A theoretical-applied model has been built for analyzing industrial-technological development directly within the system of economic security. A system of indicators has been constructed that are mutually agreed in the context of the analysis of the state of economic security and components of industrial-technological development (investment, international, environmental, educational, scientific, industrial, innovative, technological). Based on the system of indicators, analysis of variance in the industrial-technological development and level of economic security was carried out. The levels of correlation of indicators (high, medium, low) have been determined, based on which the interrelations of industrial-technological development and economic security were systematized. A graphic-analytical and regression procedure was used to define the correlation dependence of industrial-technological development on economic security. The industrial-technological development has been forecasted in terms of the indicators with high correlation (the level of investment, openness of the economy, export of high-tech products, industrial products index) and medium correlation (the share of renewable energy consumption, the level of expenditures on education to GDP, the share of specialists performing scientific and technical work). The system of indicators of economic security assessment has been expanded in terms of its individual components (investment-innovative, foreign economic, energy, social, macroeconomic security), taking into consideration aspects in the industrial-technological development. Using the reported analytical and predictive results makes it possible to establish groups of factors that influence the industrial-technological development and economic security. In this way, it becomes possible to identify those tools and means whose application could ensure an increase in the level of industrial-technological development and economic security

Keywords: industrial-technological development, national economy, innovative development, economic security, multidimensional analysis, forecasting

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MULTIDIMENSIONAL ANALYSIS AND FORECASTING THE RELATIONSHIP BETWEEN INDICATORS OF INDUSTRIAL-TECHNOLOGICAL DEVELOPMENT AND THE LEVEL OF ECONOMIC SECURITY

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1. Introduction

Commitments in the process of preparing a voluntary national review on the implementation of the 7, 9 and 17 goals of sustainable development for the next decade require the development of strategic and program documents for innovative progress and strengthening of state industrial policy in the short term. They require the development of strategic

and policy documents on innovative progress and strengthening of the state industrial policy in the short term. Given this, the task of determining the main drivers of marketing innovations for implementing the industrial-technological development policy in strategic and operational purposes to ensure the economic security of the state requires scientific justification.

At the same time, there is a lack of the state policy regarding the industrial-technological development of the national economy, which is due to foreign economic, technological, investment, environmental, and educational and scientific challenges, as well as threats to compromise the positive international image and competitiveness of the economy. This is reflected in the decrease in investment attractiveness, the increase in the volume of innovative industrial products sold, the decrease in the level of openness of the economy in foreign trade and industrial policy, a steady decline in the index of the introduction of new technological processes and patent productivity. In the social aspect, in the low rating of the national higher education system, the lack of a coherent state policy to stimulate capital investments in environmental protection, to preserve the raw material orientation of the state in global value chains.

A new strategy of the industrial policy is needed, implementing which is possible by searching for tools for the effectiveness of public administration using a marketing approach. It should be added that the state marketing policy is in place in the public administration of developed countries of the world. Thus, the U.S. strategy not only stimulates research and development at educational institutions but also considers education as a market resource of the state, which forms a high level of human capital development. Japan and France use marketing elements in the information openness of public administration bodies. In addition, the use of innovative approaches to reforming public administration mechanisms is actively implemented by Canada, Germany, the United Kingdom, Poland, the Czech Republic, and other countries, by building a positive image of the country on the world stage, maintaining the reputation of state institutions. In addition, increased interest in state programs and projects is being implemented through PR technologies related to state communications. Studies by many scientists in the world point to the need to implement the strategy of economic security of the state by improving industrial production technologies.

Determining the key factors of strengthening the economic security of the state, empirical confirmation of their impact determine the prospects and directions of economic security management. Research on this issue is relevant as it ensures the implementation of the results from using multidimensional statistical analysis tools in strategic management of the economic security of the state.

2. Literature review and problem statement

The issues related to the theory and methodology of the relationship of factors of industry development, its technological level, and the state of economic security of the country are particularly relevant at present. The influence of factors of industrial development of the country on its socio-economic state has been the object of scientific research since the first industrial revolution. Such studies became especially relevant during the period of sharp structural changes in the national economies of many countries and in the world economy in general.

In work [1], the main tasks in strengthening the economic security of the country include strengthening the competitiveness of national production, the balance of trade advantages, ensuring the advantages of the national economy in world markets, protecting the interests of the state in technological fields. Thus, as early as in the period of industrial technological order, the state and development of the country's industry and its technological level were important for the economic security of the state. However, the cited work does not reflect how technological development affects the economic security of the country. Considering the economic security of the country through a set of factors that form it, a series of empirical studies have shown the importance of technology and innovation for economic development [2, 3]. In particular, paper [2] defines the rating of the countries of the world in terms of their technological potential, the development of which ensures security and strengthens the relevant national economies. Despite important developments and evaluation of new indicators of national technological potential, the authors focused mainly on the nature of technology as determining factors of technological development. In work [3], the distribution of countries by the level of economic development showed its dependence on the level of technological knowledge that is produced and used in the relevant economies. Without denying the importance of those studies, it is determined that in works [2, 3], without the use of a mathematical apparatus, the authors did not define close relationship between technological development and the level of development of the country. The feedback presented in paper [4] suggests that the high innovation and technological development of each country stimulates the productivity of social work and affects the reproduction of human capital. In addition, technological development through disruptive industrial technologies determines the socio-economic and cultural consequences for sustainable development, and, therefore, security [5]. Changes in the social sphere, according to research [6], largely depend on the introduction of reforms of technological levels of production. That is, technology and innovation are considered in a set of key factors of economic security. In addition to existing scientific publications, research in [7] reflects that the high innovative and technological development of each country stimulates the productivity of social labor. That is, the growth of technological development of the country stimulates its strengthening, provides economic security. Thus, the reviewed works confirm an important place in the set of indicators of economic security of technological development of the country. However, they do not demonstrate the strength of the factors under study and their place in the aggregate of factors influencing economic security. While determining among the factors of ensuring the economic security of the country the importance of investment security, work [8] does not define the relationship between the innovative development of the country and its industrial-technological development. In addition, the importance of investment and innovation activity of the state and its industrial enterprises to increase the level of economic security is confirmed by studies [9, 10]. At the same time, while paper [9] determines that the relationship between investments that "... are transformed into innovations and new competitive production...", the authors did not explain what kind of social effect is achieved in the process of such transformations. The need for investment support for the innovative development of the national economy under the conditions of its import dependence is determined by the necessary condition for ensuring

the economic security of the state [10]. However, the connection between technological and innovative development, directions of state support for industrial-technological development as a factor of economic security of the state is not determined. Thus, those studies reflect a set of key factors for strengthening the economic security of the country, among which the growth of technological and innovative potential is decisive. Without denying the importance of those theoretical studies, in the absence of detailed empirical studies, the question of the degree of influence of factors of industrial-technological development on the economic security of the state remained unresolved.

Paper [11] reports a study into the factors of technological development of the country, which contribute to the improvement of its economic security, include innovative information support of production processes. Without denying the right point of view, we can assume that such innovations are generally combined into an indicator "introduction of new technological processes", which is expedient to consider in the system of economic security of the state.

Scientific work [12] testifies to the significance of the impact of economic growth of the state and sectors of the economy on ensuring economic security. However, the main factors of ensuring economic security are the main indicators of economic development of sectors of the economy and its individual social indicators (employment of the population, the level of income of the population), which does not reflect the complete set of factors necessary for taking the factors into consideration.

It should be noted that the experience of different countries indicates a methodical approach to determining the level of economic security approved at the legislative level. Methodological recommendations are based on certain methods of selection of indicators of economic security, taking into consideration the peculiarities of the country [13]. The methodological approach includes a comprehensive system analysis of indicators of economic security of the country with the detection of potential possible threats. The totality of the following threats has been identified: a high level of material and energy consumption of production; reduction of investment and innovation activity and scientific, technical, and technological potential, reduction of research into strategically important areas of innovative development. Therefore, the cited study confirms the importance of the technological level of industrial products, the innovative activity of the country's industry as an important area of economic security, which is a reflection of global sustainable development goals [14]. The proposed option to ensure technological development of the country is the introduction of innovations in industrial production, its equipment, technology and organization, which is given in work [15]. This involves the use of modern decision-making methods for the development of the economy and technologies [16], which could ensure the formation and implementation of a strategy for ensuring the economic security of the state.

An important role in the research of economic security of the state belongs to paper [17]. In particular, the introduction into scientific terminology of the concept of "compliance security" creates opportunities for the research and management of responsible sustainable development of enterprises and the state. However, it is important in managing the sustainable development of the state to reflect the place of industrial-technological development as one of the defining components of the modern world economy.

Most of those studies presented a system of main factors and indicators of economic security, determined the place of technological and innovative development to ensure the strengthening of the state. However, the cited works do not substantiate how the proposed changes would affect the economic security of the state. In addition, the closeness of the impact of the factors under study on economic security, the possibility of its strengthening or weakening have not been determined.

All this allows us to affirm the need to solve a scientific problem, which implies the development of theorical-applied tools for ensuring the industrial-technological development of the country in the system of its economic security.

3. The aim and objectives of the study

The purpose of this authentic research is to substantiate theorical and methodological principles of multidimensional analysis and forecasting of the relationship of indicators of industrial-technological development and the level of economic security. This will make it possible to reasonably approach the definition of a set of parameters of the state policy of managing technological support for industrial development in the economic security system. In particular, the quality of determining the role of technological development of the industry in the context of reducing risks and threats to economic security may be improved.

To accomplish the aim, the following tasks have been set:

– to conduct an analysis of variance of indicators of the industrial-technological development and the level of economic security;

– to determine the relationship of indicators of industrial-technological development with economic security through graphical, analytical, and regression analyses;

– to predict the level of industrial-technological development in the context of the indicator system;

– to expand the system of indicators of economic security assessment taking into consideration aspects of industrial-technological development.

4. The study materials and methods

An important element of this study is the establishment of the relationship of indicators of industrial-technological development and the level of economic security of the state. To identify such a relation, it is advisable to use the method of correlation-regression analysis, which studies the interdependence of factors with a fuzzy relationship. As a result, the search and evaluation of the density of the relationship between the factors is carried out, and a certain dependence between the parameters under study is subsequently established.

To make a forecast of industrial-technological development in the economic security system, we shall use a Holt exponential smoothing method. The advantage of this method is that the forecast can be carried out for a longer period with a small range of initial data, taking into consideration the multifactor complexity of industrial-technological development.

In the proposed algorithm, the values of the level and trend are smoothed using exponential smoothing, and their smoothing parameters are different (1) [18].

$$\begin{cases} \Omega_t = \alpha \cdot Y_1 + (1-\alpha)(\Omega_{t-1} - T_{t-1}), \\ T_t = \beta \cdot (\Omega_1 - \Omega_{t-1}) + (1-\beta) T_{t-1}, \\ Y_{t+p} = \Omega_1 + pT_1, \end{cases} \quad (1)$$

where Ω_t is the forecast value for the current time;

T_t – determining the trend of values;

Y_t – the value of the time series;

Y_{t+p} is the forecast value for t periods in the future.

The first equation characterizes the smoothed series of the general level, the second equation is necessary to evaluate the trend, the third – determines the forecast for p periods of time forward. Smoothing constants in Holt's method ideologically play the same role as a constant in regular exponential smoothing. After selecting a pair, which gives the greatest accuracy of the model on the test set, it is used for real forecasting.

The reported theoretical-methodical model of evaluation of industrial-technological development in the economic security system provides for a comprehensive diagnostic of the level of individual indicators using various research methods. The choice of a method of evaluation depends on the accurate and justified determination of measurements and standards of evaluation, based on a comprehensive assessment of industrial-technological development within the selected ingredients.

To assess the factor impact and interrelationships of the development of industry and economic security of the state, we formed a system of indicators in the context of individual components (Table 1).

Table 1

System of indicators of industrial technological development of the national economy in the system of economic security (compiled by Author)

Designation		Indicator	Influence probability
1		2	3
*M*1		Investment component	
1	N_1	Share of foreign direct investment in GDP, %	Ensuring a positive image of the country on the world stage. Increasing the investment attractiveness of the industry
2	N_2	Growth of foreign direct investment in GDP, %	
3	N_3	Level of investment, %	
4	N_4	Index of economic freedom, EO	
5	N_5	Integrated index of investment favorable business environment, EO	
*M*2		International component	
6	N_6	Openness of the economy, %	Increasing foreign trade flows. Increasing innovative products in commodity exports
7	N_7	The size of Ukraine's economy, % of world GDP	
8.	N_8	Exports of high-tech products, % of total exports	
9	N_9	The share of the leading partner country in total exports of goods, %	
*M*3		Environmental component	
10	N_{10}	Capital investments for environmental protection UAH in GDP, %	Industry orientation to the development of environmentally oriented products and the formation of demand for these products. Stimulation of industrial enterprises to transition to energy-efficient production and the use of alternative energy in production
11	N_{11}	Emissions of pollutants and carbon dioxide into the atmosphere by stationary sources, million tons	
12	N_{12}	The share of renewable energy consumption, %	
13	N_{13}	Share of publications with international cooperation in the field of ecology and environment, %	
*M*4		Educational component	
14	N_{14}	Human Development Index, EO	Shaping the demand for STEM education. Provision of the industrial sector with highly qualified specialists
15	N_{15}	Level of education expenditures to GDP, %	
16	N_{16}	Education level index, EO	
17	N_{17}	Literacy rate of the country's population (expected duration of training), EA	
18	N_{18}	Rating of the national system of higher education, EO	
*M*5		Scientific component	
19	N_{19}	The level of expenditures on scientific and technical work in GDP, %	Formation of demand for science-based knowledge in society. Commercialization of scientific projects. Stimulating the private sector to increase research and development spending
20	N_{20}	Government spending on research and development, % of GDP	
21	N_{21}	The share of scientific and technical work performed in GDP, %	
22	N_{22}	The share of specialists performing scientific and technical work, % of the total number of employees	
23	N_{23}	Private sector spending on research and development, USD	
24	N_{24}	Patent performance, patents per 1,000 employed in research and development	
*M*6		Industrial component	
25	N_{25}	Volumes of sold industrial products, USD	Research and comprehensive market analysis in order to identify and form the demand for industrial products in the national and foreign markets. Creating conditions for increasing the competitiveness and sales of industrial products
26	N_{26}	Share of sold innovative products in the total volume of sold industrial products, %	
27	N_{27}	Volume of gross value added of industry of Ukraine, %	
28	N_{28}	Share of enterprises engaged in innovation in the total number of industrial enterprises, %	
29	N_{29}	The share of enterprises that implemented innovations in the total number of industrial enterprises, %	
30	N_{30}	Industrial production index, %	

Continuation of Table 1

1		2	3
*M*7		Innovation component	
31	N_{31}	Global Competitiveness Index, EO	Increased interest in the introduction of innovations in production. Search for new areas and means of using the potential of industry to develop and promote new products and technologies on this basis
32	N_{32}	Level of financing of innovation activity, % of GDP	
33	N_{33}	Innovative potential, EO	
34	N_{34}	Implemented production of innovative products, units	
35	N_{35}	Effectiveness of innovations, EO	
*M*8		Technological component	
36	N_{36}	The share of high-tech products in the total volume of sold industrial products, %	Stimulation of industry to technological renewal of fixed assets, technology transfer, cluster development, international cooperation, growth of innovative enterprises
37	N_{37}	New technological processes introduced, units	
38	N_{38}	Level of production technology, share of GDP in output, %	
39	N_{39}	Development of technology and knowledge economy, EO	
40	N_{40}	The state of development of clusters, EO	

The generalized system of indicators of industrial-technological development of the national economy is the basis for analysis of variance of key factors of ensuring economic security.

5. Results of studying the industrial-technological development and level of economic security

5. 1. Analysis of variance of the indicators of industrial-technological development and the level of economic security

The dependence of the competitiveness of the state on the development of industry and its ability to modernize and innovate to a greater extent form the policy of industrial-technological development and directions of the policy of ensuring the economic security of the state.

At the same time, there is a need to ensure timely monitoring of relevant trends, which is mostly carried out by state institutions. It is customary to use various procedures that take into consideration both the peculiarities of the national economy and global trends. In particular, in Ukraine, the assessment of the economic security of the state is carried out on the basis of nine components, and industrial and technical development is studied through a set of domestic and globalization characteristics. At the same time, the existing methodology for evaluating the effectiveness of the state policy on industrial-technological development in Ukraine is not enough to identify external and internal threats to economic security.

The correlation-regression analysis of factor traits to detect the density of connection was carried out using the program *R*. Table 2 gives the estimated correlation and determination coefficients in the context of the components of the industrial-technological development of Ukraine.

Table 2

Coefficients of connection density and results from the analysis of variance of indicators of industrial-technological development and the level of economic security of the state

Components of industrial and technological development	Indicator	Correlation coefficient (r)	Determination coefficient (R^2)
1	2	3	4
Investment component, M1	N_1	0.0447	–0.1999
	N_2	0.0419	–0.1497
	N_3	0.6931	0.6317
	N_4	0.1110	–0.0668
	N_5	0.0201	–0.1758
International component, M2	N_6	0.7996	0.7595
	N_7	0.1776	0.0131
	N_8	0.8203	0.7844
	N_9	0.1108	–0.0670
Environmental component, M3	N_{10}	0.0584	–0.1298
	N_{11}	0.0052	–0.1938
	N_{12}	0.3759	0.2511
	N_{13}	0.0821	–0.1015
Educational component, M4	N_{14}	0.1620	–0.0056
	N_{15}	0.4343	0.3211
	N_{16}	0.0132	–0.1842
	N_{17}	0.2703	0.1244
	N_{18}	0.2744	0.1293

Continuation of Table 2

1	2	3	4
Scientific component, M5	N_{19}	0.0607	–0.1272
	N_{20}	0.0095	–0.1886
	N_{21}	0.0722	–0.1134
	N_{22}	0.3166	0.1799
	N_{23}	0.0247	–0.1704
	N_{24}	0.0511	–0.1387
Industrial component, M6	N_{25}	0.1685	0.0022
	N_{26}	0.0103	–0.1877
	N_{27}	0.3472	0.2166
	N_{28}	0.0107	–0.1871
	N_{29}	0.0181	–0.1782
	N_{30}	0.7047	0.6457
Innovation component, M7	N_{31}	0.3206	0.1847
	N_{32}	0.1325	–0.0411
	N_{33}	0.1474	–0.0232
	N_{34}	0.1474	–0.0232
	N_{35}	0.0248	–0.1703
Technological component, M8	N_{36}	0.0103	–0.1877
	N_{37}	0.1847	0.0217
	N_{38}	0.0080	–0.1904
	N_{39}	0.3710	0.2452
	N_{40}	0.4135	0.2962

In the process of calculating the linear correlation coefficient of indicators of industrial-technological development and the level of ensuring economic security, the obtained values made it possible to distinguish four groups of indicators depending on the density of connection.

The following indicators demonstrate a high correlation:

– investment level (N_3);

– openness of the economy (N_6);

– export of high-tech products in total export (N_8);

– industrial products index (N_{30}).

At the same time, the average correlation was found among the following indicators:

– the share of renewable energy consumption (N_{12});

– the level of education expenditures (N_{15});

– the share of specialists performing scientific and technical work (N_{22});

– the volume of gross added value of industry (N_{27});

– Global Competitiveness Index (N_{31});

– the index of technology development and knowledge economy (N_{39});

– cluster development index (N_{40}).

We highlight the indicators for which there is a low correlation, namely:

– index of economic freedom (N_4);

– the size of Ukraine's economy (N_7);

– the share of the leading partner country in the total export of goods (N_9);

– human development index (N_{14});

– patent performance (N_{24});

– the level of financing of innovation activity (N_{32});

– innovative potential (N_{33});

– the number of implemented innovative types of products (N_{34});

– introduction of new technological processes (N_{37}).

It was possible to establish a list of indicators that do not have a correlation, in particular:

– an increase in the foreign direct investment to GDP (N_2);

– the integrated index of investment favorability of business environment (N_5);

– capital investments on environmental protection in GDP (N_{10});

– emissions of pollutants and carbon dioxide into the atmosphere by stationary sources (N_{11});

– the share of publications with international cooperation in the field of ecology and environment (N_{13});

– education level index (N_{16});

– literacy level of the country's population (expected duration of training) (N_{17}).

5. 2. Graphic-analytical and regression analyses of the relationship of indicators of the industrial-technological development with economic security

Given the significant number of variables, to represent the results of the calculation of the pair correlation of variables, a special method for displaying correlations was chosen – a map of correlations using the *corrplot* function in the *R* programming language. Therefore, it is appropriate to determine the close relationship between indicators of industrial and technological development and economic security. Our results of the integrated evaluation would reflect the relationship between the eight components of the industrial-technological development – investment, international, environmental, educational, scientific, industrial, innovation, and technological.

Thus, to construct a correlation map, the component of economic security (Y) is dependent while 11 indicators of industrial-technological development would serve an independent one. The values (high and medium) for the correlation

coefficient over 2013–2019 form an information base and are shown in Fig. 1.

$$Y=\begin{pmatrix}1.039\\0.954\\0.933\\1.018\\1.018\\1.039\\1.039\end{pmatrix}.$$

Thus, it is believed that the decrease in the level of industrial-technological development (in terms of components) affects the decrease in the level of economic security in general.

In the continuation of this seminal study, linear regression models for indicators with high and medium traios were constructed on the basis of estimated coefficients:

– high correlation
$$\begin{cases}Y=27.7600+1.2800\cdot N_3,\\ Y=58.2605-0.7021\cdot N_6,\\ Y=63.8348-2.3437\cdot N_8,\\ Y=21.0350+0.2713\cdot N_{30};\end{cases}$$

– medium correlation
$$\begin{cases}Y=42.4814+1.3319\cdot N_{12},\\ Y=67.9290-3.3330\cdot N_{15},\\ Y=53.5240-9.4820\cdot N_{22},\\ Y=36.4496+0.5093\cdot N_{27},\\ Y=46.3175+0.04220\cdot N_{31},\\ Y=67.5966-0.5772\cdot N_{39},\\ Y=26.4725+0.6171\cdot N_{40}.\end{cases}$$

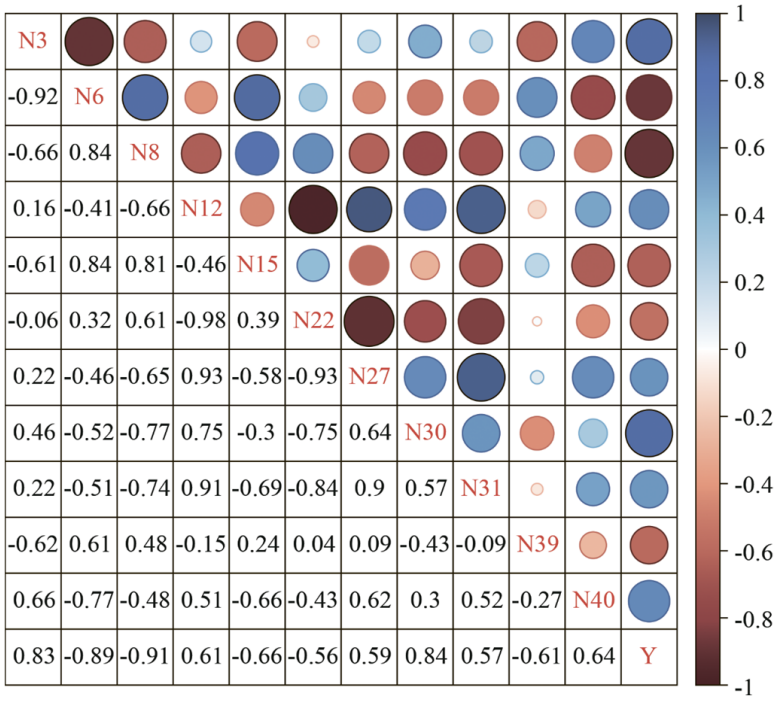

Fig. 1. Correlation map of the relationship of indicators of industrial-technological development with the economic security of the state

Our results determine different levels of interrelationship of indicators of industrial-technological development with economic security. Accordingly, it is possible to reasonably approach the design of technological trends in the context of ensuring industrial development, which makes it possible to achieve an appropriate level of economic security. This is important because as risks and threats increase, it is necessary to have an information and analytical base for proper management of economic security, and, with constant technological changes, it is appropriate to form a model of industrial development design.

5. 3. Forecasting the level of industrial-technological development in the context of the indicator system

It is important to carry out forecasting, which will make it possible to form more qualitative measures of state policy on industrial-technological development of the national economy and avoid risks that could lead to a decrease in the level of economic security of Ukraine.

Forecasting the level of development of industrial-technological development in the context of marketing indicators with high and medium correlation to the level of ensuring economic security was carried out with the help of Holt function and the programming language *R*. The forecast of development level was made for a period of three years at α=0.8, β^*=0.2, and ϕ=0.9. The results of the forecast are given in Tables 3–5 and Fig. 2, 3.

The comparison of Holt models in the export of high-tech products (6.757518) and the openness of the economy (16.61497) indicates a slight increase, although by 2022 the level of investment (13.41187) and the industrial development index (97.37857) will continue to decline.

One should note the preliminary results of forecasting, namely the high dynamics of the openness of the economy, the export of high-tech products, and the index of industrial products. Thus, the openness of the economy increased significantly in 2015 but the lack of resource support did not make it possible to maintain this trend in subsequent years. Evidence of resource constraints in the economy is a rapid decline in exports of high-tech products, although since 2013 the indicator grew rapidly. However, we should expect positive dynamics of indicators in the following years, which is confirmed by the modeling results. Conversely, despite positive changes in the level of investment and the index of industrial products, there will be a deterioration in indicators. As for the index of industrial products, we should expect such changes, because the indicator in recent years is characterized by constant fluctuations. It is more negative to assess the decrease in the level of investment because the indicator since 2015 is characterized by positive dynamics.

In summary, such results indicate the need to develop an effective investment mechanism based on a combination of public and private investment instruments. It is also important to form an effective system of interaction between international and domestic partners participating in investment activities. Of practical importance is the introduction of mechanisms for transforming the interaction of various sectors in the economy, which could become platforms for the implementation of strategic goals of technological development in the industry.

Table 3

Results of forecasting the industrial-technological development in terms of indicators with high correlation for the period to 2022

Year	Investment level, N_3		Openness of the economy, N_6		Export of high-tech products, N_8		Industrial production index, N_{30}	
	Holt method	Damping method	Holt method	Holt damped method	Holt method	Holt damped method	Holt method	Holt damped method
2020	13.35302	14.73314	16.96409	14.75094	6.843206	6.560799	97.06542	98.95488
2021	11.48143	14.03773	19.81248	15.73201	7.181723	6.664335	94.64546	98.12524
2022	9.60984	13.41187	22.66087	16.61497	7.520240	6.757518	92.22550	97.37857
α	0.8		0.8		0.8		0.8	
β*	0.2		0.2		0.2		0.2	
ϕ	–	0.9	–	0.9	–	0.9	–	0.9

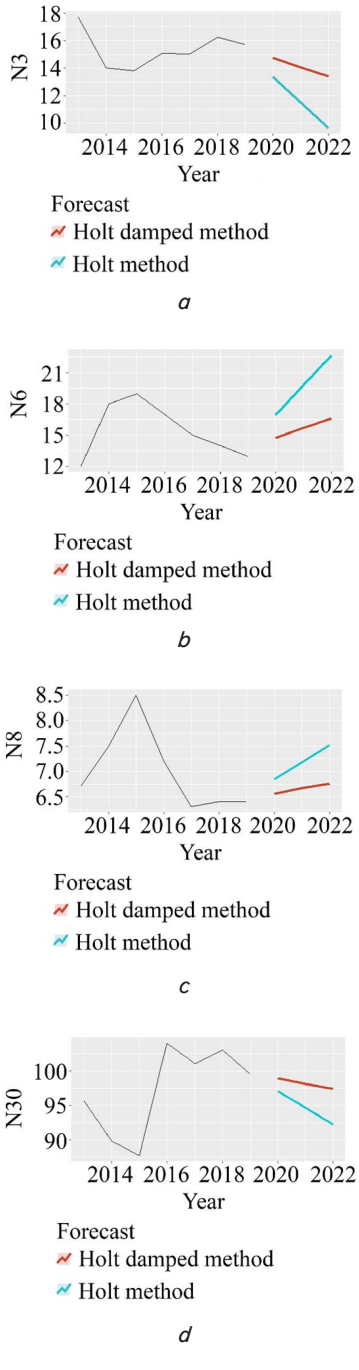

Fig. 2. Forecasting the industrial-technological development in terms of indicators with high correlation to the level of economic security for the period to 2022: *a* — investment level; *b* — openness of the economy; *c* — export of high-tech products; *d* — index of industrial products

Understanding the complexity of the development and implementation of innovative policies requires the development of programs for the creation of technical schools and paid international corporations to train unskilled workers in the field of information technology. It is important to develop and implement strategies for involving multinational organizations in labor training in Ukraine.

Thus, in three years, the projected value would equal 5.143742 for the share of renewable energy consumption, 26.03699 for the gross added value of industry, 66.47696 for the global competitiveness index, 38.83011 for the development of technologies and knowledge economy. The level of education expenditures (5.786700) would remain almost unchanged.

For the most part, among all indicators, previous changes showed their continuation in the future. However, the level of spending on education to GDP, the development of technologies and knowledge economy, as well as the development of clusters, showed other results. Such changes are mainly due to the lack of stable dynamics. While the level of spending on education to GDP from 2013 to 2016 increased, then, in subsequent years, there was a rapid decline in the indicator. Accordingly, the forecast results showed the next wave-like growth. Similar changes are demonstrated by other specified indicators.

Due to the use of tools of multidimensional statistical analysis, coordination of indicators of industrial-technological development and economic security, the impact of a significant number of environmental, technological, and educational-scientific indicators has been differentiated. The densest level of connection was identified for such indicators as investment level, the openness of the economy, export of high-tech products, industrial product index. At the same time, the medium level of correlation was established relative to the following indicators: the share of renewable energy consumption, the volume of gross added value of industry, the global competitiveness index, the state of cluster development. And lastly, the low level of correlation was revealed regarding the financing of innovation activity, innovation potential, the number of innovative productions implemented, and the introduction of new technological processes. The results of forecasting the consequences of the influence of indicators of industrial-technological development on the economic security of Ukraine in the future would make it possible to determine a set of factors (in groups: political, economic, social, technological) for the growth of competitiveness of the state.

Table 4

Results of forecasting the industrial-technological development in terms of indicators with a medium correlation for the period to 2022

Year	The share of renewable energy consumption, N_{12}		The level of expenditures on education to GDP, N_{15}		The share of specialists performing scientific and technical work, N_{22}	
	Holt method	Holt damped method	Holt method	Holt damped method	Holt method	Holt damped method
2020	4.977530	4.958258	5.859682	5.748350	0.4331471	0.4585804
2021	5.104337	5.055881	5.969658	5.768534	0.3843352	0.4332503
2022	5.231144	5.143742	6.079633	5.786700	0.3355233	0.4104533
α	0.8		0.8		0.8	
β*	0.2		0.2		0.2	
ϕ	–	0.9	–	0.9	–	0.9

Table 5

Results of forecasting the industrial-technological development in terms of indicators with high correlation for the period to 2022

Year	The volume of gross added value of industry, N_{27}		Global Competitiveness Index, N_{31}		Development of technologies and knowledge economy, N_{39}		The state of development of clusters, N_{40}	
	Holt method	Holt damped method	Holt method	Holt damped method	Holt method	Holt damped method	Holt method	Holt damped method
2020	25.55449	25.25157	61.99044	60.74872	38.82794	36.61742	34.44287	35.95113
2021	26.26389	25.66495	66.41395	63.76358	41.88438	37.78199	32.64941	35.41219
2022	26.97329	26.03699	70.83746	66.47696	44.94083	38.83011	30.85594	34.92714
α	0.8		0.8		0.8		0.8	
β*	0.2		0.2		0.2		0.2	
ϕ	–	0.9	–	0.9	–	0.9	–	0.9

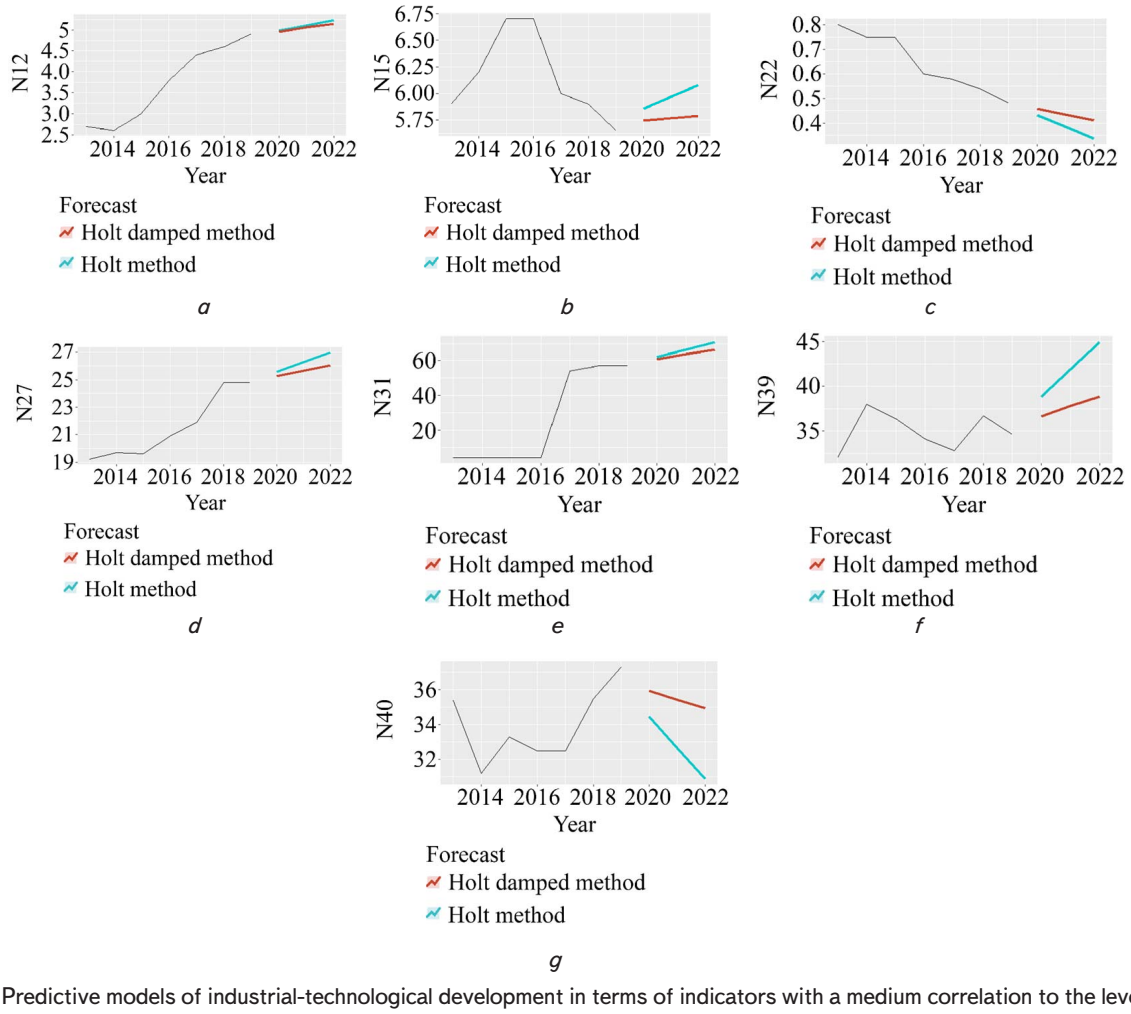

Fig. 3. Predictive models of industrial-technological development in terms of indicators with a medium correlation to the level of economic security for the period to 2022: *a* – share of renewable energy consumption; *b* – the level of education expenditures to GDP; *c* – the share of specialists performing scientific and technical work; *d* – the volume of gross added value of industry; *e* – global competitiveness index; *f* – development of technologies and knowledge economy; *g* – the state of cluster development

5. 4. Extending the system of indicators of economic security assessment taking into consideration aspects of the industrial-technological development

Neglecting to solve the problems of previous years and the lack of effective reforms in the industrial-technological development of the national economy forms a number of threats and risks of ensuring the level of economic security. Our correlation analysis makes it possible to affirm the need to extend the indicator system and include in the system of assessment of the level of economic security, according to the relevant components, such indicators as:

– level of investment (investment and innovation security);

– export of high-tech products in total exports (investment and innovation security);

– the share of renewable energy consumption (energy security);

– the level of education expenditures (social security);

– global competitiveness index (macroeconomic security);

– the development of technologies and knowledge economy (investment and innovation security), the state of cluster development (investment and innovation security) (Table 6).

Table 6

Improved system of indicators of assessment of the level of economic security indicators of industrial-technological development of high and medium level of correlation

Indicators of industrial-technological development	Components of economic security
High correlation indicators	
Level of investment	Investment and innovation security
Export of high-tech products in total exports	Foreign economic security
Medium correlation indicators	
The share of renewable energy consumption	Energy security
The level of expenditure on education	Social security
Global Competitiveness Index	Macroeconomic security
Development of technologies and knowledge economy	Investment and innovation security
The state of development of clusters	

Adding the component of investment and innovation security with marketing indicators will make it possible to evaluate:

– the levels of technology development, knowledge economy and clusters;

– economic freedom, patent productivity, and innovative potential;

– the levels of investment and financing of innovation activities;

– the introduction of new technological processes that will provide conditions for effective state regulation of innovative processes and creation of new economic systems, factors, prerequisites, and conditions for innovative development of the national economy.

Taking into consideration in the foreign economic security the measurement of the volume of exports of high-tech products in general exports and the size of the Ukrainian economy will counteract negative factors of reducing economic security in global markets and ensure sustainable economic development.

Regarding the development of the energy sector, it should be noted that the rapid growth of the share of renewable energy stimulates changes in the calculations of global energy security and generates new incentives for technological development. At the same time, the prerequisite for ensuring a high level of economic security is the level of competitiveness, which led to the inclusion of the global competitiveness index in macroeconomic security indicators. Determining the human development index and the level of education expenditures will make it possible to use the potential of human capital as a factor in strengthening the social security system. Accordingly, this actualizes the problem of developing recommendations for the formation and implementation of state influence measures to increase the level of human capital development. The identified indicators will complement the system of monitoring the level of economic security of the state, and timely monitoring of factors will make it possible to counteract threats and risks of its reduction.

6. Discussion of results of studying the relationship of indicators of industrial-technological development and the level of economic security

Assessment of industrial-technological development and economic security of the state confirms their mutual correlation and dependence in ensuring the required level of each of them. Accordingly, the need to study the impact of industrial-technological development on economic security led to the expediency of combining 40 most representative indicators into seven groups (Table 1). In particular, for each component, we note the following:

– the investment component reflects the level and effectiveness of investment in the country's economy;

– the international component summarizes indicators that reflect the level of international economic activity and its effectiveness;

– the ecological component reflects the direction of industrial enterprises to maintain an adequate environmental level;

– the educational component combines a reflection of the level of education of the nation and the quality of education in the country;

– the scientific component reflects the level of science intensity of industry products through quantitative and cost indicators;

– the industrial component reflects the demand and innovation of domestic industrial products;

– the innovation component summarizes the level of innovation in the country's industry and the demand for such products on the world market;

– the technological component reflects the technological level of industrial production of the country and its products.

The peculiarity of our results is the use of the procedure of multidimensional statistical analysis (Table 2). In the context of studying methodological approaches, it was possible to identify a series of differences that confirmed the practical significance of the chosen method of multidimensional statistical analysis. In particular, the difference from the structural and functional methodology is that the modeling and forecasting of the impact of industrial-technological development processes on ensuring economic security was preceded by ranking of factors of its change in terms of density and direction of influence. The advantage over structural

analysis is the grouping of factors and defining development criteria, identification of both positive aspects and critical shortcomings of industrial development of the national economy. It is thanks to the use of tools of multidimensional statistical analysis, absent in the method of system design, that the coordination of indicators of industrial-technological development and economic security, the influence of indicators – factors of industrial-technological development on the state of economic security of the state is differentiated.

To determine the relationship of indicators of industrial-technological development with economic security, the techniques of graphic-analytical and regression analyses were used. The construction of the correlation map of indicators (Fig. 1) successfully established their interdependence, which made it possible to reasonably approach the forecasting stage.

It is worth noting the different levels of correlation of indicators (high, medium, low), in the context of which it is possible to successfully determine the system of solutions in each direction of technological development in the system of ensuring economic security. In particular, it is possible to more thoroughly determine the timing and scale of the implementation of management decisions in the context of their interdependence.

The increase in the subjectivity of the choice of means of ensuring industrial-technological development and economic security is possible subject to difficulties in the reliability of information sources. Thus, often the collision of economic development consists in the relentless development of false economy (shadow economy). Due to the state of total coverage of all spheres of public relations, the economy is falling apart from the middle, which has a significant negative impact on the economic security of the state.

Ensuring the effectiveness of the state policy of management of industrial-technological development and economic security is appropriate to associate precisely with the level of interrelation of indicators. In particular, in the context of their regression distribution, it is possible to qualitatively determine the need for individual decisions, predictive results of implementation, and the choice of controls.

The obtained predictive values of the level of industrial-technological development in the context of the system of indicators (Tables 3–5, Fig. 2, 3) became a logical continuation of its analysis of variance (Table 2). The revealed advantages of Holt technique (1) made it possible to establish that one of the key method-applied places in the context of the study of management of industrial-technological development in the system of economic security of the state is given to empirical analysis and definition of indicators.

Predictive modeling has significant limitations on the formation of a sufficient information base for a broad consideration of the influence of factors and objective evaluation. The disadvantage of the methodology is the use of criteria, the boundaries of which have different scientific justifications and, accordingly, the obtained conclusions acquire a rather subjective content. This can be seen from the dynamics in the openness of the economy, export of high-tech products, and industrial products index (Fig. 2), as well as the level of expenditures on education to GDP, the development of clusters, technologies, and the knowledge economy (Fig. 3).

As the scientific views were studied, the lack of a unified approach to the choice of indicators of analysis of industrial-technological development and the level of economic security was revealed. Accordingly, it was possible to develop a new analytical approach, which involves expanding the set of evaluation criteria; this makes it possible to strengthen the validity of scientific assumptions, to develop a wider set of means and tools to ensure industrial-technological development and economic security of the state (Table 6). At the same time, there may be difficulties in justifying the limits of the proposed assessment indicators, their correlation relations, and the need to take into consideration the directions for reducing the impact of risks and threats on the level of economic security of the state in general.

7. Conclusions

1. A methodical toolset of the analysis of variance was used to form a set of indicators of industrial-technological development and the level of economic security of the state. As a result of our analytical calculations, the correlation levels between the relevant indicators have been determined, in particular:

– the densest – the level of investment, openness of the economy, export of high-tech products, industrial product index;

– medium – the share of renewable energy consumption, level of education expenditures, share of specialists performing scientific and technical work, the volumes of gross added value of industry, global competitiveness index, the development of technologies and knowledge economy, the state of development of clusters;

– low – the index of economic freedom, GDP, share of the partner country in the total export volume, human development index, patent productivity, financing of innovation activities, innovation potential, the development of production of innovative products, the introduction of technological processes.

The correlation of indicators forms a set of strategic assumptions about the likelihood of successful industrial-technological development and strengthening economic security. In compliance with the relevant recommendations, the quality of design of technological weapons of industrial operations and the use of progressive resource opportunities for maintaining a sufficient level of economic security are enhanced.

2. The graphic-analytical and regression analyses of the relationship of indicators of industrial-technological development and economic security have made it possible to determine its dependence on the development of knowledge economy, the quantity and quality of research and development, the level of human capital of the state. Thus, a correlation map was built, the use of which simplifies the procedures for choosing priority areas for ensuring industrial-technological development in the context of which it is possible to improve the quality of economic security management. According to this scheme, it is possible to more effectively develop a system of management decisions, in which all contradictions can be adjusted as the selection of indicators changes.

3. Due to the forecasting of the impact of indicators of marketing support to industrial-technological development on the economic security of Ukraine, a set of factors has been determined (in groups: political, economic, social, technological), the impact on which makes it possible to achieve the following positive changes in the greatest extent:

– to increase investment volumes and strengthen the openness of the economy;

– to increase the volume and share of high-tech exports;
– to ensure the growth of production and sales of competitive products of industry.

The obtained forecast estimates can be widely used in the development and implementation of the state policy of industrial-technological development, which ensures the economic security of the state. In addition, such results should be considered as strategic benchmarks in the design of macroeconomic changes in the system of achieving a sufficient degree of industrial-technological development and economic security.

4. In the context of expanding the system of indicators for assessing the economic security of the state, it is taken into consideration that the introduction of new technologies affects the growth of economic security of the state with an equal level of industrial development in different ways. Therefore, states with lower levels of development need more investment to strengthen their own economic security by increasing the technological level of industry. The set of indicators in subsequent periods may also change, because the development of technologies is a highly dynamic process and threats and risks of economic security are constantly increasing.

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