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Analysis of fluctuations in the national economy: Models and development scenarios

Abstract. The purpose of the study was to analyse the prospects for the development of the Ukrainian economy, taking into account the cyclicality and fluctuations of economic processes, which are provoked by both evolutionary trends and fluctuations in force majeure circumstances. The construction of a cluster analysis model made it possible to identify priority types of economic activity and prove the significance of their impact on the country's economic development. The analysis of trends in the development of the economy and its priority types of economic activity was studied for two periods of development: normal and force majeure. The study showed that economic processes in the country have non-linear development trajectories. Therefore, to forecast the development of the country's economy the spectral analysis method and the adaptive forecasting method were used. The analysis of the non-linearity of the development of priority types

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of economic activity showed their impact on the wave nature of the development of the national economy. "Agriculture, Forestry and Fishing", "Manufacturing" and "Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles" were identified as the most prevalent economic activity types by the cluster analysis. Analysis of the development of cyclical components using spectral analysis showed the formation of cointegration effects when cyclical components at the resonance of crisis points intensify the general economic crisis. Local bifurcation points as crisis points of the national economy were identified and it was proven that they are provoked by economic fluctuations of its priority types of economic activity. As a result, three main scenarios for managing the national economy were developed – a support scenario, a crisis scenario, and a growth scenario; for each scenario, general recommendations for regulating the national economy were developed

Keywords: types of economic activity; cycle; time series; adaptive forecasting model; scenario of development

INTRODUCTION

The national economy as a complex system, which includes a huge number of economic agents of different types of economic activity (TEAs), develops along a non-linear trajectory. Achieving stability of the behaviour of this system should be based on modelling wave processes and their special case – cyclic processes (Kosarchyn, 2023). The problem of cyclical fluctuations is gaining particular importance both at the national level and in the international arena, which is connected with the transition of economically developed countries from an industrial to an information society. The cyclical nature of the behaviour of the economic system is characterised by a permanent transition from one phase of development to the next for the formation of operational, medium-term, final, and final cycles. There is a periodic transition from one equally important state to another equally important state through a transitional crisis period, which is characterised by increased instability, a decline in production, force majeure changes, and a surplus economic structure. In this situation, the economic system adapts to new global sentiments and national changes, striving for stability and sustainability.

To accelerate and control the passage of the economic cycle and develop effective state tools, V. Mykhailov & R. Kulynych (2023) studied the essence and causes of macroeconomic instability, manifestations of unemployment and inflation. They believed that cyclicality should be considered as a movement of the national economy, a form of its development and improvement. A. Tkacova & B. Gavurova (2023) claimed that the turbulent process of economic cycles of the EU countries constantly demonstrates the need for quality forecasting mechanisms. Therefore, it is necessary to choose the economic sentiment indicator (ESI) as a predictive indicator. The authors proved that the ESI and its components are capable of providing high-quality forecasting of the economic cycle. X. Li & Z. He (2023) for the study of business cycles and economic growth proposed to use an economic model that includes both deterministic trends and stable fluctuations obtained as a result of the general process of generating economic data obtained using the dimensionless NLARI – nonlinear autoregressive integrated. The authors proposed a unified test to study the nature and causes of economic fluctuations and growth. This test allows to determine whether the mechanism of formation of economic data is stable fixed points, unit roots, cyclical fluctuations or chaos.

To analyse macroeconomic trends, including economic cycles and unforeseen/prolonged crises, A. Husenova *et al*. (2022) presented a model toolkit that allows to assess the relationship between the calculated indices of economic sentiment and confidence for the main TEAs. The authors also established the nature of the economic sentiment index and investigated its forecasting capabilities regarding monthly and annual growth rates of real gross domestic product (GDP) using autoregression and error correction models. E. Ahmadova (2021) studied the problem of identifying cyclical components from the general dynamics of the country's economic situation. In order to solve this problem, the author proposed to use the algorithm of asynchronous harmonic analysis based on spectral analysis and the algorithm of decomposition filtering. It is proposed to use GDP or gross value added by TEAs as an information basis.

To effectively manage waves and, as a special case, cyclical processes in the economy, it is necessary to create and maintain the effective functioning of monitoring systems based on the widespread use of the latest information and communication technologies, big data techniques, data mining tools, etc. In addition, important components of the monitoring system are the database as an information space for analysis and the knowledge base as a set of approaches, methods, classifiers, methods, and models that allow building a monitoring strategy and tactics. The article aimed to study the prospects for the development of the Ukrainian economy, taking into account the cyclicality and nonlinearity of the development of TEAs caused by both the established evolutionary trends and fluctuations in force majeure circumstances in 2022-2024. The conceptual basis of this study is the following hypotheses. Hypothesis 1: economic changes can be cyclical and fluctuating in nature. The first is due to the evolution of the development of the economic process; the second is of an irregular nature and is associated with the technological and innovative shocks of the 21st century. Hypothesis 2: to identify local bifurcation points in the development cycles of economic processes, it is advisable to use spectral analysis; to forecast crisis points in irregular fluctuation processes caused, for example, by force majeure circumstances, it is advisable to use adaptive forecasting methods. Hypothesis 3: the emergence of crisis points in the cyclical development of the national economy is caused by economic fluctuations in priority TEAs.

MATERIALS AND METHODS

The hypotheses formed the basis of the conceptual model of the study, the sequence of stages of which reveals the logic of the study (Fig. 1). The methodological basis for

constructing the model was formed by the systemic, structural-logical, and functional approaches, which made it possible to form: the structure of the model as a sequence of stages for achieving the research goal; a set of tasks for each stage, the solution of which allows to confirm or refute the hypotheses put forward in the study; economic and mathematical tools for solving problems to achieve the main function of the model, namely monitoring changes in the country's macroeconomic environment, considering the nonlinear nature of the development of economic processes.

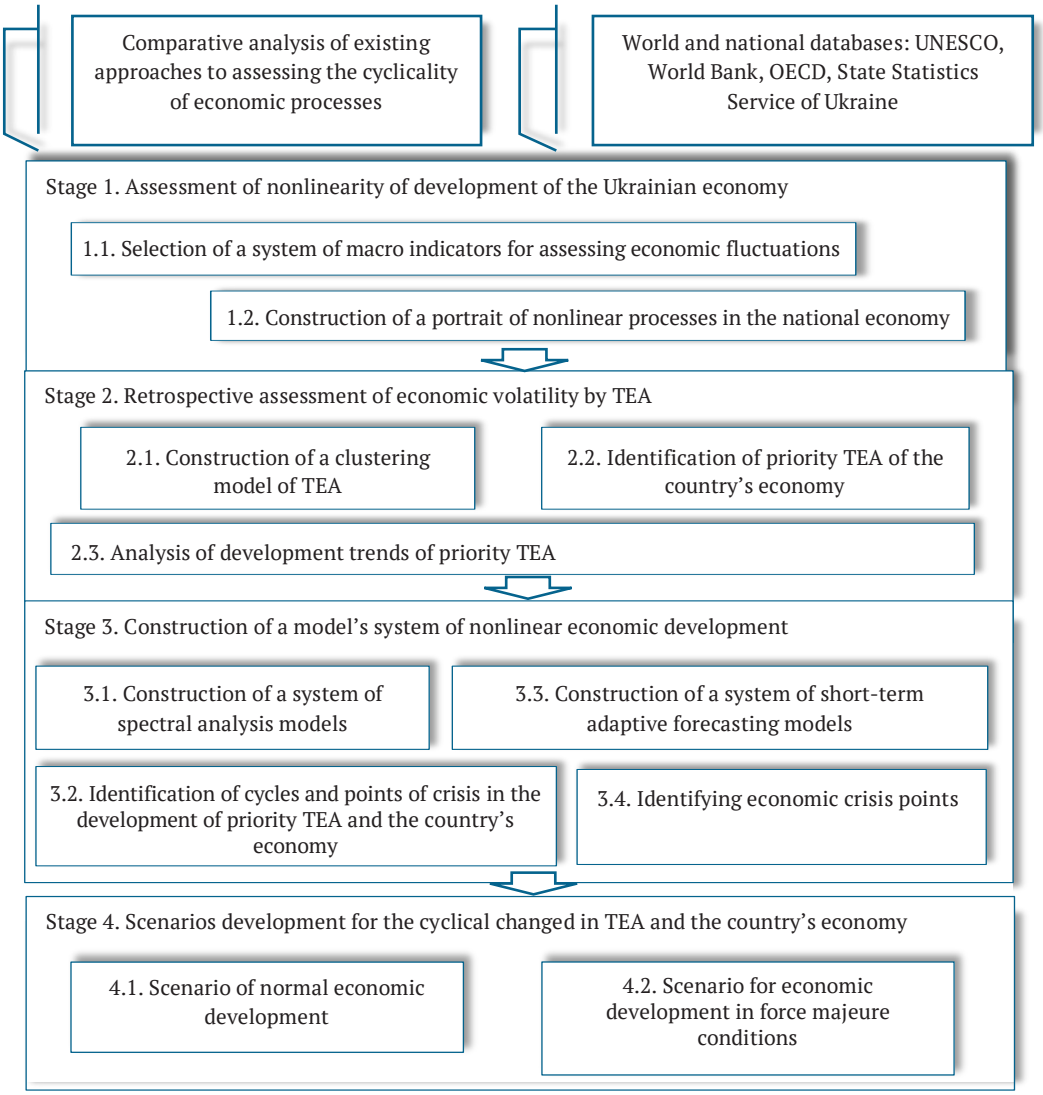

Figure 1. Conceptual model of the study

Source: developed by the authors

The methods and models of each stage of the model should be considered in more detail. To address the tasks of Stage 1 of the study, several methods were employed. These included the information search method, as well as the monographic analysis of literary sources (Ahmadova, 2021; Li & He, 2023; Tkacova & Gavurova, 2023). Additionally, the comparative method was used alongside graphical, structural, and dynamic analysis (Rayevnyeva *et al.*, 2023a; Rayevnyeva *et al.*, 2023b; Wang & Kong, 2023). Furthermore, the study relied on the works of T.O. Pasichnyk (2024), V. Rădulescu *et al.* (2024) and S. Zhe (2024) for further theoretical and methodological insights. This toolkit made it possible to create a list of indicators that should be used to assess economic fluctuations in the country. The information basis for solving the tasks of this stage is the analysis of macroeconomic indicators of the development of Ukraine for the period 1987-2024. The sources of statistical information are international and national statistical institutions (OECD, n.d.; State Statistics Service of Ukraine, n.d.; UNESCO Institute for Statistics, n.d.; World Bank, n.d.).

At Stage 2, tasks related to the assessment of economic volatility of TEAs from shocks of macroeconomic development were solved. To construct homogeneous clusters of the contribution of foreign economic activities to the country's GDP, one of the methods of artificial, non-hierarchical classifiers (partitioning algorithms) was used – the *k* means method, which allowed for the decomposition of foreign economic activities. One of its advantages is the ability to form the number of clusters required for the study, which improves the quality of their economic

interpretation. The criterion for selecting optimal clusters was the minimum value of the total within-cluster variation (W_{total}) (Fair, 2025):

$$W_{total} = \sum_k W(C_k) \to \min, \quad (1)$$

where $W(C_k)$ – within-cluster variation for each cluster; k – number of clusters. The selection of the optimal number of clusters was carried out based on the use of the "elbow method", which considered the nature of the change in the spread W_{total} with an increase in the number of groups. To solve the clusterisation task, a multidimensional clustering model was built using the software Statistica 13.0. The information space was formed by indicators of gross value added (GVA), wages of employees, and gross profit by TEAs for the period 2010-2022. The identification of priority activities in the country's economic development was carried out based on the use of the results of cluster and structural-dynamic analysis. This made it possible to identify priority types of foreign economic activity based on their contribution to the country's GDP.

To solve the tasks of Stage 3, the study used spectral analysis models (Task 3.1; 3.2) and adaptive forecasting models (Task 3.3; 3.4). Since many economic processes in Ukraine are strongly influenced by external factors caused by force majeure circumstances, they demonstrate periodic behaviour. This justifies the appropriateness of using spectral analysis in the study (Prymostka & Chub, 2021). The covariance of a time series is represented by a spectral density function using a periodogram. The latter expresses the square of the correlation between the time series and the cos and sin functions of different frequencies that are present in the time series:

$$f(x) \sim \frac{a_0}{2} + \sum_{n-1}^{\infty} (a_n \cos_{nx} + b_n \sin nx), \quad (2)$$

where $a_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x) cos\ nxdx$, $n = 0, 1, 2, \ldots$; $b_n = \frac{1}{\pi}\int_{-\pi}^{\pi} f(x) sin\ nxdx$, $n = 1, 2, 3, \ldots$ Identification of periodic dependencies made it possible to determine the coincidence/mismatch of periods of occurrence of local points of the crisis of various TEAs and to determine points of the global crisis in the development of the country's economy. To construct a system of spectral analysis models, models of cyclic components of a time series were developed based on its decomposition. The type of decomposition model was determined based on the graph of the corresponding series and its multiplicative form of the following type was proven:

$$Y(t) = T(t) \times C(t) \times S(t) \times I, \quad (3)$$

where $T(t)$ – trend component; $C(t)$ – cyclic component; $S(t)$ – seasonal component; I – residual. The application of adaptive forecasting models is especially relevant when analysed time series are characterised by high volatility and strong variability of factors that influence it. Adaptation in models is provided by small discrete shifts, which are calculated as the deviation of the forecast from its actual value. The resulting error is used to adjust the model parameters when calculating each new value of the series. Thus, this model is appropriate for forecasting crisis points of TEAs in force majeure conditions of the development of the Ukrainian economy in 2022-2023. The calculations of the models were carried out using the Statistica 13.0 software; the criterion for selecting an adequate model was the mean percentage absolute error (MAPE) in percent, which is calculated using the following formula:

$$MAPE = \frac{1}{n}\sum_{i=1}^{n} \frac{|Y_t - \hat{Y}_t|}{Y_t} \times 100, \quad (4)$$

where Y_t – actual indicator value; $(\hat{Y}_t)$ – model indicator value; n – length of the series. The initial data for solving the tasks of construction of a model's system of nonlinear economic development is the amount of GVA of the priority TEAs for the period 2001-2022 in a quarterly section.

RESULTS

Stage 1. Assessment of nonlinearity of development of the Ukrainian economy

Task 1.1: Selection of a system of macro indicators for assessing economic fluctuations. Based on the research, the following list of indicators was formed, namely: the volume of GDP, the level of inflation, the level of the unemployed in the economy, the volume of currency reserves of countries. Task 1.2: Construction of a portrait of nonlinear processes in the national economy. Figure 2 shows the non-linear nature of the development of the Ukrainian economy. During the analysed period, several periods of decline and rise in the development of the country's economy were distinguished.

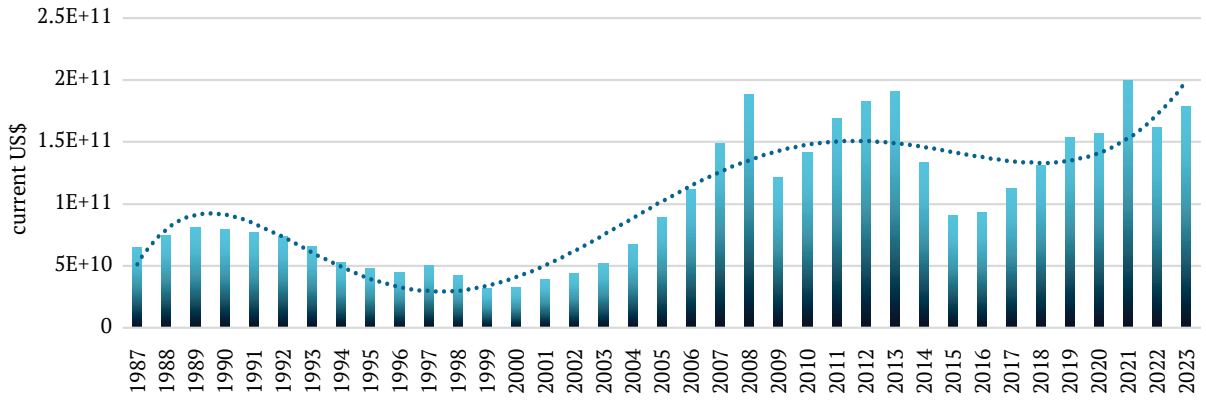

Figure 2. Dynamics of changes in the country's GDP, current US$

Source: created by the authors based on World Development Indicators (n.d.)

The first period (1991-2000) was a period of decline, provoked by the collapse of the Soviet Union, the emergence of independent Ukraine, changes in the form of ownership and the formation of market mechanisms. This period is characterised by a low level of production of competitive goods in the conditions of a free market, the presence of a commodity deficit, and a low level of income of the population. The second period (2001-2013) was a period of growth, adaptation of the economy to market rules of doing business, rapid growth of the country's GDP, which indicates the country's high economic development. The fall in GDP in 2009 was a response of the economy to the global financial, and subsequently political and economic crisis. But, the weak integration of Ukraine's economy into the world economic market made it possible to restore economic activity in 3 years and in 2013 to reach the GDP level of 2008. The third period (2014-2015) was an economic decline caused by political changes in the country's development. The fourth period (2016-2023) was a period of fluctuating growth. This period is characterised by a general upward trend in the development of the country's economy, its adaptation both to global force majeure conditions (the COVID-19 pandemic) and to the military conflict on the territory of the country.

Figure 3 shows the non-linear trend of changes in the inflation rate in the country. Thus, during the period 1993-2000, the level of inflation in the country decreased rapidly and already in 2003 it was 8.2%. However, in 2004 inflation accelerated to 12.3%, in 2005-2006 its level decreased. Starting from 2007 to 2009, there was a gradual increase in the level of inflation, and from 2009 to 2012, the opposite dynamics was observed. Ukraine ended 2012 with deflation of 0.2%. Before that, the last time this happened was in 2002, when deflation was 0.6%. Over the entire period under study, the lowest level of inflation was recorded in 2013 and amounted to 0.5%, but then it began to rise to a record: in 2014, the price increase was 24.9%, in 2015 – 43.3%. Starting from 2016 to 2020, a period of decreasing inflation was observed, and from 2021, a period of growth again. All this indicates that this economic indicator has a wave nature of development.

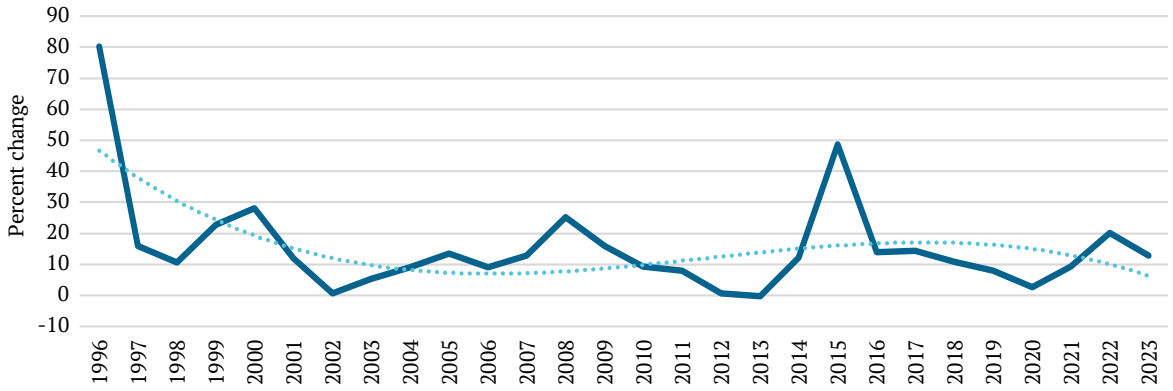

Figure 3. Dynamics of changes in the inflation rate, %

Source: created by the authors based on World Bank (n.d.)

Figure 4 shows the trend of changes in the unemployment rate indicator. The level of unemployment in Ukraine also has a non-linear nature of development. From 1995 to 2023, several periods of decline/rise can be distinguished. The recession periods were 1990-1997, 2000-2008, 2010-2013, 2017-2019, 2023-present. During these periods, there was a decrease in the number of the unemployed population, which indicates an increase in the welfare of the population and the economic development of the country. Boom period (1998-1999, 2009, 2014-2016, 2022) reflects an increase in the number of unemployed people, unstable economic development of the country, which is associated with political and economic crises and the military conflict on the territory of Ukraine.

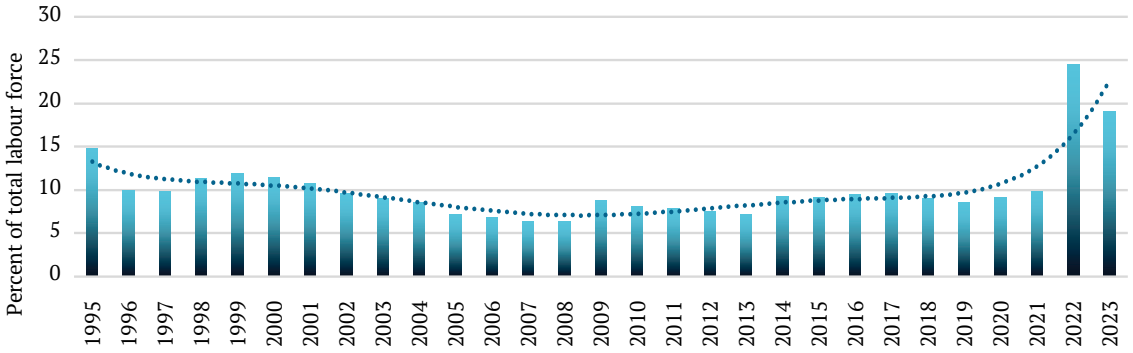

Figure 4. Dynamics of changes in the unemployment rate, %

Source: created by the authors based on State Statistics Service of Ukraine (n.d.)

Figure 5 shows the dynamics of changes in the volume of foreign exchange reserves. The analysis made it possible to distinguish several periods. The first period (1993-2007) was the formation and development of the country as an independent state that had sufficiently large reserves for stable economic development. The second period (2008-2009) was a decline associated with the global financial crisis. The third period (2010-2014) was a period of significant decrease in the volume of the country's currency reserve. The largest drop in the volume of gold and foreign exchange reserves took place in 2012 and amounted to 7.25 billion dollars by 21 absolute indicators, with a relative indicator of a 22.8% decrease compared to the volumes of 2011. The fall in the National Bank of Ukraine reserves this year was largely related to the desire to maintain the hryvnia exchange rate on the eve of the 2012 parliamentary elections. In the following 2013-2014, the steady trend towards a decrease in gold and foreign exchange reserves continued, reaching the mark of 7.533 billion dollars as of January 1, 2015. 2014 became the leader in reducing the volume of foreign exchange reserves by 63.1% compared to 2013. The main reason for the decrease in reserves during this period was repayment of International Monetary Fund loans, entry into the foreign exchange market with interventions, payments on state bonds loans.

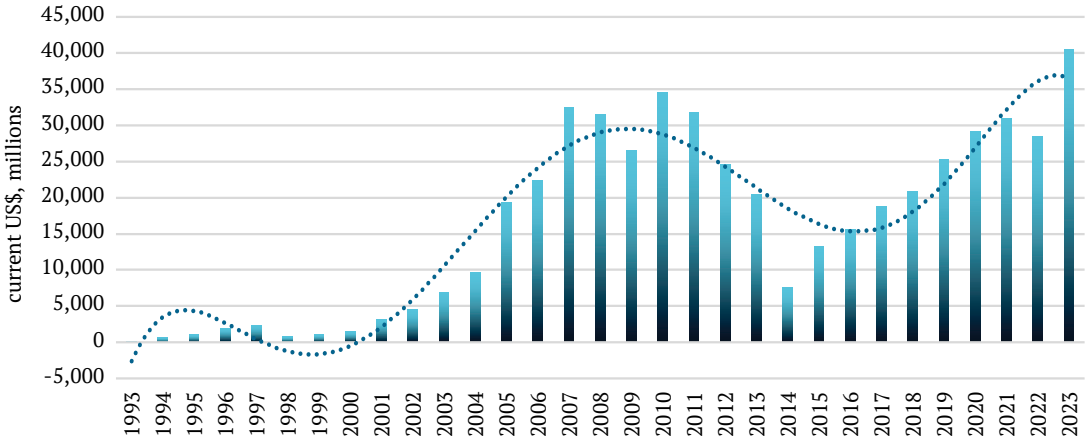

Figure 5. Dynamics of the volume of the country's currency reserve, current US$, millions
Source: compiled by the authors based on Statista (n.d.), International Monetary Fund (2024)

The fourth period (2015-2021) was characterised by growth of gold and foreign exchange reserves of Ukraine, due to the increase of assets in convertible currencies (securities, currency and deposits). In 2022, there was a sharp reduction in the country's currency reserves due to the full-scale invasion of Russia on the territory of Ukraine, which is a force majeure circumstance for the country. However, starting from 2023, Ukraine began to gradually adapt to force majeure circumstances. Thus, the analysis of the main macroeconomic indicators of the country showed the presence of non-linearity in their development.

Stage 2. Retrospective assessment of economic volatility by TEAs

Task 2.1: Construction of a clustering model of TEAs (Table 1). For a clearer view of the results presented, the results of the cluster analysis are shown separately in Table 2.

Table 1. Clusterisation of TEAs

Cluster	Cluster features	Type of economic activity
1	TEAs that have a strong impact on the country's GDP	"Agriculture, Forestry and Fishing"; "Manufacturing"; "Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles"
2	TEAs that have an average impact on the country's GDP	"Mining and Quarrying"; "Transportation and Storage"; "Information and Communication"; "Real Estate Activities"; "Public Administration and Defence; Compulsory Social Security"; "Education"
3	TEAs that have a low impact on the country's GDP	"Electricity, Gas, Steam and Air Conditioning Supply"; "Water Supply; Sewerage, Waste Management and Remediation Activities"; "Construction"; "Accommodation and Food Service Activities"; "Financial and Insurance Activities"; "Professional, Scientific and Technical Activities"; "Administrative and Support Service Activities"; "Human Health and Social Work Activities"; "Arts, Entertainment and Recreation"; other service activities

Source: developed by the authors

Table 2. Cluster analysis data

Year	Parameters	Agriculture, Forestry and Fishing	Mining and Quarrying	Manufacturing	Electricity, Gas, Steam and Air Conditioning Supply	Water Supply; Sewerage, Waste Management and Remediation Activities	Construction	Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	Transportation and Storage	Accommodation and Food Service Activities	Information and Communication	Financial and Insurance Activities	Real Estate Activities	Professional, Scientific and Technical Activities	Administrative and Support Service Activities	Public Administration and Defence; Compulsory Social Security	Education	Human Health and Social Work Activities	Arts, Entertainment and Recreation	Other service activities
2010	GVA	80,385	63,436	142,700	30,295	7,736	35,366	154,994	83,027	8,932	33,011	61,263	57,699	27,265	11,832	49,863	53,462	38,555	6,074	8,577
	Remuneration of employees	17,301	34,171	92,794	21,297	6,562	17,435	65,116	44,437	4,370	17,079	27,791	10,333	17,462	6,589	45,757	48,547	32,970	4,985	3,188
	Gross profit	63,381	35,008	47,287	8,718	1,201	17,401	86,531	37,805	4,375	16,274	32,703	46,988	9,313	5,145	4,048	4,823	5,891	1,627	5,118
2011	GVA	106,555	84,872	154,675	39,994	7,302	39,575	193,357	103,179	10,256	38,390	58,213	69,035	30,471	14,300	53,464	59,377	41,855	7,161	10,527
	Remuneration of employees	21,988	40,577	112,260	26,928	7,121	22,298	81,140	54,666	5,137	19,287	29,932	14,185	18,080	7,916	49,748	54,171	35,315	6,004	3,862
	Gross profit	84,861	51,134	38,336	12,440	295	16,784	109,221	47,713	4,875	19,038	27,408	54,465	11,867	6,331	3,662	5,115	6,280	1,870	6,351
2012	GVA	109,785	81,660	173,912	43,491	6,625	39,049	200,763	98,859	10,122	43,379	61,055	83,502	41,966	16,135	59,752	71,771	49,234	9,727	12,282
	Remuneration of employees	25,920	44,232	125,284	25,232	7,416	23,167	95,098	63,275	6,070	22,120	33,226	20,243	26,873	11,206	53,933	65,544	42,542	8,935	5,521
	Gross profit	83,694	53,926	43,375	24,324	404	14,655	102,315	33,925	3,693	19,360	27,000	64,372	14,635	3,422	5,756	6,120	6,393	4,271	6,377
2013	GVA	128,738	81,259	165,055	42,366	6,573	36,902	212,090	104,483	10,150	48,372	66,232	95,272	47,712	17,715	68,225	77,986	48,247	12,704	13,731
	Remuneration of employees	30,055	48,599	114,931	25,276	7,276	22,118	100,108	64,945	5,995	23,924	33,576	21,920	29,908	11,991	63,162	70,562	40,705	9,815	5,787
	Gross profit	97,968	45,721	44,563	17,562	-400	13,449	107,387	38,444	3,747	23,389	31,806	73,158	16,048	4,940	4,998	7,323	7,399	5,246	7,474
2014	GVA	161,145	79,120	194,050	44,836	7,236	36,876	233,702	100,889	9,927	52,724	70,601	99,144	47,139	18,061	78,731	76,068	46,250	12,339	13,881
	Remuneration of employees	31,274	34,726	123,632	29,586	6,710	20,998	102,761	62,100	5,859	24,075	32,733	19,238	30,355	13,601	72,538	69,059	39,267	9,912	6,519
	Gross profit	128,518	51,989	64,374	22,767	1,771	14,680	126,510	37,721	3,641	26,952	36,471	82,144	15,448	3,690	6,102	6,902	6,795	4,420	6,886
2015	GVA	239,806	95,141	236,692	53,385	7,924	38,928	273,989	134978	11,946	72,596	67,512	123,021	55,789	21,624	95,085	82,778	51,480	12,357	14,356
	Remuneration of employees	35,131	34,219	132,968	32,641	8,028	20,060	101,419	73,271	5,858	26,268	26,996	15,976	29,001	14,724	86,329	74,753	43,041	10,181	6,782
	Gross profit	203,286	61,307	97,161	24,393	765	17,256	168,601	60,418	5,778	43,472	38,747	106,303	25,183	6,111	8,638	7,895	8,100	4,504	7,069
2016	GVA	279,701	131,650	291,471	73,809	8,502	47,457	318,075	156,745	15,551	89,268	65,445	145,984	68,460	29,584	123,065	88,996	58,858	13,554	17,053
	Remuneration of employees	40,834	39,644	137,331	36,899	7,944	22,419	115,838	81,551	6,724	29,621	30,797	16,129	32,351	17,863	111,927	78,640	49,065	10,622	7,630
	Gross profit	238,555	93,433	150,706	37,283	913	24,509	199,123	75,478	8,550	59,401	32,619	129,220	35,191	11,364	11,064	10,272	9,824	5,589	9,100
2017	GVA	303,949	177,170	359,867	85,970	9,880	64,431	409,994	191,209	18,727	110,296	81,369	171,674	86,537	35,471	163,798	133,213	76,140	17,376	22,490
	Remuneration of employees	54,657	50,939	186,003	43,444	9,779	31,614	153,059	113,473	7,805	37,074	37,211	19,189	45,942	22,716	148,689	120,015	63,889	14,626	10,623
	Gross profit	252,566	127,963	170,374	43,691	685	32,169	253,203	78,851	10,497	71,652	41,776	151,860	39,516	12,283	15,044	13,098	12,365	6,846	11,424
2018	GVA	361,173	214,260	411,467	111,856	11,394	81,259	471,844	227,256	25,112	138,828	97,807	206,085	113,354	48,571	212,789	158,620	77,130	20,375	29,010
	Remuneration of employees	74,229	62,668	231,364	52,791	11,355	41,595	195,824	150,596	9,827	47,536	47,274	23,300	58,543	29,044	192,600	142,888	69,475	17,708	13,704
	Gross profit	287,131	153,705	178,302	59,882	1,092	38,795	271,946	77,728	14,704	89,350	48,097	181,900	53,418	18,923	20,120	15,586	7,587	7,652	14,726
2019	GVA	356,795	222,352	430,228	124,908	14,436	107,430	526,299	264,866	35,311	182,667	114,658	241,493	141,523	62,238	266,656	172,645	95,435	24,053	38,837
	Remuneration of employees	82,016	69,471	258,311	63,163	15,748	53,305	242,153	158,825	14,547	64,193	56,692	29,173	68,838	40,077	241,747	153,930	83,004	20,438	17,142
	Gross profit	274,742	155,643	170,344	61,363	617	52,949	279,603	107,757	19,967	115,726	54,571	211,360	71,056	21,281	24,823	18,514	12,304	8,306	20,967
2020	GVA	393,077	193,120	426,483	122,878	16,257	119,441	588,365	262,453	30,834	209,394	131,903	268,980	137,192	59,895	306,533	186,049	113,642	24,338	35,891
	Remuneration of employees	84,882	66,402	254,649	74,656	18,558	57,871	258,345	158,860	11,137	69,408	61,561	30,075	75,519	40,834	272,271	162,522	102,683	21,508	15,472
	Gross profit	305,119	128,695	168,767	47,781	750	61,281	322,356	106,214	15,075	135,404	67,813	236,629	61,002	17,681	30,716	18,276	10,312	6,366	17,719
2021	GVA	580,519	364,199	562,471	183,176	19,240	151,826	755,201	303,614	38,002	246,021	165,316	304,060	159,284	69,275	341,242	236,599	140,401	30,729	40,444
	Remuneration of employees	140,755	84,671	315,464	88,058	22,149	79,720	315,519	178,072	14,353	77,154	69,873	39,592	72,858	44,131	302,141	207,131	133,802	27,231	18,532
	Gross profit	472,991	290,882	263,560	104,360	3,270	79,240	452,026	135,233	21,426	161,475	91,935	266,602	84,211	20,210	36,235	29,881	7,504	8,734	22,971
2022	GVA	426,817	295,550	393,312	231,492	15,818	62,782	641,703	204,547	34,605	238,589	148,269	253,176	96,163	38,987	1,097,257	215,550	126,905	22,669	36,202
	Remuneration of employees	140,755	84,671	315,464	88,058	22,149	79,720	315,519	178,072	14,353	77,154	69,873	39,592	72,858	44,131	302,141	207,131	133,802	27,231	18,532
	Gross profit	472,991	290,882	263,560	104,360	3,270	79,240	452,026	135,233	21,426	161,475	91,935	266,602	84,211	20,210	36,235	29,881	7,504	8,734	22,971

Source: created by the authors based on State Statistics Service of Ukraine (n.d.)

Task 2.2: Identification of priority TEAs of the country's economy. Figure 6 graphically presents the contribution to the country's GDP of certain TEAs in 2022. Based on the comparison of the results of structural-dynamic (Fig. 6) and cluster analysis (Table 2), the dominant TEAs were identified: "Agriculture, Forestry and Fishing", "Manufacturing" and "Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles". These TEAs form a third of the country's GDP.

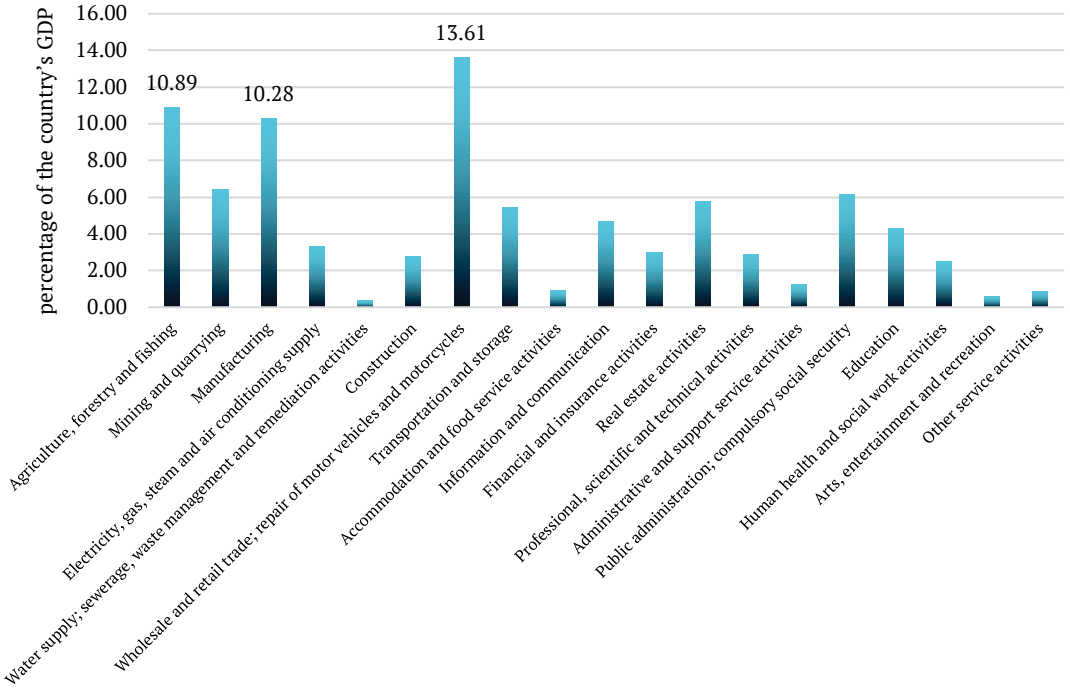

Figure 6. The structure of the contribution of TEAs to the development of the country's GDP in 2022, %
Source: created by the authors based on State Statistics Service of Ukraine (n.d.)

Task 2.3: Analysis of development trends of priority TEAs. Priority TEAs have a significant impact on the country's economy, which is confirmed by the nature of their development (Fig. 7).

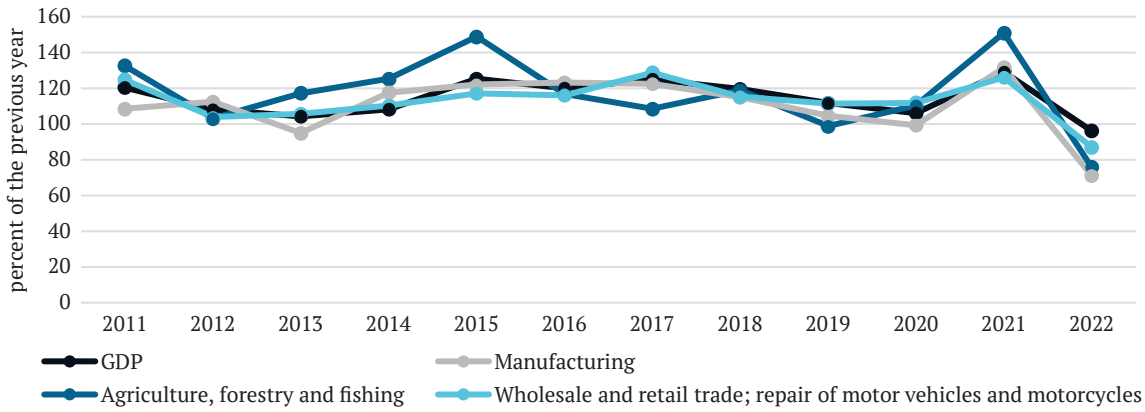

Figure 7. Growth rates of the country's GDP and priority TEAs (in % compared to the previous year)
Source: created by the authors based on State Statistics Service of Ukraine (n.d.)

In terms of tempo, they have practically a unidirectional trend of their development with the economy of Ukraine. But the question of co-integration of the development of the priority TEAs with the general cyclical development of the country is open for research.

Stage 3. Construction of a model's system of nonlinear economic development

The initial data for solving the tasks of this stage is the amount of GVA of the priority TEAs for the period 2001-2022 in a quarterly section. Figure 8 reflects the trends in GVA change for priority TEAs.

Task 3.1: Construction of a system of spectral analysis models. To build the models of cyclic components of the time series, the following steps were taken. Step 1: Decomposition of the time series on the determination and irregular parts. The results of eliminating the seasonal factor for the three studied time series are shown in Table 3.

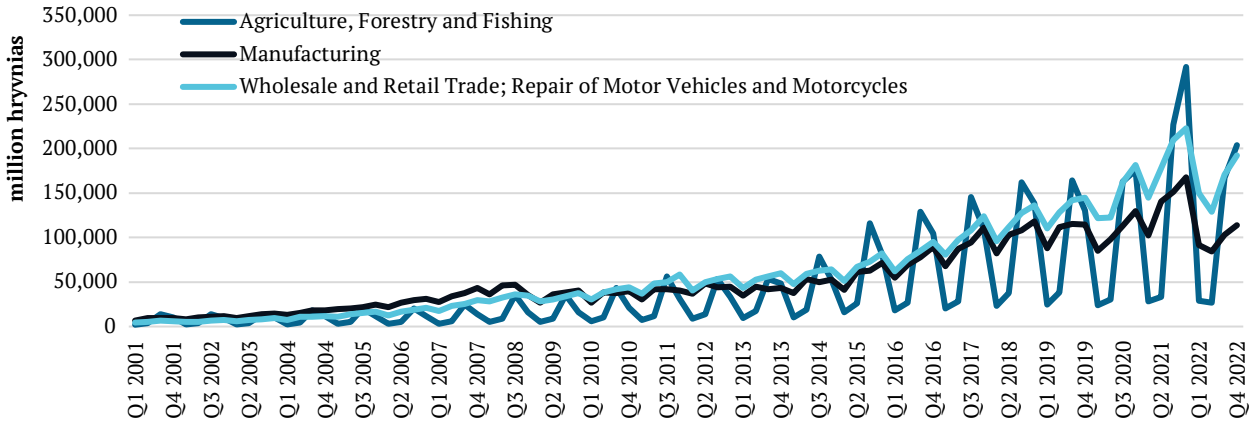

Figure 8. Dynamics of the volume of GVA of priority TEAs
Source: created by the authors based on State Statistics Service of Ukraine (n.d.)

Table 3. Seasonal factors for three time series

Number of the quarter in the year	Type of the economic activity		
	Agriculture, Forestry and Fishing	Manufacturing	Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles
1	31.2288	83.0888	85.1996
2	47.5210	103.3685	98.8435
3	190.2583	104.9755	105.4314
4	130.9919	108.5672	110.5255

Source: calculated by the authors

Calculations have shown that the highest values of seasonal factors occur in the Q3 and Q4. While the Q1 has the lowest value of the seasonal factor. On the other hand, Table 3 shows that agriculture, forestry, and fishery have the highest value of seasonal factor. This means that this type of economic activity is more dependent on seasonal fluctuations than others. Step 2: Determination of the trend component. At this step, the smoothed trend-cyclic component was studied, the trend type was found, and the parameters of trend models were calculated. Based on the analysis of the graph, it was concluded to use a linear trend in the work. The parameters of the trend components are given in Table 4.

Table 4. Parameters of trend models and criteria for model adequacy

	Agriculture, Forestry and Fishing	Manufacturing	Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles
Models	$Y(t) = -16{,}243 + 1{,}299.7t$	$Y(t) = -5{,}827 + 1{,}344.6t$	$Y(t) = -24{,}812 + 1{,}973.2t$
Determination coefficients (R^2)	0.85	0.81	0.88

Source: calculated by the authors

The values of the determination coefficient are high, which indicates the high quality of trend models. Also, the correlation coefficients show the influence of trend components, and R^2 shows the influence of cyclical components. Thus, it is concluded that the variability of the values of the analysed time series is strongly determined by the trend and weakly depends on cyclical changes. Step 3: Determination of the cyclic components. To calculate the cyclical components of the series, it is necessary to divide the smoothed trend-cyclical components by the trend values. The graphs of the cyclical components are presented in Figure 9.

Figure 9 shows that there are abnormal observations in the cyclic components. There are two reasons for this. The first reason is the multiplicative type of the decomposition model since negative values are in trend. The second reason is the presence of long-term memory in the time series. Therefore, it is necessary to select an observation to study the cyclic components. The analysis of the cyclic components gives an observation interval from 17 to 84 observations. The graphs of the new cyclic components are shown in Figure 10.

Step 4: Calculation of the cyclic models for cyclic components. Fourier spectral analysis was used to determine local cyclic components (harmonics). The calculations performed allowed to identify six fundamental harmonics based on spectral densities. The values of the sine, cosine coefficients, period, and spectral periodogram are in Table 5.

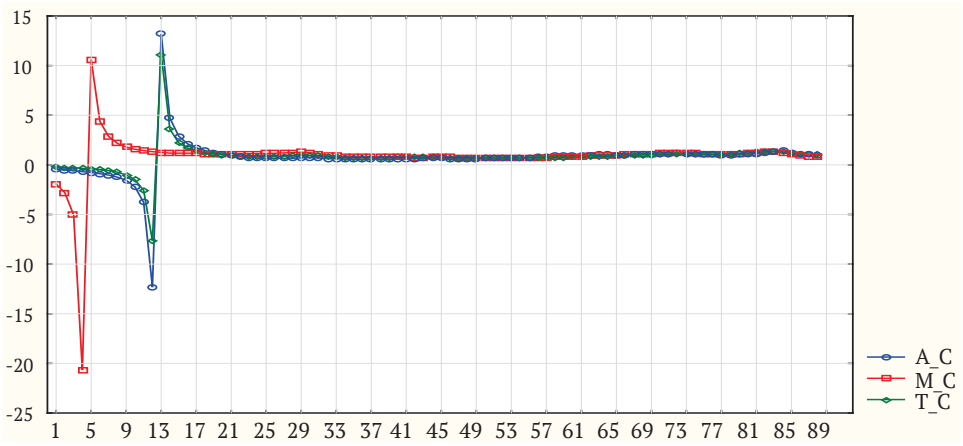

Figure 9. Cyclic components of the time series
Note: A_C – cyclic component of the "Agriculture, Forestry and Fishing"; M_C – cyclic component of the "Manufacturing"; T_C – cyclic component of the "Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles"
Source: calculated by the authors

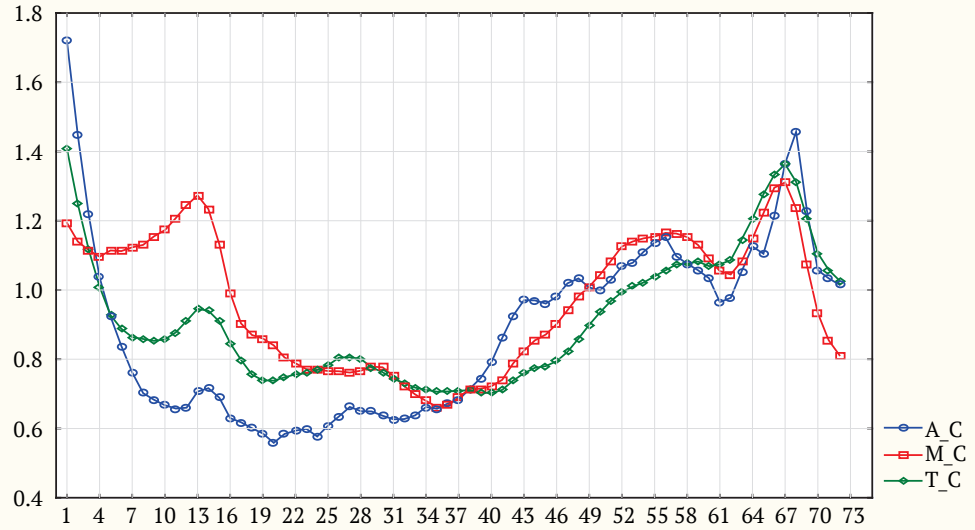

Figure 10. Part of the cyclic components
Note: A_C – cyclic component of the "Agriculture, Forestry and Fishing"; M_C – cyclic component of the "Manufacturing"; T_C – cyclic component of the "Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles"
Source: calculated by the authors

Table 5. Main characteristics of Fourier spectral analysis

Period (*T*)	Cosine coefficients	Sine coefficients	Periodogram	Part of the periodogram
Agriculture, Forestry and Fishing				
72.0000	0.171879	−0.125808	1.633323	62.3%
24.0000	0.091755	0.011950	0.308222	11.8%
36.0000	0.071132	0.053613	0.285627	10.9%
10.2857	0.010016	0.065944	0.160163	6.1%
6.5455	0.036036	0.044928	0.119414	4.6%
9.0000	0.017255	0.053659	0.114374	4.4%
Manufacturing				
72.0000	0.209922	−0.067399	1.749956	71.9%
36.0000	−0.070868	0.062543	0.321624	13.2%
18.0000	−0.044843	−0.033275	0.112253	4.6%
9.0000	−0.006106	0.050149	0.091880	3.8%
24.0000	−0.029728	0.039586	0.088228	3.6%
10.2857	−0.005209	0.043955	0.070530	2.9%

Table 5. Continued

Period (*T*)	Cosine coefficients	Sine coefficients	Periodogram	Part of the periodogram
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles				
72.0000	0.202028	–0.041643	1.531776	86.1%
10.2857	0.006363	0.045753	0.076818	4.3%
12.0000	0.015501	0.037313	0.058772	3.3%
9.0000	0.008455	0.038164	0.055006	3.1%
36.0000	0.008774	–0.027278	0.029559	1.7%
24.0000	0.023713	0.013128	0.026446	1.5%

Source: calculated by the authors

Table 5 shows that $T = 72$ quarters is the most powerful long-term cycle, which is typical for all TEAs. This is especially true for "Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles" (86.1%). Medium-term cycles ($T = 18/24/36$ quarters) are more important for "Agriculture, Forestry and Fishing" (22.7%), and "Manufacturing" (21.4%). For retail trade, they account for 3.2%, which indicates their insignificant impact on the trend of foreign economic activity development. Short-term cycles ($T = 10.3/9/6.5$ quarters) have a strong influence on retail trade (10.8%). In "Agriculture, Forestry and Fishing", and "Manufacturing" they have an average influence on the trends of foreign economic activity development 15.1 and 6.7%, respectively).

Task 3.2: Identification of cycles and points of crisis in the development of priority TEAs and the country's economy. The study calculated theoretical/model values of the cycle components to identify cycles and crisis points in the development of priority TEAs (Fig. 11-13). Step 1: Agriculture, Forestry and Fishing (Fig. 11). Step 2: Manufacturing (Fig. 12). Crisis phenomena in agriculture began to form from the Q2 of 2001, which characterises the descending stage of the cycle with the point of local minimum in the 18th period (Q2 2005). The period of the 18th period – 38th period (Q2 2010) reflects the period of the global crisis, after which the trend of development of foreign economic activity gradually moves to the stage of ascending development.

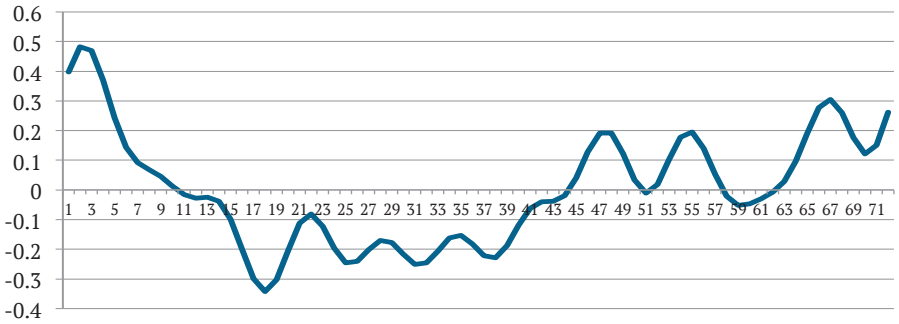

Figure 11. Cyclic component for the "Agriculture, Forestry and Fishing"

Source: calculated by the authors

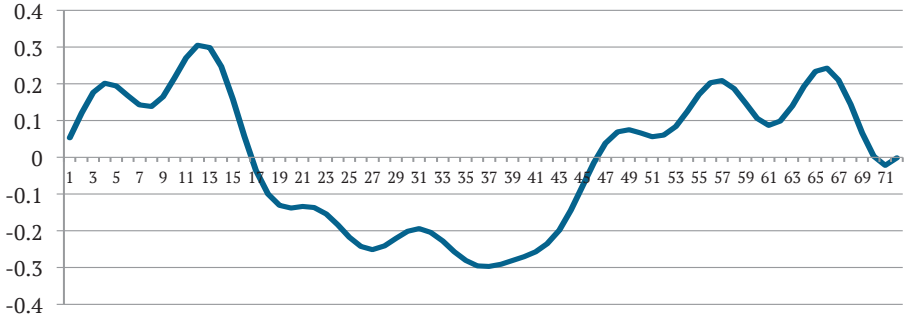

Figure 12. Cyclic component of the "Manufacturing"

Source: calculated by the authors

Crisis phenomena in the industry began to form from the 14th period (Q2 2004) and reached a local minimum point in the 37th period (Q1 2010). Then the TEA moved to the ascending stage of development, which continued until the local maximum point in the 67th period (Q3 2017), where the trend changed. The TEA moved to the descending stage of development. Step 3: Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles (Fig. 13).

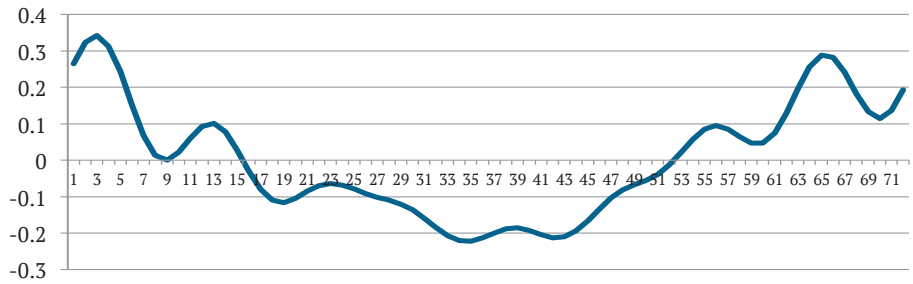

Figure 13. Cyclic component of the "Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles"
Source: calculated by the authors

The deterioration of the situation in the TEA began in fourth period (Q1 2002) and continued until 34th period – the point of local crisis, which corresponds to Q2 2009. From periods 34 to 43, an unstable trend in the development of the TEA was observed, which then moved to an ascending stage of development. The global crisis for this TEA covers periods 19-43 (Q3 2005-Q3 2012) and is the longest among priority TEAs. Thus, the analysis of cyclical components shows similar trends in long-term and short-term cycles. This is determined by the wave nature of economic activity and the similar nature of the development of priority foreign economic activities within the national economy.

Task 3.3: Construction of a system of short-term adaptive forecasting models. Force majeure conditions of military aggression from Russia provoked significant destructive changes in the development of all TEAs. This required the use of adaptive methods of short-term forecasting in the study. Several model experiments were conducted in the software Statistica 13.0 and, according to the criterion of minimising the MAPE value, models for forecasting GVA for priority TEAs were built (Table 6).

Table 6. Results of the construction of forecast models

The name of the TEA	Model	MAPE	Forecast value			
			Q1 2023	Q2 2023	Q3 2023	Q4 2023
Agriculture Forestry and Fishing	Model with a seasonal component and no trend	2.40	44,253.8	72,224.5	300,731.5	203,023.3
Manufacturing	Model with a seasonal component and no trend	1.39	87,002.3	108,375.5	110,078.6	113,832.6
Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles	Model with a seasonal component and no trend	2.37	138,448.2	154,232.1	177,885.1	191,067.4

Source: calculated by the authors

Task 3.4: Identifying economic crisis points. Figures 14-16 show graphs of actual and forecast values of the gross value added indicator for priority TEAs. Analysis of the obtained dynamics allows to conclude that the most sensitive to external fluctuations in foreign economic activity is "Agriculture, Forestry and Fishing". Figure 14 shows that since 2014, "Agriculture, Forestry and Fishing" had high volatility of the indicator values and a gradually increasing range of its values. The forecast values support the formed trend, but the range of values is decreasing. "Agriculture, Forestry and Fishing", due to the preferences opened by Europe for Ukraine, is at a weak ascending stage of its development and is a source of replenishment of the country's budget.

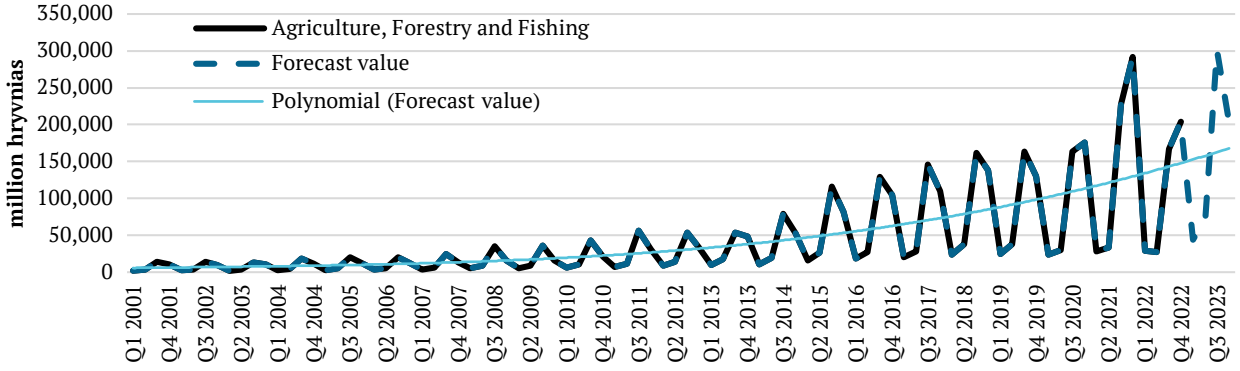

Figure 14. Forecast model of GVA "Agriculture, Forestry and Fishing"
Source: calculated by the authors

"Manufacturing" (Fig. 15) has always been a key source of budget replenishment before Russia's aggression against the eastern regions of Ukraine, where the country's industry is concentrated.

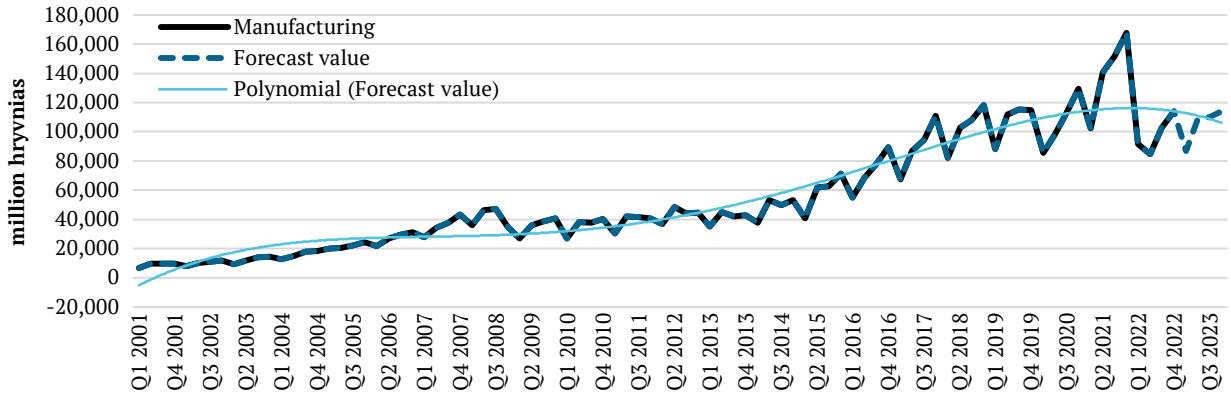

Figure 15. Forecast model of GVA "Manufacturing"
Source: calculated by the authors

The forecast of GVA "Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles" (Fig. 16) shows a decrease in the indicator values, but no clear trend reversal is observed. This TEA is in the fluctuation zone and its further development will be associated with changes in the economic situation in the country.

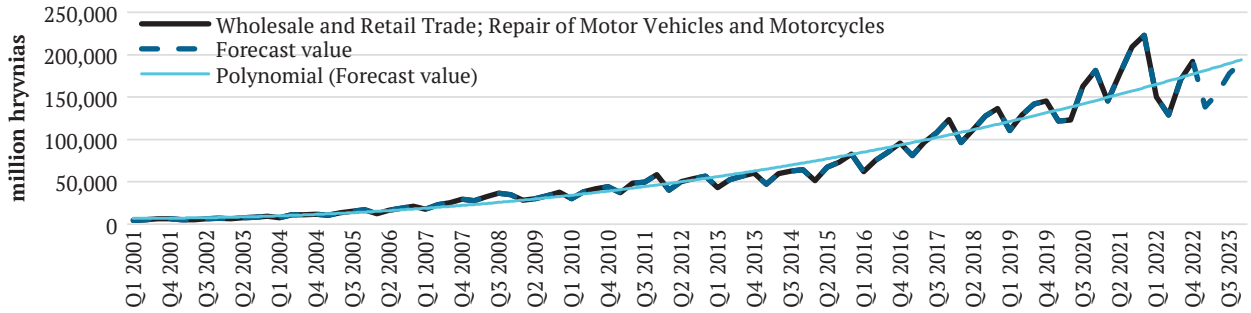

Figure 16. Forecast model of GVA "Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles"
Source: calculated by the authors

This TEA has a high growth rate until the Q4 2021, which characterises it as low-sensitive to economic fluctuations and political changes. Starting from the Q1 2022, these rates began to decline significantly. Manufacturing entered a stage of downward development, which was provoked by the military conflict.

Stage 4. Scenarios development for the cyclical changed in TEAs and the country's economy

Analysis and forecasting of the nonlinear nature of the development of economic processes in the country is a strong signal for the development of strategy and tactics of the behaviour of agents of economic relations in the market. Therefore, the study developed 2 main scenarios – normal and force majeure for the development of the country's economy and its main types of activity. Task 4.1: Scenario of normal economic development. At Stage 2 and Stage 3 of the conceptual model (Fig. 1), three priority TEAs that determine the development of the national economy were identified, and a set of models of their cyclical behaviour is developed. Therefore, to understand the cyclical nature of the development of the economy as a whole, it is necessary to combine these models into one (Fig. 17).

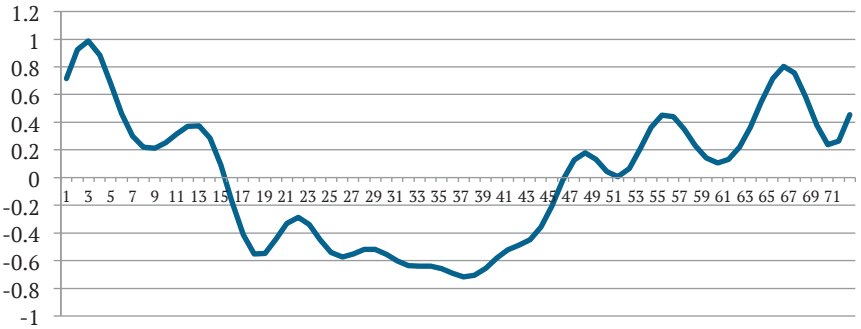

Figure 17. Combination of the cyclic components of the three investigated industries
Source: calculated by the authors

The analysis of the dynamics of Figure 17 allowed to propose three main scenarios for managing the national economy. "Support" scenario: this scenario begins to be implemented in the event of a decrease in the values of the national economic activity indicator. To slow down the rate of decline and stabilise the trend of the indicator, it is necessary to use measures to support the national economy. It is important that if a trend of a significant decline in the national economic indicator has formed, it is necessary to introduce measures to stabilise the development of priority TEAs since they make a significant contribution to the country's budget. In this case, a synergistic effect of the interaction of TEAs occurs, which will stabilise the general state of the macroeconomic system. Examples of such compensatory measures are an increase in government procurement; the formation of a preferential complex for industry; protection of foreign economic activity from imports, etc.

"Crisis" scenario is a scenario for periods of global crises in economic activity. It is advisable to implement this scenario at a point of low development – at a bifurcation point. In such a state, the economy cannot overcome the crisis on its own, so it is important to develop various actions to reverse the crisis trends and shorten the crisis period. An important tool in this scenario is subsidising TEAs, supporting them with various legislative initiatives, and creating conditions for activating the functioning of business entities.

"Growth" scenario is used during periods of upward trends in economic activity and is aimed at creating conditions for increasing the growth period and preparing for the trend reversal point. This scenario requires actions related to non-interference in the development of economic systems, creating conditions for stimulating growth. These government initiatives will increase the period of sustainable development of enterprises and, as a result, change the period of occurrence of the bifurcation point in the macroeconomic cycle and create prerequisites for the formation of a new upward trend. This period provides an opportunity to prepare for a new positive crisis and create a basis for a higher cycle of economic development, bypassing the decline stage. Based on the research results, a timeline for various scenarios was developed (Fig. 18).

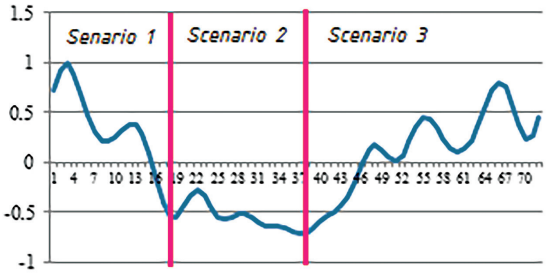

Figure 18. Timeline of the normal economic development scenario
Source: calculated by the authors

Scenario 1 ("Support" scenario) should be used from the first to the 18th period, Scenario 2 ("Crisis" scenario) should be used from the 19th to the 38th period, and Scenario 3 ("Growth" scenario) should be used from the 39th to the end. The third scenario is the longest scenario in the study. Based on the developed timeline, starting from the 68th period (Q4 2020), the economy will move to Scenario 1, which requires state support for key TEAs. This will prevent the emergence of a systemic crisis in the country's economy and will create conditions for shortening the period of economic decline.

Task 4.2: Scenario for economic development in force majeure conditions. An analysis of the contribution of the dominant TEAs (Fig. 6) and the forecast values of their GVA (Fig. 14-16) allowed to formulate the following development scenario. For "Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles", the turning point of the trend from ascending to descending (the point of negative crisis) corresponds to Q1 2022. These TEAs are highly sensitive to force majeure circumstances. But, the reasons for such sensitivity are different. Thus, for "Manufacturing", this is the conduct of active military actions in eastern Ukraine, where the country's industry is concentrated; for "Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles", this is a sharp drop in the purchasing power of the population, caused by its movement both within and outside the country, loss of sources of income.

For "Agriculture, Forestry and Fishing", the GVA values decreased, but there was no trend reversal. This foreign economic activity is at the stage of weakly ascending development due to the assistance of the European and world community. However, the force majeure situation associated with the war contributes to the threat to global food security, for example, due to the blockade of Ukrainian ports or interruptions in the supply of mineral fertilizers and fuel. This requires solutions that go beyond the economic or trade policy agenda. In particular, the financial capacity of both the domestic government and international partners may not be sufficient in the short term to ensure Ukraine's economic recovery. Therefore, it is important to ensure the most favourable conditions for the development of the private sector, which would help generate and attract private capital to overcome the economic consequences of the war.

The question of the temporary nature of the change in the sensitivity of individual TEA to crisis phenomena remains open. In the authors' opinion, to solve this problem, it is necessary to combine crisis diagnostics with the identification of specific factors that provoke its onset. The task of managing the economic situation in order to overcome crises is interesting. The study proposed to focus attention on three system-forming TEAs, namely to analyse the trends of their non-linear development taking into account the maximisation of their GVA contribution to the country's GDP. According to Hypothesis 3, it has been proven that the significant contribution of these TEAs to the country's budget requires primary attention to the trends of their development by the state, the identification of crisis points that arise in them provokes the emergence of a general economic crisis.

The novelty of the article is the justified application of different classes of models for the formation of two scenarios of the behaviour of economic systems – in the case of standard development and in the presence of force majeure circumstances. In the standard development scenario, spectral analysis methods were used, for force majeure circumstances, adaptive forecasting methods were used, which allowed to increase the prognostic quality of

models in conditions of high level of unpredictability of the behaviour of the external environment in the future. The use of such a combination of methods allowed to confirm Hypothesis 2. That is, the occurrence of crisis points in a stable economic process is expedient to forecast by building models of the cyclical component and determining the dominant harmonics; if the process is inherently fluctuating, then it is proposed to use adaptive methods to determine future crisis points, where the adaptation parameter makes it possible to take into account fluctuating fluctuations that do not correspond to the evolution of the economic process. Thus, the obtained results fully confirmed the hypotheses formed in the study and made it possible to develop corresponding scenarios for the nonlinear development of macroeconomic processes. This is the basis for managing the enterprise's behaviour, which must adapt to the variability of the market environment.

DISCUSSION

The source of such attention to this problem by scientists and practitioners is the high level of dynamism and unpredictability of market processes, which is caused by the existence of global markets. Questions such as the choice of the indicator space of analysis, the justification of the feasibility of applying economic and mathematical methods of forecasting nonlinear processes, the creation of support systems and decision-making based on the results of determining the future trends of the development of processes – these are the main problems of scientific and practical research and research. The article reflects the author's approach to solving these problems. The results of studies of the main indicators of the development of the national economy made it possible to determine the wave nature of the course of macroeconomic processes, which is confirmed by the corresponding developments by the P. Adair & O. Nezhyvenko (2021) and C. Li (2024). Although the authors considered cyclicality more from a theoretical point of view, this made it possible in the current research to put forward a hypothesis about the presence of cyclicality in the indicators under study, which was successfully proven.

A. Brandt & S. Manzoni (2020) investigated the use of the Fourier transform as the main tool of spectral analysis. This transformation has become a set of mathematical tools for research. With the help of this transformation, harmonics were obtained, which represent local cycles with different lengths and amplitudes, which allowed to study short-term and long-term cycles in TEAs. The different periodicity of harmonics in their additive composition allows to construct an analytical function that can be used to predict the cyclical component of the development of the national economy. The study has proven this nonlinear nature, which allowed to analyse the long-term and short-term components of economic development and develop effective development scenarios.

O. Dobrovolska *et al*. (2024) studied the dynamics of the Ukrainian economy and proved that the uneven growth of the Ukrainian economy in the short term was shaped by shocks of external conditions, and in the medium term by institutional economic cycles, which, in turn, influenced the formation of the long-term trend of the development of domestic commodity production. This allowed the study to consider the cyclical component in this research as one that forms shocks for the scenarios of the development of the economic system. Unlike S. Bosi & T. Ha-Huy (2024), who observed the emergence of cycles and their negative impact on the reproduction processes in the case of describing such processes in the form of a logistic law, the current work proved the presence of cycles in the main macroeconomic processes, and that cyclicality is not a negative factor of reproductive processes. Cyclicality within the framework of the authors' study is a natural process of development of socio-economic phenomena, which can have both a crisis component and a growth component.

The obtained results of the study of fluctuations in the national economy fully correlate with the results of the study by G. Petrakos *et al*. (2023), who noted in their work that there is a high correlation between the quality of governance and economic growth. It should be noted that there is a strong causal relationship between the quality of governance and economic growth and a weak relationship in the opposite direction. R.K. Fair (2025) covered a wide range of indicators and factors, including inflation and unemployment, the magnitude of wealth effects, the behaviour of the Federal Reserve and its impact on the economy, the impact of fiscal policy, Okun's law, as well as contractions and expansions. This work is a continuation of research in the field of forecasting the macroeconomic state of the national economy. The study proved this non-linear nature, which made it possible to analyse the long-term and short-term components of economic development. Also, within the framework of the study, the TEAs that make a significant contribution to the national economic development of the country were identified and studied, which made it possible to form various scenarios for the development of TEAs and the national economy and propose measures to improve the economic situation. Similar studies were conducted within the framework of the studies of I. Sievidova *et al*. (2024), who considered the logic of modelling economic reforms and their impact on the development of Ukraine in the context of transformation processes. In addition, the authors considered various scenarios for increasing the rationality of modelling in the structure of transformation processes of the national economy. All this confirms the relevance of the research topic and the homogeneity of the areas of scientific research.

The study of the cyclical component was carried out using spectral analysis. Researchers such as E. Ahmadova (2021) modelled the economy of Azerbaijan using spectral analysis. In the authors' opinion, one of the most important aspects in the study of structural economic systems is not only modelling each indicator but also considering it in the context of cointegration with other macroeconomic factors. Therefore, in the future, it is important to use cross-spectral models to study the relationship of macroeconomic processes. An important feature of the studies of these authors is the use of wavelet analysis functions, which, unlike classical spectral analysis, can determine aperiodic functions. But in this case, this is a contradiction to the essence of the cyclical component, since the cycle has a certain frequency and amplitude, and in wavelet analysis, the wave has a variable frequency. J. Babirath *et al*. (2020) used spectral analysis to forecast stock price dynamics. An important condition for using this tool is the absence of stochasticity in the studied series. Therefore, the issue

of using the expansion of a stationary series into a Fourier series remains debatable, since a stationary time series should not contain dependencies on previous periods. The cyclic component is due to the wave nature and has a certain period of recurrence. In addition, with a decrease in the quantisation periods of the original time series, the influence of stochasticity increases, so spectral analysis is advisable to use with quantisation periods such as half a year, or a year. Of particular interest is the sensitivity of various TEAs to shock and crisis phenomena. The study showed that the definition of TEAs that react differently to crisis phenomena in the economy gives authorities an effective tool for forming measures to overcome the general economic crisis. That is, for example, TEAs with high sensitivity to the crisis should develop preventive decisions of a cardinal nature in advance to localise crisis phenomena, and TEAs with resistance to negative impacts can support further positive economic development. It is to solve this problem that cluster analysis is used in the study.

CONCLUSIONS

Based on the results of the research, it was proved that the country's economic system has a non-linear development, that is, there are economic fluctuations that are cyclical and fluctuating in nature. The cluster analysis model made it possible to identify the following TEAs as dominant: "Agriculture, Forestry and Fishing", "Manufacturing", "Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles" and to justify their significant contribution to the country's GDP. The study of the time series of development of TEAs using the proposed tools allowed to determine the cyclical and fluctuation components of the development of the national economy, which confirmed Hypothesis 1.

The conducted analysis of the nonlinearity of the development of dominant TEAs showed their influence on the wave nature of the development of the national economy. Two main scenarios of nonlinear development of the economy and dominant foreign economic activities were developed: a scenario of normal development based on the use of spectral analysis; and a scenario of force majeure development using adaptive forecasting methods. Spectral analysis of the time series of dominant economic activities showed that their dynamics include long-term, medium-term, and short-term cycles. The use of spectral analysis and such decomposition into cycles of different lengths and amplitudes allowed to identify bifurcation points, which proved the proposed Hypothesis 2. Based on this, three main scenarios for managing the national economy under normal conditions were developed, namely, a support scenario, a crisis scenario, and a growth scenario. It was determined that the economy would be at the stage of weakly downward development, which suggests the use of a support scenario for its development.

Analysis of the development of cyclical components using spectral analysis showed the formation of cointegration effects when cyclical components at the resonance of crisis points intensify the general economic crisis, which allowed to confirm Hypothesis 3 regarding the nature of crises in the development of the national economy. In the force majeure conditions of military aggression, the stages of the development cycle of dominant foreign economic activities were determined, and bifurcation points were found for "Manufacturing" and "Wholesale and Retail Trade; Repair of Motor Vehicles and Motorcycles", which corresponds to Q1 2022. Further studies of the analysis and modelling of the behaviour of the country's economy lie in the classification of crises and the determination of specific factors that provoke their occurrence; determination of TEAs' sensitivity to different types of crisis phenomena; application of variance analysis to diagnose the mutual influence of non-linear development of the individual TEA.

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CONFLICT OF INTEREST

None.

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Аналіз коливань у національній економіці: моделі та сценарії розвитку

Анотація. Метою дослідження було проаналізувати перспективи розвитку української економіки з урахуванням циклічності та коливань економічних процесів, які спровоковані як еволюційними тенденціями, так і коливаннями форс-мажорних обставин. Побудова моделі кластерного аналізу дала змогу визначити пріоритетні види економічної діяльності та довести значущість їх впливу на економічний розвиток країни. Аналіз тенденцій розвитку економіки та її пріоритетних видів економічної діяльності досліджено для двох періодів розвитку: нормального та форс-мажорного. Дослідження показало, що економічні процеси в країні мають нелінійні траєкторії розвитку. Тому для прогнозування розвитку економіки країни використовувалися метод спектрального аналізу та метод адаптивного прогнозування. Аналіз нелінійності розвитку пріоритетних видів економічної діяльності показав їх вплив на хвилеподібний характер розвитку національної економіки. «Сільське, лісове та рибне господарство», «Переробна промисловість» та «Оптова та роздрібна торгівля; Ремонт автотранспортних засобів і мотоциклів» були визначені як найбільш домінуючі види економічної діяльності за результатами кластерного аналізу. Аналіз розвитку циклічних складових за допомогою спектрального аналізу підтвердив існування коінтеграційних ефектів, коли циклічні компоненти в резонансних точках кризи посилюють загальноекономічну кризу. Визначено локальні точки біфуркації як кризові точки національної економіки та доведено, що вони спровоковані економічними коливаннями її пріоритетних видів економічної діяльності. У результаті було розроблено три основні сценарії управління національною економікою – сценарій підтримки, сценарій кризи та сценарій зростання; для кожного сценарію розроблено загальні рекомендації щодо регулювання національної економіки

Ключові слова: види економічної діяльності; цикл; часові ряди; адаптивна модель прогнозування; сценарій розвитку