000	13,1833	0,0000	4518,8	5098,5	
17	0,326923	3,05882	-7,9395	-9,8058	4138,9	6431,1	
25	0,480769	2,08000	1,4434	-12,2765	3972,7	7287,5	
24	0,403846	2,46619	3,9858	7,3334	1811,3	5549,6	
14	0,269231	3,71429	-3,6271	-5,1520	1032,2	10088,7	
15	0,288462	3,46667	3,3811	4,0645	726,8	3370,0	
0	0,000000		-0,0000	0,0000	0,0	125802,7	**0,035714**

Figure 15. Results of spectral analysis for the FTSE index. *(Source: built by the authors in the package Statistica)*

Predicted values and the calculated M.A.P.E. indicator are presented in Table 3.

The M.A.P.E. is equal to 0,82%, which indicates the high accuracy of the spectral analysis and the implemented model (since the error value does not exceed 10%).

Table 3. Predicted values and calculated M.A.P.E. *(Source: built by the authors in the package Statistica)*

t	FTSE_pr	APE	MAPE=	0.815019
1	**2**	**3**	**4**	**5**
1	6424.327	1.708845		
2	6433.867	1.297609		
3	6405.225	0.591203		
4	6438.516	1.7055		
...	...	...		
49	7139.367	1.308584		
50	7162.238	0.587294		
51	7171.247	0.916376		
52	7212.394	0.51047		
53	7272.398			

The calculated forecast value of the index for the next week (53rd period) based on the spectral model is equal to 7272,4 units. A graphical representation of the initial data and forecast data obtained on the basis of the spectral model is shown in Figure 16.

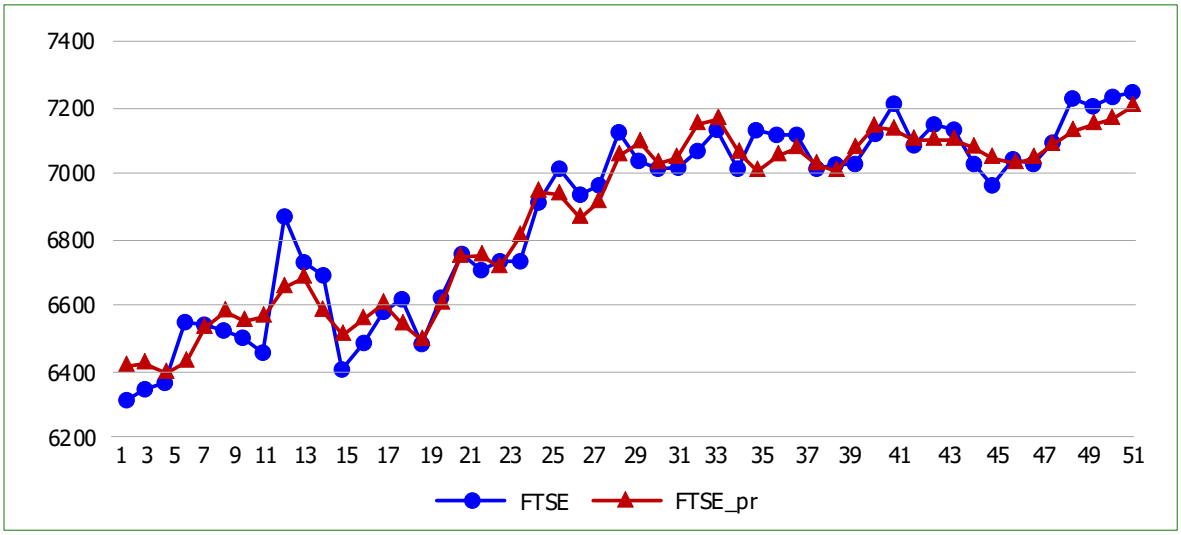

Figure 16. Schedule of estimated and actual volume values by the FTSE index.

Similarly, we will perform a spectral analysis for the DAX index. The graph of the values of the series is shown in Figure 17. The results of the regression analysis of the sample are presented in Figure 18.

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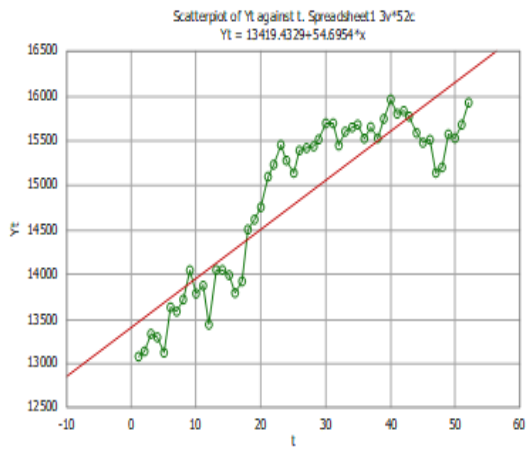

Figure 17. Graph of the detrended series of the DAX index. *(Source: built by the authors in the package Statistica)*

N=52	Regression Summary for Dependent Variable: Yt (Spreadsheet 1) R=.89119669 R?=.79423154 Adjusted R?=.79011617 F(1.50)=192.99 p<.00000 Std. Error of estimate: 426.10					
	b*	Std. Err. of b*	b	Std. Err. of b	t(50)	p-value
Intercept			13419.43	119.9053	111.9169	0.000000
t	0.891197	0.064151	54.70	3.9371	13.8921	0.000000

Figure 18. The result of the regression analysis according to the DAX index. *(Source: built by the authors in the package Statistica)*

Thus, the time series trend model for the DAX index is (3):

$$y_t = 13419{,}43 + 54{,}7t \quad (3)$$

The resulting coefficients of the components of the Fourier series are shown in Figure 19.

	Spectral analysis: P_R: = Yt+13419.433+54.6954*t (Spreadsheet 1) No. of cases: 52						
	Frequency	Period	Cosine Coeffs	Sine Coeffs	Periodogram	Density	**Hamming Weights**
1	0.019231	52.00000	-495.347	-61.5363	6478029	3235779	**0,241071**
3	0.057692	17.33333	-47.771	180.9010	910188	735205	**0,241071**
5	0.096154	10.40000	118.227	-62.8895	466248	245523	
2	0.038462	26.00000	63.053	93.6904	331592	1929257	**0.446429**
10	0.192308	5.20000	-64.889	17.6361	117563	63476	
13	0.250000	4.00000	-18.870	59.7162	101975	72268	
12	0.230769	4.33333	59.949	-5.6448	94268	75270	
17	0.326923	3.05882	-28.251	-49.4315	84281	59176	
22	0.423077	2.36364	-1.749	54.3490	76879	55251	
7	0.134615	7.42857	16.191	-48.3128	67503	61564	
16	0.307692	3.25000	22.066	-40.5565	55425	49238	
8	0.153846	6.50000	32.982	31.3584	53851	46479	
21	0.403846	2.47619	44.640	3.5877	52147	47670	
18	0.346154	2.88889	-20.916	-28.2723	32157	37742	
24	0.461538	2.16667	-26.683	-21.7142	30771	36363	
23	0.442308	2.26087	-3.339	32.1404	27148	40344	
20	0.384615	2.60000	-0.285	-27.7636	20043	25786	
11	0.211538	4.72727	-19.878	-15.3445	16395	62287	
26	0.500000	2.00000	24.698	0.0000	15860	14817	
14	0.269231	3.71429	-10.869	-19.1981	12654	38156	
25	0.480769	2.08000	-8.399	-19.2691	11488	17750	
15	0.288462	3.46667	-11.928	-16.3968	10690	27836	
9	0.173077	5.77778	-0.258	-16.7049	7257	47559	
6	0.115385	8.66667	-4.951	-14.8494	6370	133576	
4	0.076923	13.00000	1.456	-12.0497	3830	345599	**0.035714**
19	0.365385	2.73684	-3.937	6.6301	1546	18147	
0	0.000000		0.000	0.0000	0	3147020	**0.035714**

Figure 19. Results of spectral analysis for the DAX index. *(Source: built by the authors in the package Statistica)*

Predicted values and calculated M.A.P.E. are presented in Table. 4.

Table 4. Predicted values and calculated M.A.P.E. *(Source: built by the authors in the package Statistica)*

t	DAX_pr	APE	MAPE=	0.60787464
1	**2**	**3**	**4**	**5**
1	13028.53	0.368515		
2	13247.56	0.839709		
3	13333.67	0.015076		
4	13300.73	0.013301		
...	...	...		
50	15673.69	0.840963		
51	15755.72	0.426722		
52	15743.07	1.236704		
53	15872.69			

The M.A.P.E. is equal to 0,61%, which indicates the high accuracy of the spectral analysis and the implemented model (since the error value does not exceed 10%).

The calculated forecast value for the DAX index for the next week (53 period) based on the spectral model is equal to 15872,69 units. A graphical representation of the initial data and forecast data obtained on the basis of the spectral model is shown in Figure 20.

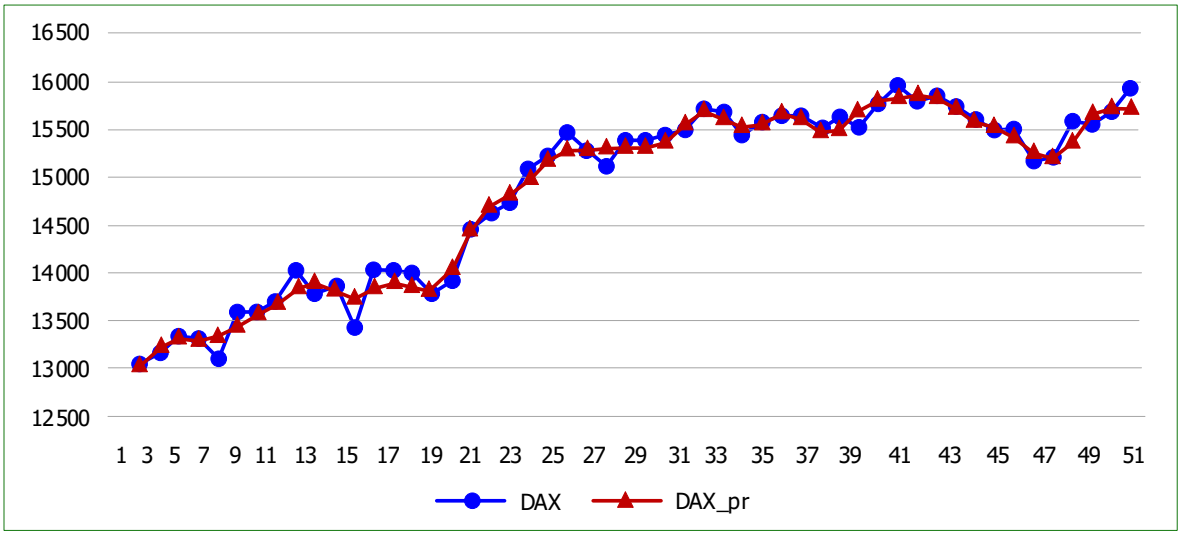

Figure 20. Schedule of estimated and actual volume values by the DAX index.

Therefore, the simulated spectral analysis shows fairly accurate models for all the investigated stock indices. Also, according to all models, the accuracy of the M.A.P.E. forecast is quite high. The highest accuracy has such an index as DAX (0,61%), and the rapid growth of quotations (15872,69 units).

Adhering to the research methodology indicated in Figure 1, the last stage for modeling stock indices is the analysis and forecasting of world stock indices based on expert information inherent in this market (analysis of news and events) (Figure 21).

Market research is carried out on the basis of news analysis and expert opinions. News can significantly affect the stock market. Back in 2013, researchers from the Warwick Business School published the results of an experiment in which the Google Trends service was used as a tool for forecasting stock market trends (Preis et. al., 2013). It makes it possible to work with information about search queries that are ranked by popularity. The researchers assumed that there is a correlation between the increase in the number of searches on certain political and economic topics and significant events in the stock markets. Information about search queries on topics that can affect share prices can indicate possible rapid

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changes in the market trend. Analysis systems that use publications in mass media and social networks to make transactions are also appearing on the market. Special systems are being developed, with the help of which articles will be created and published to help buyers and sellers of financial assets based on the processing of world news.

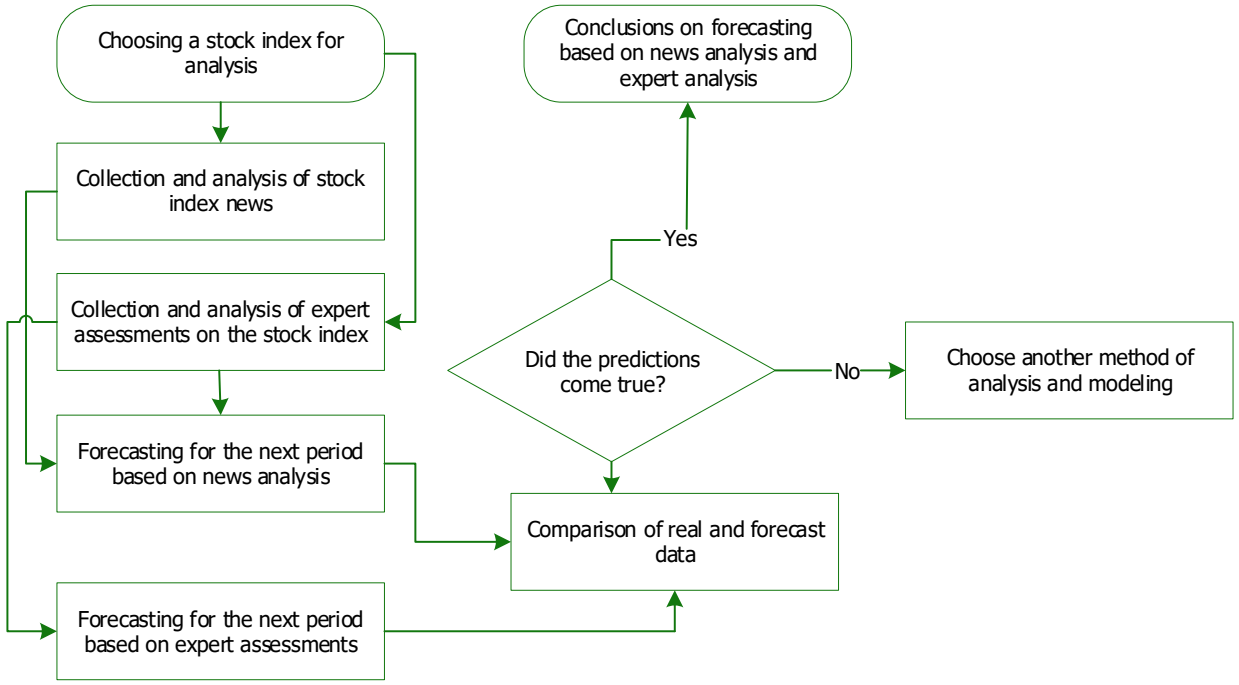

Figure 21. Algorithm of expert assessment and forecasting of world stock indices based on analysis of news and events.

DISCUSSION

The influence of external circumstances on the world market state and its development prospects remain debatable. The stock market is constantly adapting to external conditions, but in the case of taking concerted and targeted measures to stabilize the world economy, further slow growth of the world economy should be expected. It is also necessary to consider various development scenarios and conduct a constant analysis of news in the world economy. In the study, trends for further growth of the world indices given in the work and the state of the world economy as a whole were revealed. In order to evaluate the ARIMA model and the spectral model of the development of world stock indices, a predictive model was built based on a series of dynamics. Thus, the main trends in the development of stock indices due to financing were determined, which may be strengthened due to the fact that inflation will be higher than the forecast indicators, as well as due to the fact that financial conditions may become more rigid, due to the reassessment of the prospects of monetary and credit policies in countries with developed economies. Thus, it can be noted that currently there are countries that have a chance of normalizing economic activity.

CONCLUSIONS

In the article, the complex of economic and mathematical models of assessment, analysis, and forecasting of the world stock indices state was built for effective investment management. The complex involves the construction of an ARIMA model and a spectral model of world stock indices, on the basis of which possible trends in the development of stock indices for future periods were analyzed.

The proposed algorithm for forecasting stock indices based on the ARIMA model was implemented for the European market. When compiling the sample for the European market, such stock indices were selected as the FTSE index and DAX index because experts first of all closely monitor these indices and draw conclusions about the state of the economy in the European sector. Based on the results of the simulation, it turned out that countries with emerging market have downward trends by mid-June 2022. Countries with developing economies have a forecast of index growth. At the next stage, in order to assess the spectral model of the development of world stock indices, a forecast model was built based on the series of dynamics. Thus, the main trends in the development of stock indices due to financing were determined,

which may be strengthened due to the fact that inflation will be higher than the forecast indicators, as well as due to the fact that financial conditions may become more rigid, due to the reassessment of the prospects of monetary and credit policies in countries with developed economies.

Thus, it can be noted that currently there are countries that have a chance of normalization and stabilization of economic activity at the end of the current year. Therefore, according to the results of the paper, it can be stated that the stock market constantly adapts to external conditions, but in the case of taking coordinated and targeted measures to stabilize the world economy, further slow growth of the world economy should be expected. It is also necessary to consider various development scenarios and conduct a constant analysis of news, events, and facts in the field of the world economy.

ADDITIONAL INFORMATION

AUTHOR CONTRIBUTIONS

Conceptualization: *Olena Serhiienko, Valeria Baranova, Maryna Tatar*
Data curation: *Mykhailo Bril, Valeria Baranova, Maryna Tatar*
Formal Analysis: *Mykhailo Bril, Valeria Baranova, Oleksandr Bilotserkivskyi*
Methodology: *Maryna Tatar*
Software: *Olena Serhiienko, Maryna Tatar, Oleksandr Bilotserkivskyi*
Resources: *Valeria Baranova, Oleksandr Bilotserkivskyi*
Supervision: *Olena Serhiienko, Maryna Tatar*
Validation: *Olena Serhiienko, Maryna Tatar*
Investigation: *Olena Serhiienko, Mykhailo Bril, Maryna Tatar, Oleksandr Bilotserkivskyi*
Visualization: *Mykhailo Bril, Valeria Baranova, Oleksandr Bilotserkivskyi*
Project administration: *Olena Serhiienko, Maryna Tatar*
Writing – original draft: *Olena Serhiienko, Mykhailo Bril, Valeria Baranova, Maryna Tatar, Oleksandr Bilotserkivskyi*

REFERENCES

1. Guryanova, L. S., Klebanova, T. S., Prokopovich, S. V. and others (2016). Applied econometrics: teaching. manual in 2 parts. Part 1. Kharkiv: HNEU named after S. Kuznetsa. http://www.repository.hneu.edu.ua/handle/123456789/19846
2. Guryanova, L. S., Klebanova, T. S., Prokopovich S. V. and others (2016). Applied econometrics: teaching. manual in 2 parts. Part 2. Kharkiv: HNEU named after S. Kuznetsa. http://www.repository.hneu.edu.ua/handle/123456789/19842
3. Kedong, Yin, Zhe, Liu, & Peide, Liu (2017). Trend analysis of global stock market linkage based on a dynamic conditional correlation network. *Journal of Business Economics and Management*, 18(4), 779-800. https://www.webofscience.com/wos/woscc/full-record/WOS:000408730100012
4. Klebanova, T.S., Guryanova, L.S., Chagovets, L.O. and others (2018). Business analytics of multidimensional processes: training. manual Kharkiv: HNEU named after S. Kuznetsia.
5. Klebanova, T. S., Kurzenev V. A., Naumov, V. M. and others (2015). Forecasting socio-economic processes: a study guide for students of the 6.030502 "Economic cybernetics" full-time study progra. Kh.: KHNEU named after S. Kuznetsia.
6. Kolupaev, Y. B., Zalyubovska, S. S., & Yakovenko, M. A. (2018) Justification of directions of perspective development of the stock market of Ukraine. *Effective economics*, 8. http://www.economy.nayka.com.ua/?op=1&z=6570
7. Levkovich, O. V., & Finko, A. V. (2019) Ways to improve the development of the bond market in Ukraine. *Business Inform*, 9, 287-292. https://doi.org/10.32983/2222-4459-2019-9-287-292
8. Marszk, A., & Lechman, E. (2020). Application of Diffusion Models in the Analysis of Financial Markets: Evidence on Exchange Traded Funds in Europe. *Risks*, 8, 18. https://www.webofscience.com/wos/woscc/full-record/WOS:000524496300029
9. Preis, Tobias, Moat, Helen Susannah, and Stanley, H. Eugene (2013). Quantifying trading behavior in financial markets using Google Trends. *Scientific Reports*, 1684. https://www.nature.com/articles/srep01684

DOI: 10.55643/fcaptp.4.51.2023.4038

10. Prymostka, L., Krasnova, I., Kulish, G., Nikitin, A., & Shevaldina, V. (2020). Modeling the segment interactions of Ukraine's financial market. Investment Management and Financial Innovations, 17 (2), 101-112. http://dx.doi.org/10.21511/imfi.17(2).2020.09

11. Rakhman, M. S., & Shevtsova, V. V. (2019). The financial market as a potential for investment revitalization of the economy of Ukraine. *Business Inform*, 10, 192-199. https://doi.org/10.32983/2222-4459-2019-10-192-199

12. Razzaq, Al Rababa'aAbdel, Saidat, Zaid, & Hendawi, Raed (2021). Forecasting stock returns on the Amman Stock Exchange: Do neural networks outperform linear regressions? *Investment management and financial innovations*, 18(4), 280-296. http://dx.doi.org/10.21511/imfi.18(4).2021.24

13. Rudra P. Pradhan, Mak B. Arvin, Mahendhiran Nair, & Sara E. Bennett (2020). Unveiling the causal relationships among banking competition, stock and insurance market development, and economic growth in Europe. *Structural Change and Economic Dynamics*, 55(2020), 74-87. https://www.webofscience.com/wos/woscc/full-record/WOS:000600572400007 https://doi.org/10.1016/j.strueco.2020.08.006

14. Shkolnyk, I., Frolov, S., Orlov, V., Dziuba, V., & Balatskyi, Y. (2021). Influence of world stock markets on the development of the stock market in Ukraine. *Investment management and financial innovations*, 18(4), 223-240. http://dx.doi.org/10.21511/imfi.18(4).2021.20

15. Shuba, O. A. (2021). Peculiarities of the integration of the stock market of Ukraine into the world stock market. *Business Inform*, 4, 183-189. https://doi.org/10.32983/2222-4459-2021-4-183-189

16. Siriopoulos, C., Svingou, A., & Dandu, J. (2021). Lessons for Euro markets from the first wave of COVID-19. *Investment Management and Financial Innovations*, 18(1), 285-298. http://dx.doi.org/10.21511/imfi.18(1).2021.24

17. Slepecký, J., Vorontsova, A., Plastun, A., Makarenko, I., & Zhyhlei, I. (2022). Net investment position and the stock market: The case of traditional and ESG indices. *Investment management and financial innovations*, 19(2), 51-66. http://dx.doi.org/10.21511/imfi.19(2).2022.05

18. Spectral analysis. http://ieee.tpu.ru/system/time.html

19. Stock Markets Analysis & Opinion. https://www.investing.com/analysis/stock-markets

20. Tretyakova, O. V., Kharabara, V. M., & Greshko, R. I. (2020). Stock market of Ukraine: features of functioning in modern conditions. *Economy and state*, 5, 103 – 107. http://www.economy.in.ua/pdf/5_2020/20.pdf

21. Tymoshenko, O. V., & Gudyma, L. O. (2020). The Efficient Development of the National Securities Market as an Imperative of Ukraine's Economic Growth. *Business Inform*, 3, 293 - 298. https://doi.org/10.32983/2222-4459-2020-3-293-298

22. What algorithms and tools are used for forecasting the movement of stock prices. https://habr.com/ru/company/iticapital/blog/391979/

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АНАЛІЗ ДИНАМІКИ РОЗВИТКУ ФОНДОВИХ РИНКІВ ЄВРОПИ

У статті запропоновано комплекс економіко-математичних моделей оцінки, аналізу та прогнозування стану розвитку світових фондових індексів для ефективного управління інвестиційними потоками. Розглянуто сучасну концепцію та стратегію розвитку фондового ринку країн Європи, проведено аналіз існуючих методів діагностики рівня розвитку фондового ринку. Побудовано ARIMA-моделі та здійснено спектральний аналіз основних світових індексів. Із використанням прогнозних моделей проаналізовано можливі тенденції розвитку фондових індексів на майбутнє, що дозволяє визначити напрями підвищення ефективності фондового ринку та стратегії інвестування в сучасних умовах. Запропонований комплекс моделей оцінки, аналізу та прогнозування стану світових фондових індексів може бути використаний для тестування різних торгових стратегій і для перевірки різних гіпотез стосовно всього портфеля акцій конкретної компанії або одного фондового індексу. Результати дослідження можуть бути використані в розробці теоретичних положень та методичного інструментарію оцінки ефективності світового фондового ринку в сучасних умовах і тенденцій розвитку на локальних ринках.

Ключові слова: фондовий ринок, фондовий індекс, моделювання, спектральний аналіз, ARIMA-модель, прогнозування

JEL Класифікація: D53, E44, G15