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ENSURING SECURITY OF ECONOMIC AND INFORMATIONAL INTERESTS OF MINING ENTERPRISES TAKING INTO ACCOUNT INNOVATIVE TECHNOLOGICAL TRENDS

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It was revealed that mining enterprises are poorly focused on rapid introduction of innovative technologies and developments in line with modern technological trends. Conceptual approach to ensuring the security of economic and informational enterprises` interests with innovative technological trends has been developed. Developed approach, in contrast to existing ones, makes it possible to determine directions of ensuring security in current period from perspective of future. It has been substantiated that proposed approach has high scientific explanatory potential for revealing substantive factors that determine current and desired enterprises` economic and informational interests' security state. Highlighting security of economic and informational interests as component which is one of the first is responding to integration of innovation and technology degree will help to improve entire enterprise`s economic security ensuring quality. It is proposed to use ratio indicator of IT capital value to sum of fixed and intangible assets as indicator of security state of enterprise`s economic and informational interests. Verification of this indicator has been implemented. It is shown that automation of verification makes it possible to exclude subjective decision factor. On basis of verified indicator, state of economic and informational interest's security of mining enterprises was assessed. The value obtained at PrJSC Northern GZK is 1, which corresponds to very high security state. Estimated values at all enterprises in sample are 0 and so they correspond to catastrophic security state. Obtained results are important, since they allow to reasonably make management decisions regarding the directions of ensuring the economic and informational interests security of mining enterprises on basis of IT capital value increasing

Keywords: security, economic and informational interests, innovative technological trends, IT capital, robotization

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1. Introduction

The key trends in development of both the world economy in general and the mining industry in particular cause turbulent changes in external environment of enterprises. It should be emphasized that taking into account modern technological trends no longer acts only as means of enterprise`s efficiency increasing and gaining competitive advantages. At present, taking into account these trends acquires, in our opinion, the imperative status from the standpoint of possibility of maintaining (achieving the desired) state in future as the individual components of economic security of the enterprise and it as a whole.

Ensuring the desired security state of economic and information enterprise interests should be based on the awareness of future business enterprise environment parameters. At the same time, it is expedient to structure the uncertainty of external environment on basis of the innovative technological trends. The results of such the analysis should form management actions set for the strategic alignment of the enterprise. Strategic alignment is an effective tool for shaping all components of the enterprise business strategy in accordance with the future environment context.

At the same time, the modern economic research has a wide range of the methods and approaches to enterprise economic security assessing. In addition, in professional economic literature there is a variety not only of the author's approaches, but also the interpretation of evaluation results: some scientists differentiate its levels, and others – states [1]. At the same time, one of the aspects of adequate assessment of the economic security of a modern enterprise is to take into account its procedural activities in terms of resource use maximum efficiency. This is possible if the indicator of security assessment of economic and information interests has one of the properties of the single system-based efficiency indicator. The economic and information interests' security assessment indicator should also be systematically substantiated.

In turn, the system validity involves the verification of indicator in relation to the presence in its mathematical model of certain properties in order to provide this indicator adequate presentation of information on changes in the factors influencing the enterprise procedural activities. In particular, such properties may be the sensitivity of mathematical model to changes in the environmental factors, internal conditions, operations time, prediction of the operation potential effect and more.

Thus, the turbulence of the enterprises external environment highlights the need to develop a conceptual approach to ensuring of their economic and information interests security, which are allowed to support innovative technological trends.

2. Literature review and problem statement

Among the global trends already widely described in scientific literature is the trend of total digitization [2]. It should be understood that the experts of industrial enterprises point to the "digitalization" and "digital transformation" concepts dissimilarity. Thus, the first of them means point improvements due to the latest technologies local use. The second concept is characterized as a complex change of business processes based on the opportunities provided by these technologies. Instead, the transformation is seen in integration into a single network of entire production chain – from the raw material extraction to interaction with the final consumer. In any case, the technologies underlying digital transformation (digitization) represent a very broad field of interdisciplinary researches.

Regarding the consideration of the external environment opportunities, which arise under the influence of innovative technological trends in ensuring the security of economic and information enterprises interests, it is necessary to point out the fragmentary nature of existing approaches. This fragmentation is manifested in the fact that the approaches by which to take into account individual capabilities of the external environment do not allow to combine operational and strategic levels of this security. Instead, approaches to strategic security do not include tools to take into account future environmental parameters in the current period. Thus, the author of [3] focuses on resource potential determining and consistency of interests of all participants within the enterprise, in which threats of internal and external nature will be minimized. At the same time, the omission of approach under consideration is the failure to take into account the opportunities provided by the external environment and, accordingly, lack of the ways to implement them in the developed model. An option to overcome above the omission could be the approach outlined in [4], according to which security can be built on processes that reflect its essence. Since the essence of security is not limited to protective context, this approach could take into account at least the possibilities of the most rational resources use. However, in [4] the safety essence and its assessment are reduced to indicator approach, which does not take into account either the capabilities of the external environment or the studied enterprise prognostic capabilities. Therefore, an approach that would take into account the outlined aspects should be complex. In this context, it is worth paying attention to the four-stage methodology described in [5]. Its advantage is the presence of analysis stage of strategic and tactical decision-making processes. However, this technique does not allow to take into account future environmental parameters in the current period. In addition, all stages are based on subjective judgments, because the method does not use verified criteria, the assessment adequacy of which must be checked automatically.

In [6], the components of economic security system are included autonomous blocks, which are responsible, among other things, for the external environment influence, resource provision, management functions quality, and so on. However, the selected blocks are responsible for solving only those tasks that are currently set [6]. Therefore, the approach in [6] neutralizes the potential of strategic alignment in ensuring the desired state of security, which takes into account innovative trends and the corresponding future parameters of the external environment. In addition, it is not explained exactly how the safety assessment indicators are selected and whether the selected indicators are verified.

One of the first components of economic security, which responds to the introduction of innovative developments (equipment, technologies) is the security of economic and information enterprise interests. The traditional understanding of information security involves mainly assessing of the information space protection degree, computer systems and information technology [7–9], as well as the effectiveness of countering cyberattacks [1, 10, 11]. It is significant that the existing indicators of information security do not take into account the very presence of information systems and technologies in enterprise, and degree of their compliance with modern innovation trends. The analysis of professional literature, in particular [10–12] allows to differentiate the existing indicators of these security types into the following groups of indicators:

– they are technical: special protection codes, programs, etc.;

– they are economic, which mainly relate to the costs amount incurred for protection against unauthorized access, ensuring uninterrupted operation, etc.;

– they are mixed, which include both technical and economic indicators.

Existing economic indicators are controversial, because modern information and intelligence systems are more reliable, and so they require lower costs for protection and maintenance. Without denying the importance of these areas of protection, let's note that it is advisable to distinguish between the security of the information system and the information space of the enterprise and the security of its economic and information interests. Both types of security are closely related. However, their content is different. Therefore, if the first type (security of information system and information space) is embodied mainly in technical characteristics and cost indicators, the second type – it is advisable to consider in the context of IT capital increasing. The concept of IT capital as an indicator that includes the cost of software, hardware, etc. is disclosed in [13]. Therefore, let's propose to choose ratio of the IT capital value to the total fixed assets and intangible assets as an indicator of economic and information interests' security of enterprise.

As IT capital is characterized by high obsolescence, the most secure among the competing companies will be those that can update it more quickly. Therefore, the need to estimate the time after which the amount of IT capital available to company at current moment, will reach a certain threshold.

Regarding the assessment of the information security level, the time is practically not used in relevant methods. It is used only in some indicators, for example, as scientists have done in determining of software security coefficient (*Cs*) [12]:

$$Cs = \frac{Tu}{Tr}, \qquad (1)$$

where *Tu* – the time of uninterrupted operation of corporate information system, h; *Tr* – normative time of corporate information system functioning, h.

Without excluding the importance of taking into account the time of uninterrupted operation of corporate system, it should be noted that this approach to the assessment of information security is somewhat limited. Thus, the approach does not take into account other components of IT capital, there are no elements of benchmarking analysis. The latter becomes extremely important in a competitive market environment, when industry leaders not only have a competitive advantage, but also are able to oust other companies from the market. The existence of threat of displacement or reduction of market share makes other enterprises more unprotected, which increases the need to ensure their security.

Indirectly, the time category is also used in determining the ratio of staff experience, which ensures the information security of the enterprise [12]:

$$C_{\exp} = \frac{NE1}{NE_T}, \qquad (2)$$

where $C_{\exp}$ – the coefficient of staff experience that provides enterprise information security, the share of units; *NE*1 – the number of employees who have access to trade secrets and work at the company for more than one year, persons; NE_T – the total number of employees who have access to trade secrets, persons.

However, the use of the staff experience ratio ($C_{\exp}$) can't be used as an independent indicator of information security assessment, but only as an auxiliary indicator.

At the same time, in the economic professional literature on safety there are no studies of indicators` verification of security assessment of economic and information enterprise interests [7]. There are many types of criteria for different areas of security, which further form the economic enterprise security. However, as stated in the relevant sources, such as security criteria for computer systems [8], security criteria for information technology [9], as well as the functioning of industrial control systems [10], do not pass a systematic justification in solving applied problems.

In turn, there are already studies concerning to development of verification methods, which are developed on the basis of operations models. The method allows to choose the indicator as criterion of matching the results of the managed systems procedural activities with owner`s cybernetic and economic purpose [14].

Cybernetic goal, which allows to maximize the capabilities of the enterprise through the efficient use of system limited resources, is the key to achieving the economic goal – the profit maximization. Intensive steps in this direction have also been taken in the field of software development [14]. The choice of the reasonable criterion as a guide to effective operation, allows to make effective decisions at all stages of the enterprise`s life cycle and, thus, to ensure a high level of security.

The authors of [14] proposed a method of formal verification of evaluation indicators for their possibility of use as a criterion for optimization of managed systems based on a general system operation simple model. But this method was not demonstrated in the verification of economic security assessment indicators. Also, the procedure of verification by the method of verification of evaluation indicators does not take into account operations with time-distributed input and output parameters. This type of operation is very common in enterprises with periodic operating processes, which also have a direct impact on the level of economic security. And as further stated in [15], the advantage of formal type of procedure is the implementation of test of the object (evaluation indicator), which is performed for all possible types. Only under the conditions of the prescribed rules on the possibility of passing the procedure of indicator`s verification, the presence of standard for comparison [16], the described properties invented as a result of testing, it is allowed to consider the verification finished [17].

The study [18] proposed a method that involves the formation of operations in classes according to certain rules. The essence of the method is that a comparative evaluation of the operation of a certain class using an indicator that is tested reveals a certain property of this indicator, respectively. Since the formation of models is implemented according to the cybernetic-economic approach, in this paper it is proposed to take the method as a basis for checking the security status of economic and information interests. The principle of operation of the method is also presented in this study.

The above suggests that it is appropriate to conduct a study on the development of a scientific approach to ensuring the security of economic and information interests of the enterprise, taking into account innovative technological trends, which would be based on the verified indicator of security.

3. The aim and objectives of research

The aim of research is to develop a conceptual approach to ensuring the security of economic and information interests of mining companies, taking into account innovative technological trends. This will provide an opportunity to determine the directions of this security in the current period from the standpoint of the future.

To achieve this aim the following objectives are set:

– to develop a procedure to ensure the security of economic and information interests of the enterprise, taking into account innovative technological trends, combining operational and strategic levels;

– to verify the indicator of assessment of the state of security of economic and information interests of the enterprise and to carry out its approbation at the mining enterprises of Ukraine.

4. Materials and methods of research to ensure the security of economic and information interests of the enterprise, taking into account innovative technological trends

The theoretical and methodological basis of the study is formed by the scientific works of leading scientists on safety. The information base of such studies made it possible to identify omissions related to the fragmentary approaches to take into account innovative technological trends in the implementation of measures to ensure the security of economic and information interests of enterprises.

The study used general and special methods: abstract-logical and comparative analysis, synthesis – in the study of the nature and role of innovative technological trends in the activities of the mining enterprise; grouping, systematization – when grouping promising technologies in accordance with the main production processes of mining enterprises; system-structural method, methods of induction, deduction and logical generalizations – when developing a scheme of influence of innovative technological trends on improving the security of economic and information interests of enterprises; when developing a procedure for ensuring the security of economic and information interests of the enterprise, taking into account innovative technological trends, which combines operational and strategic levels; tabular method – to visualize the results of assessing the security of economic and information interests of enterprises; graphic method – for a schematic representation of the proposed developments; method of expert assessment – to develop a scale of differentiation of safety conditions; statistical analysis – to construct trend equations in order to determine the period during which the actual values of the safety indicator will reach the threshold value; methods of empirical research (observation, comparison, measurement), methods used at theoretical and empirical levels (analysis, synthesis, induction, deduction), methods of system analysis, mathematical methods of operations research, cybernetic-mathematical methods and applied models were used for verification, optimal planning – to develop classes of models and the operation models themselves, to determine local criteria for evaluating models of one class, to substantiate the reliability of the verification method by itself.

The study takes into account the lack of unity of views of scientists in the perception of the subject of safety assessment is the state or its level. Let's Note that traditionally the level of security is characterized by a retrospective slice of certain, well-founded indicators. It is possible to say that the level of security is a given and a fixed fact. In contrast, the state of security is determined by a set of circumstances and conditions in which the company is in view of the available resources, reserves and processes. The state of safety reflects the possibility of restoring its necessary (basic) properties, taking into account the time required for this and the trends in the enterprise. It is the state of security of economic and information interests that shows whether the enterprise will be able to change the achieved level of this security "on its own" and after what time. If the calculated amount of time is unacceptable and characterizes, for example, the unsatisfactory state of security of the enterprise, it indicates the need for appropriate management influences [19]. This approach is considered the most relevant for use in the work.

The question of renewal of fixed assets at mining enterprises is formed to a greater extent on the basis of the degree of their physical operation. In this case, the accounting for depreciation is carried out mainly during the selection of fixed assets (intangible assets) of a newer generation in the existing range of relevant assets. However, taking into account innovative technological trends involves the introduction of fundamentally new, state-of-the-art developments and technologies. They give additional effects in the form of cost reduction, improving product quality, increasing competitiveness, etc., which together contribute to strengthening economic security. Accordingly, enterprises with backward technical and technological base, outdated production and management technologies will become not only less competitive. In this case, failure to take into account these technologies and developments threatens the market share of enterprises in particular and in the future safe operation in general. Therefore, the company that will take into account innovative technological trends faster than competitors will be more secure. In this regard, the most adequate indicator that will characterize the period required for the company to achieve the degree of implementation of innovative technologies and developments at the level of industry leader is the indicator of safety, assessed on the basis of time. This indicator is the safety status indicator proposed in [19]:

$$C_i = 1 - \frac{TO_i}{TO_{cl}}, \quad (3)$$

where C_i – security status, parts; TO_i – the number of quarters required to achieve the actual value of the indicator of the set threshold value, quarters; TO_{cl} – the average duration of the economic cycle (in particular, 12 quarters for the Kitchin cycle), quarters.

The number of quarters required to achieve the actual value of the indicator set threshold can be determined by various methods. Such methods include forecasting (extrapolation of existing trends), expert surveys, etc. An approach is chosen for the research, according to which the equations of trends are built and on their basis the required period of time is determined. In this case, if TO_i exceeds 12 quarters, the condition is accepted that TO_i=12. In the calculations it is advisable to separately show the period of reaching the threshold value and the so-called number of quarters, taking into account the cycle. The last period is a value corresponding to 12 quarters. The choice of Kitchin's cycle is due to the fact that the state of safety must be achieved by the company during one business cycle, because after each "peak" over time comes the "bottom", and vice versa. In this regard, the achieved state of safety should not only allow the company to survive the phase of recession and bottom, but also provide it with the maximum use of opportunities in the phases of rise and peak. To this end, it is advisable to compare the period of time that the company will need to achieve the desired (best) state with the duration of the business cycle. It should be emphasized that forecasting the exact beginning and end of the economic cycle is complicated and depends on many factors, including the specifics of the industry. Therefore, it seems appropriate to consider the average value of the business cycle for all industries (12 quarters) [19].

To interpret the obtained values, it is advisable to use a scale determined by the expert method. The experts were employees of the safety department of the Kryvbas mining and processing plants. The result is the following differentiation of security conditions:

– C_i=0 – zero (catastrophic) state of safety;
– $0<i<0.25$ – minimum state of safety;
– $0.25 \leq C_i < 0.5$ – low safety rank;
– $0.5 \leq C_i < 0.75$ – average state of safety;
– $0.75 \leq C_i < 1.0$ – high state of safety;
– C_i=1.0 – very high state of safety.

Let's emphasize that in this way it is advisable to assess the state of economic security, as well as any of its components. This indicator is especially relevant for assessing the security of economic and information interests. Because not only its efficiency, competitiveness, but also the market share and the very existence in the market depend on how quickly the company will implement the latest technologies and modern IT tools.

Based on the data of financial statements and management accounting of Ukrainian mining enterprises – objects of study, the share of IT capital in the amount of fixed assets and intangible assets is determined (Table 1).

Each operation at the enterprise affects both its economic security in general and its individual components [18, 20, 21]. To study the adequacy of the results for the indicator of assessment of the security of economic and information interests of mining enterprises, it is proposed to use the method of verification, on the basis of which the information technology of verification is developed [14]. The indicator has a structure that meets the requirements for passing the test by this method. The verification algorithm involves the introduction of a mathematical model that is being tested in information technology and developed a verification application [18]. Next, according to the mathematical model, the application evaluates the models of operations, the classes of which are generated automatically according to the developed rules of information technology. The principle of formation of operations in each class is given in Table 2.

Table 1

Initial data on the amount of IT capital, fixed assets and intangible assets of Ukrainian mining companies

Indicator	Amounts, thousand UAH					
	2014	2015	2016	2017	2018	2019
PrJSC Northern GZK						
IT capital value amount	109,618	125,686	116,780	142,979	158,432	140,120
Fixed assets amount	13,685,846	15,304,822	13,712,130	16,353,088	18,070,873	15,807,338
Amount of intangible assets	16,396	22,680	26,682	272,326	287,448	298,369
Share of IT capital in amount of fixed assets and intangible assets	0.80 %	0.82 %	0.85 %	0.86 %	0.863 %	0.870 %
PrJSC Central GZK						
IT capital value amount	19,419	21,228	32,705	38,697	50,105	55,400
Fixed assets amount	3,084,268	3,317,846	5,094,971	5,965,325	7,714,793	8,446,581
Amount of intangible assets	47,794	51,690	55,425	81,101	89,742	76,440
Share of IT capital in amount of fixed assets and intangible assets	0.62 %	0.63 %	0.635 %	0.64 %	0.642 %	0.650 %
PrJSC InGZK						
IT capital value amount	27,273	36,543	37,433	44,351	52,810	53,959
Fixed assets amount	9,066,808	11,390,999	11,485,051	13,267,933	15,776,876	15,225,083
Amount of intangible assets	24,337	28,800	32,880	171,856	177,938	191,802
Share of IT capital in amount of fixed assets and intangible assets	0.30 %	0.32 %	0.325 %	0.33 %	0.33 %	0.350 %
JSC Southern GZK						
IT capital value amount	9,285	10,644	13,075	14,813	18,054	22,279
Fixed assets amount	4,627,776	4,816,787	5,528,742	6,275,398	7,611,783	9,304,805
Amount of intangible assets	14,557	21,536	156,086	165,227	170,301	175,447
Share of IT capital in amount of fixed assets and intangible assets	0.20 %	0.22 %	0.23 %	0.23 %	0.23 %	0.235 %
PrJSC Poltava GZK						
IT capital value amount	33,957	38,873	41,540	46,688	51,213	85,907
Fixed assets amount	9,565,518	10,648,032	11,070,906	12,051,245	13,165,416	21,739,560
Amount of intangible assets	136,461	150,018	156,036	235,195	241,106	287,904
Share of IT capital in amount of fixed assets and intangible assets	0.35 %	0.36 %	0.37 %	0.38 %	0.382 %	0.39 %
PrJSC Suha Balka						
IT capital value amount	9,714	10,759	10,859	11,367	11,537	12,497
Fixed assets amount	3,234,080	3,355,650	3,386,598	3,429,260	3,531,321	3,643,672
Amount of intangible assets	3,779	6,600	6,719	15,152	18,449	31,784
Share of IT capital in amount of fixed assets and intangible assets	0.30 %	0.32 %	0.32 %	0.33 %	0.33 %	0.34 %
PJSC Kryvyi Rih iron ore plant						
IT capital value amount	7,299	8,337	9,385	10,606	11,221	13,051
Fixed assets amount	7,295,897	7,574,744	7,816,267	8,153,616	8,545,361	9,235,166
Amount of intangible assets	3,409	3,962	4,153	5,144	86,079	86,895
Share of IT capital in amount of fixed assets and intangible assets	0.10 %	0.11 %	0.12 %	0.13 %	0.13 %	0.14 %
PrJSC Zaporizhzhia iron ore plant						
IT capital value amount	1,644	6,049	6,344	6,944	8,267	8,537
Fixed assets amount	32,66,607	11,180,191	11,477,956	12,343,842	14,445,375	14,660,154
Amount of intangible assets	21,146	22,364	56,118	57,001	58,416	58,684
Share of IT capital in amount of fixed assets and intangible assets	0.050 %	0.054 %	0.055 %	0.056 %	0.057 %	0.058 %

Source: information is processed on basis of data of financial statements and management accounting of PrJSC Northern GZK, PrJSC Central GZK, PrJSC InGZK, JSC Southern GZK, PrJSC Poltava GZK, PrJSC Suha Balka, PJSC Kryvyi Rih iron ore plant, PrJSC Zaporizhzhia iron ore plant

Table 2

Principles of formation of operations models for each class

Class	Input data	Principles of model formation	Local criteria of economic security
1	IRE_x, TO_x, k_x, $\{IRE_x;TO_x\}\in Q^+$, $k_x\in(1;2]$, where *IRE* is indicator of operation input parameters value, *TO* – is operation time, IPE is operation output products cost	$IRE_y=IRE_x$; $TO_y=TO_x$; $IPE_x>IRE_x$; $IPE_y>IRE_y$; $IPE_x=(k_x+1)\cdot IRE_x$; $k_x\neq k_y$; $IPE_y=(k_y+1)\cdot IRE_x=(k_y+1)\cdot IRE_y$	*IPE, AOE, k* – operation equalization ratio
2	IRE_x, TO_x, k_x, $\{IRE_x;TO_x\}\in Q^+$, $k_x\in(1;2]$,	$k_y=k_x$; $IRE_y=IRE_x$; $TO_y\neq TO_x$; $IPE_x>IRE_x$; $IPE_y>IRE_y$; $IPE_x=(k_x+1)\cdot IRE_x$; $IPE_y=(k_y+1)\cdot IRE_y$	*TO*
3	IRE_x, TO_x, k_x, $\{IRE_x;TO_x\}\in Q^+$, $k_x\in(1;2]$,	$IRE_y\neq IRE_x$; $TO_y=TO_x$; $IPE_y=IPE_x$; $IPE_x>IRE_x$; $IPE_y>IRE_y$; $IPE_x=(k_x+1)\cdot IRE_x$; $k_x\neq k_y$; $k_y=\frac{IPE_y-IRE_y}{IRE_y}$	*IRE, AOE, k*
4	IRE_x, TO_x, k_x, $\{IRE_x;TO_x\}\in Q^+$, $k_x\in(1;2]$,	$IRE_y\neq IRE_x$; $TO_y=TO_x$; $IPE_y\neq IPE_x$; $IPE_x>IRE_x$; $IPE_y>IRE_y$; $k_x\neq k_y$	*k*
5	IRE_x, TO_x, k_x, n=0.5, $\{IRE_x;TO_x\}\in Q^+$, $k_x\in(1;2]$,	$IRE_y\neq IRE_x$; $TO_y=n\cdot TO_x$; $IPE_x>IRE_x$; $IPE_x=(k_x+1)\cdot IRE_x$; $IPE_y\neq IRE_x$; $IPE_y=2\cdot IRE_x\cdot(k_x+1)$	$\begin{cases}AOE(x),\\ AME_+(\tilde{y})\end{cases}$
6	IRE_x, TO_x, k_x, $n\in N$, $\{IRE_x;TO_x\}\in Q^+$, $k_x\in(1;2]$,	$IRE_y=n\cdot IRE_x$; $TO_x>0$; $TO_y=TO_x$; $k_y=k_x$; $IRE_x>0$; $IPE_x>IRE_x$; $IPE_x=IRE_x\cdot(k_x+1)$; $IPE_y\neq IRE_x$; $IPE_y=n\cdot IRE_x\cdot(k_x+1)=IRE_y\cdot(k_y+1)$	–

Source: developed by the authors in works [14, 18]

Thus, the information technology of verification of evaluation indicators consists of a verification method, a knowledge base with rules for forming operation models for each class, a testing algorithm and an application for automatic implementation of the evaluation procedure.

The results of evaluation of pairs of formed models of operations for each class using the tested indicator are compared with the results of calculations of similar models of operations according to local criteria. Namely, the obtained calculated values according to local criteria for each operation determine the rating place of the efficiency of the operation of the class. The comparison of intra-class ranking according to local criteria and according to the indicator of security of economic and information interests is carried out. If the ratings are the same for all classes, the characteristics of the results of the consistency of the comparison are displayed on the screen [18].

Successful completion of the verification procedure is achieved if the results of the rating assessment of transaction models using the tested indicator of economic security assessment, completely coincide with the results of assessments obtained using local criteria.

Thus, each verification step can identify the presence of a certain property. For example, in the first class the sensitivity of the indicator to the change in the cost of operations by changing the input parameters is determined, the second class shows the sensitivity of the indicator to the change in the cost of the output parameters of the operation. In the third class the sensitivity of the indicator to the time factor is revealed, the fourth class reveals the nature of the relativity of the indicator. In the fifth and sixth grades, the availability of prognostic capabilities and the ability to evaluate equally effective operations, respectively, are tested.

5. The results of developing a conceptual approach to ensuring the security of economic and information interests, taking into account technological trends

5. 1. The results of the development of the procedure for ensuring the security of economic and information interests of the enterprise, taking into account innovative technological trends

Increasing the use of robotic and unmanned equipment – robotics – is one of the key modern global innovation trends. In particular, China is implementing a ten-year plan “Made in China 2025”, which aims to upgrade the country’s production base and focus on ten high-tech industries, including robotics. The Chinese government has taken steps to bring the country to the global market by providing tax breaks and subsidies for robotics startups. According to the government’s plan, in 2020 China is scheduled to produce 150 thousand robots, and by 2030 this figure should be 400 thousand.

The modern perception of the term “robot” is characterized by at least three positions: as a manipulator, as a software product, as well as autonomous (unmanned) transport. Examples of developments and technologies that meet the trend of robotics are the use of drones to assess the state of mining in quarries and the application of refractory coatings, the use of unmanned crane and other equipment under the control of artificial intelligence, and so on. The introduction of such developments and technologies creates significant opportunities for improving production efficiency and industrial safety. Major Brazilian mining companies, including VALE S.A. For more than a year now, they have been using not only robotic equipment, but also GPS reconnaissance and three-dimensional scanning. At the production stage, the basis of the latest technologies is remote control of equipment in quarries and automation of mining processes.

These areas will allow to move to unmanned production on the M2M system (machine-to-machine). The transfer of information to a single operations center allows to control all activities in real time (blasting, excavation, transport) [22]. Experts note that the use of robotic dump trucks with a predetermined route (for example, Caterpillar) can reduce fuel consumption, increase productivity and safety. Unmanned trucks at iron ore mines in Australia are actively used by BHP Billiton. The Australian-British company Rio Tinto began the transition to a fully digital autonomous ore mining and supply system thirteen years ago (the first project in 2008 was Mine of the Future). In mines in Australia, the company has gradually installed an automated drilling system (ADS), which allowed the operator to remotely use a single console to simultaneously control multiple rigs. RioTinto employs 73 robotic trucks in Australia, which receive raw materials from robotic drilling rigs and transport them to trains; robotic trains have been used since 2017. At the beginning of 2021, the company is the world's largest owner and operator of autonomous transport systems, as it uses about 140 autonomous trucks, which are controlled from a central controller. For comparison: the plans of the Eristivsky Mining and Processing Plant (Ukraine) introduce only 6 units of fully robotic trucks by the end of 2021.

Taking into account innovative technological trends in the mining industry provokes the emergence of so-called "smart (intellectual) quarries" and "smart mines". In particular, the leading aspects of the functioning of the "smart career" of world leaders in the mining industry are the following areas:

– robotic transportation by dump trucks of rock mass on a fixed route between stationary loading points – unloading in the automatically programmed mode;

– robotic transportation in the autonomous mode by dump trucks of rock mass between the robotic excavators and unloading points with equipment of their equipment with remote control;

– robotic transportation by dump trucks of rock mass in accordance with the developed software without the participation of the operator [23].

It is important to emphasize that the presence of robotic transport equipment allows to set the most rational speed, which provides an increase in productivity and rhythm of production. In turn, these indicators are some parameters of economic security, the improvement of which is an important element of economic security of the enterprise.

The automatic mode of movement of robotic dump trucks actualizes the need to ensure compliance with stricter requirements for the parameters of quarry roads. To do this, it is necessary to improve the quality of the road surface, reduce irregularities in the vertical plane of the road, eliminate sharp turns and so on. Accordingly, the role of digital road models is growing. Moreover, digital models, in principle, allow real-time data copies of existing production with the participation of machinery, mining equipment and employees. At the same time, digitalization affected not only the digitization of equipment, but also mineral deposits, mining facilities (quarries, dumps, adjacent areas), utilities and communications, infrastructure facilities, mines and more.

In this context, it should be noted that the leading foreign enterprises in the mining industry are already widely used technologies for 3D modeling of mine workings and 3D scanning. For example, 3D models of a mining enterprise with maximum accuracy reflect all its characteristics and allow to visualize the technological process: mining, rock excavation, dumping, etc. The three-dimensional model allows to determine the level of impact on the ecology of the city (region), reflecting process dynamics and phenomena that occur during the operation of the mining enterprise.

Regarding 3D scanning (laser scanning), it should be noted that this technology appeared in geodesy at the end of the last century. However, the high cost of the system and its software constrains its widespread use in the practice of most mining companies. The information provided by 3D scanning is similar in its technical characteristics to that obtained with a total station: a three-dimensional image of the object with the calculation of the area and volume of the surface and other characteristics. However, 3D scanning works much faster: an electronic total station requires millions of measurements to capture the same object. In addition, using a laser scanner, the work is carried out in real time. ZD scanning significantly speeds up and facilitates work in hard-to-reach and most dangerous areas of objects where systemic monitoring and control is required [24]. In addition, as it is known, 3D scanning allows to create a three-dimensional model of the most complex equipment, which will significantly speed up the process of installation or repair. The latter, in turn, will strengthen technical and technological safety and, as a consequence, will contribute to the economic security of the enterprise.

Ukrainian mining companies mainly use traditional technologies to control mines and quarries. In particular, mining surveyors using total stations, theodolites, levels and satellite GPS positioning systems survey workings and monitor the movement of rocks, making measurements. Often the mistakes of surveyors lead to losses and serious accidents. That is why new technologies directly affect safety performance. Quarrying of quarries with the help of unmanned aerial vehicles (drones) helps to reduce the time for collecting and processing information, increase the safety of mining both in the quarry and on the dumps, as well as to eliminate errors related to the human factor. The underground drone for mines can move autonomously underground on the ore discharge and automatically check it. According to KPMG estimates, the use of drones increases the speed of studying the actual terrain by 3–6 times, and the adjustment of documentation by 2–4 times. Experts emphasize that an important addition to flying devices should be the creation of a single digital space for storage and processing of data received from devices for the analysis of statistical information [25].

Thus, the leading mining companies are already at different stages of development of promising technologies that meet modern innovation trends, which are systematized in Table 3.

The operation of a "smart career" involves the following areas of implementation of innovative developments and technologies:

– use of autonomous robotic mining equipment;

– creation of a corporate enterprise management system based on a single distributed database and control over personnel, technological processes and equipment from a single remote control center;

– operational tracking of the processes of formation and movement of ore flows;

– control and management of product quality along the entire path of the technological scheme – from the pits to the points of shipment to the final consumer.

Table 3

Promising technologies in accordance with the main production processes of mining enterprises

Production processes	Promising directions and technologies
Exploration of iron ore deposits	Search and exploration virtualization technologies
	Remote sensing technologies
	Improvement of geographic information systems based on 3D modeling of geological environment
Iron ore production and preparation of reserves	Robotization of mining and formation of underground space
	Technologies of uninhabited excavation (without presence of people)
	Technologies of geoinformation support based on digital modeling of mechanical processes
	"Internet of Things", which covers the product and forms the complexes "intellectual mine", "intellectual (smart) quarry"
Processing, enrichment	"Internet of Things" in enrichment, which forms complex of "intelligent concentrator"
	Chemical technologies to obtain products with higher added value
	Use of nanotechnologies and biotechnologies
Transport	Use of unmanned vehicles, drones
	"Internet of Things", which forms complexes "intelligent transport and control centers"

Source: systematized by the author according to analytical reports and data from [22]

Experts note that smart quarry management is a much higher level of management, even compared to an automated mining system. They explain this by the fact that in an automated system of management decisions and process control is performed by staff in accordance with the tasks of managers. Due to the fact that the staff in this system is the main link, the probability of error with subsequent consequences is quite high. The use of robotic mining system implies that the functions of collection, processing and analysis of information flows are performed directly by the system. For this purpose the data coming from the corresponding sensors located on mobile objects are used. In this case, the functions of the staff are reduced to choosing the optimal solution among those offered by the system.

A "side" innovative direction of robotics in open geotechnology in the field of improving the completeness of reserves, safety and efficiency of mining should be called the complete exclusion of mine personnel. The latter is possible through the use of intelligent mining equipment, which is operated in conjunction with digitalized management systems of the mining enterprise. Excluding staff minimizes the impact of the human factor. In addition, it becomes possible to significantly change the quantitative values of the main parameters of the quarry and individual elements of the development system in the direction of increasing economic efficiency, reducing industrial and environmental threats. This achieves industrial and environmental safety in particular and, as a consequence, the economic safety of the mining enterprise as a whole.

Another promising trend in robotics is the use of robots in mines. Their use will expand production in mines, as the work can work in any conditions, including oxygen-free. The latter, in turn, eliminates the possibility of ignition and explosion of methane. Mining can be carried out in a continuous, round-the-clock mode, as the miner does not need to rise to the surface and does not need rest. It is possible to develop layers that lie at great depths. Taken together, this will solve the problem of safety in mines [26].

Thus, ensuring the security of economic and information interests of enterprises should combine the current and future levels. This means that already now the company must take measures to implement developments and technologies that will meet the latest innovation trends. This will help minimize the inconsistency degree of the internal system characteristics of the business with the trends of the external environment.

Therefore, taking into account the future parameter of the external environment leads to the formation of a new conceptual approach to ensuring the security of economic and information interests through the combination of current and strategic levels through strategic alignment (Fig. 1).

Let's propose to consider strategic alignment as bringing the current state of security of economic and information interests in line with future parameters of the external environment and achieving on this basis the desired state of security in the future. Strategic alignment actualizes the advanced implementation of developments and technologies that meet innovative technological trends. It is important that the degree of consideration of innovative trends and, in particular, robotics, in the activities of the enterprise in the current period characterizes the value of IT capital.

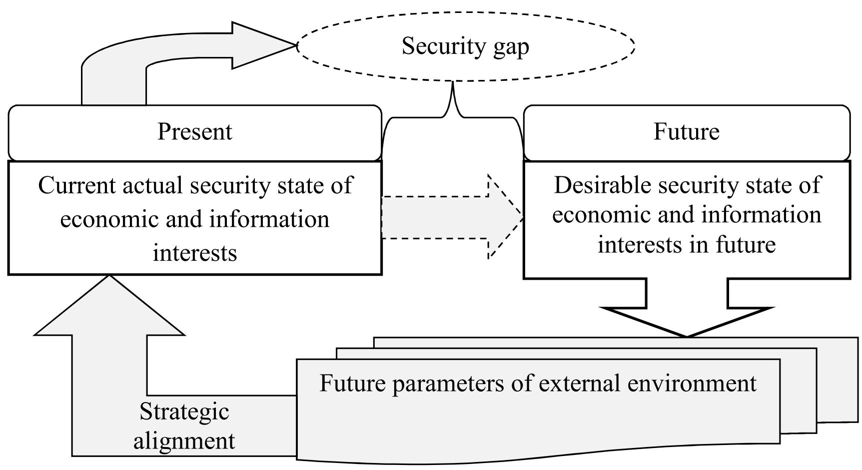

Fig. 1. Visualization of author's approach to ensuring security of economic and information interests of enterprise

IT capital can be formalized in tangible form (robotic machinery and equipment, etc.) and intangible (software). Therefore, if Ukrainian mining companies have been familiar with intangible IT capital for a long time (modern SAP software has been implemented at Metinvest's plants), the tangible form remains poorly implemented (Table 4).

Thus, technological trends have partially penetrated into the mining industry of Ukraine and post-Soviet countries and manifested themselves in a comprehensive combination of different information systems of the mining enterprise:

automation of mining processes, automation of mining, geological and surveying, repair and other assistance; automation of production planning and management (personnel management systems, accounting, warehouses, spare parts, etc.) [27]. Let's emphasize that one of the first components of economic security, which responds to changes in the size and structure of IT capital (and hence the degree of consideration of innovative technological trends) is the security of economic and information interests of the enterprise.

Thus, the study allows to propose a procedure for ensuring the security of economic and information interests of the enterprise, taking into account innovative technological trends (Fig. 2).

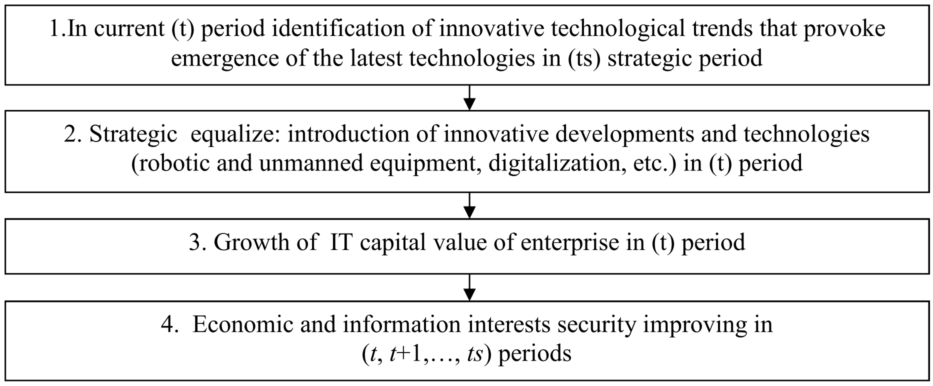

Fig. 2. Procedure for ensuring security of economic and information interests of enterprise, taking into account innovative technological trends, combining current and strategic levels

Table 4

Examples of material form of IT capital of leading enterprises of mining industry

Developer company of robotic equipment	IT capital material form
SuncorEnergy, Canada	Dumpers-works at extraction of quartz sand
"KUKA Robot-er, Germany	The robotic manipulator for installation of arch fastenings
TopTec, Germany	Dismantling robot to perform complex mining operations
SANDVIK, Spain	Robotic roadheader Alpine AM-105ex
Montabert, France	Robotic drilling rig "Robofore" providing drilling of boreholes according to set program with automatic operations of drilling and permutation of two manipulators
NitroNobelMec, Sweden	Mobile manipulators HF-51 and EG-33 with remote control for charging explosives of wells in loose workings
BrokkAB, Sweden	Dismantling serial works which are capable to carry out drilling of wells in mines without heavy equipment, development of rocks in limited space, crushing of oversize. These works are equipped with maneuverable manipulator which has a range of turn from 270 to 360 g. It allows to carry out works in various planes, in particular horizontal drilling
Group of scientists, Russia	«Robot miner», which performs all necessary operations in mine. It can be used both in drilling and blasting works, and at commissioning works. Advantages of this robot are compactness, presence of manipulator arm and location on the propulsion platform

Source: systematized by the author according to [26]

At the heart of combining the current and strategic levels in the developed procedure for ensuring the security of economic and information interests should be called the increase of IT capital. It is important that this increase in the current period was aimed at increasing the share of such types of equipment, technologies, etc., the mass emergence of which is provoked by innovative technological trends in the future. The introduction of the IT capital formed in the activity of the enterprise will provide competitive advantages, will help to improve key economic indicators and will ultimately lead to the improvement of the state of all economic security.

5. 2. The results of verification of the indicator of assessment of the security of economic and information interests of the enterprise and its testing

The property of predictive capabilities implies the presence of an indicator to determine the potential effect of the operation, i.e. it makes it possible to assess the effectiveness of the process consisting of operations generated by investing in them the added value of the priority operation [18].

The result of the verification of the indicator is presented in Fig. 3.

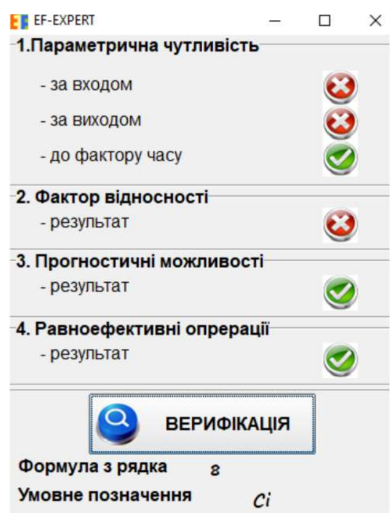

Fig. 3. Verification of indicator of security state of economic and information interests (Ci): "Параметрична чутливість" – "Parametric sensitivity"; "за входом" – "input"; "за виходом" – "output"; "до фактору часу" – "time factor"; "Фактор відносності" – "Relativity factor"; "результат"– "result"; "Прогностичні можливості" – "Predictive capabilities"; "Рівноефективні операції" – "Equally efficient operations"; "Верифікація" – "Verification"; "Формула з рядка" – "Number"; "Умовне позначення" – "Symbol"

According to the passed testing of the indicator, the properties of sensitivity to the time factor were confirmed, the presence of prognostic possibilities and the possibility to evaluate equally effective operations was revealed.

Let's assess the state of security of economic and information interests on the example of Ukrainian mining companies. Analysis of their management reporting, analytical data and professional sources (in particular, [13]) allows to state that the modern characteristic feature of the IT capital of Ukrainian mining companies is the predominance of its intangible form over the material. As a threshold value of the indicator of security of economic and information interests, let's take the maximum value among the enterprises of the industry, obtained during the evaluation period. In this case, the period of time (TO_i) for each company is determined on the basis of the equation of trends (Fig. 4).

Indicators of the state of safety of the mining enterprises of Ukraine, calculated by formula (3) are presented in Table 5.

Thus, as of December 31, 2018 and December 31, 2019, the threshold value of the share of IT capital in the amount of fixed assets and intangible assets was reached at PJSC Northern GOK. Therefore, the indicator of the security status of economic and information interests is equal to 1, which corresponds to a very high security status. At all other mining enterprises – objects of research, the achievement of the threshold value is predicted more than after the cycle period (12 quarters). In this regard, the security indicator is zero as of December 31, 2018 and December 31, 2019. The zero-security status of economic and information interests of enterprises is characterized by a low degree of implementation of innovative technologies and developments that meet modern technological trends. The use of technically and technologically backward production base, outdated technology of iron ore mining and beneficiation creates a number of problems. These problems include high energy and resource consumption of production, a significant burden on the environment and non-compliance with international requirements for the content of useful components, product quality and impurity composition. It is important to understand that Ukrainian mining companies are export-oriented. Therefore, this state of affairs creates risks for the market niche that these companies currently occupy as exporters to Europe and China. Accordingly, while maintaining the current dynamics, the safety gap instead of minimization will increase over time. This necessitates urgent management measures aimed at improving the security of economic and information interests of plants by increasing the amount of IT capital.

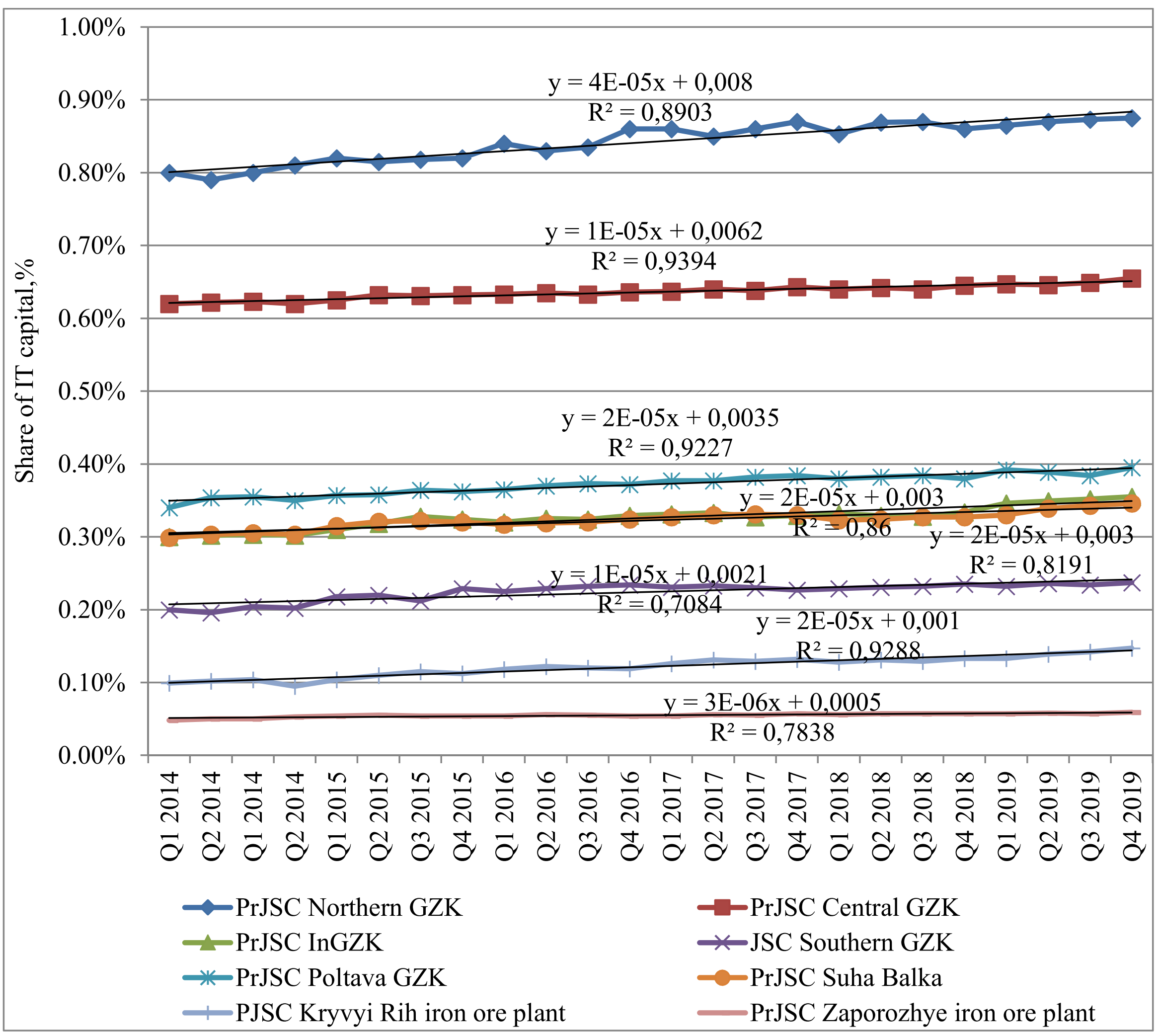

Fig. 4. Dynamics of share of IT capital in amount of fixed assets and intangible assets at mining enterprises of Ukraine (determined by author according to enterprises — objects of the sample)

Table 5

The results of assessment of security of economic and information interests of mining enterprises in 2018–2019

Indicator	31.12.2018 y.	31.12.2019 y.
Threshold (maximum) quarterly share of IT capital in amount of fixed assets and intangible assets	0.863 %	0.870 %
PrJSC Northern GZK		
Coefficient of regression equation (a)	0.0079	0.008
Speed coefficient (b)	0.00004	0.00004
Quarters required number to reach actual value of threshold indicator	0	0
Number of quarters, taking into account cycle (TO_i)	0	0
Security status (C_i)	1.00	1.00
PrJSC Central GZK		
Regression equation coefficient (a)	0.0062	0.0062
Speed coefficient (b)	0.00001	0.00001
Quarters required number to reach actual value of threshold indicator	223	226
Quarters number taking into account cycle (TO_i)	12	12
State security (C_i)	0	0
PrJSC InGZK		
Regression equation coefficient (a)	0.003	0.003
Speed coefficient (b)	0.00002	0.00002
Quarters required number to reach actual value of threshold indicator	262	261
Quarters number taking into account cycle (TO_i)	12	12
State security (C_i)	0	0
JSC Southern GZK		
Regression equation coefficient (a)	0.002	0.0021
Speed coefficient (b)	0.00002	0.00001
Quarters required number to reach actual value of threshold indicator	312	636
Quarters number taking into account cycle (TO_i)	12	12
State security (C_i)	0	0
PrJSC Poltava GZK		
Regression equation coefficient (a)	0.0035	0.0035
Speed coefficient (b)	0.00002	0.00002
Quarters required number to reach actual value of threshold indicator	237	236
Quarters number taking into account cycle (TO_i)	12	12
State security (C_i)	0	0
PrJSC Suha Balka		
Regression equation coefficient (a)	0.003	0.003
Speed coefficient (b)	0.00001	0.00002
Quarters required number to reach actual value of threshold indicator	543	261
Quarters number taking into account cycle (TO_i)	12	12
State security (C_i)	0	0
PJSC Kryvyi Rih iron ore plant		
Regression equation coefficient (a)	0.001	0.001
Speed coefficient (b)	0.00002	0.00002
Quarters required number to reach actual value of threshold indicator	362	361
Quarters number taking into account cycle (TO_i)	12	12
State security (C_i)	0	0
PrJSC Zaporizhzhia iron ore plant		
Regression equation coefficient (a)	0.0005	0.0005
Speed coefficient (b)	0.000004	0.000003
Quarters required number to reach actual value of threshold indicator	2,013	2,709
Quarters number taking into account cycle (TO_i)	12	12
State security (C_i)	0	0

*Note: * – zero means that the threshold value has already been reached during the evaluation period*

6. Discussion of the proposed approach to ensuring the security of economic and information interests of enterprises, taking into account innovative technological trends

The conducted research and systematization of perspective technologies in accordance with the main production processes of mining enterprises (Table 3) shows that these enterprises are at different stages of their development. At the same time, the share of IT capital in the value of fixed assets and intangible assets at Ukrainian mining enterprises averages 0.38 % (Table 1). From this it is possible to draw two conclusions. The first, most obvious conclusion is the very low level of implementation of innovative technologies and developments in the current period. The second conclusion is technical and technological backwardness, which threatens the security of economic and information interests of enterprises in the current period and in the future.

Understanding the possible options for formalizing IT capital (Table 4) will allow business leaders to form strategic measures to increase its value. The latter is the most important part of the procedure for ensuring the security of economic and information interests of the enterprise (Fig. 2).

The study shows that more intensive implementation of robotic geotechnology (which in economic terms is an increase in IT capital), which operates in an autonomous intelligent automatic mode, as well as other state-of-the-art developments and technologies will allow:

– to increase the economic efficiency and intensity of mining;

– to increase the completeness of subsoil use;

– to provide safer working conditions;

– to improve the quality of mining;

– to improve the rhythm of production and sales;

– to improve the value of other important economic indicators, which together will characterize the parameters of economic security.

The conceptual approach visualized in Fig. 1, discloses the factors that determine the current and desired state of security of the enterprise. The introduction of the developed conceptual approach to ensuring the security of economic and information interests on the basis of the proposed procedure (Fig. 2) is appropriate for enterprises of any sector of the economy, both Ukrainian and foreign enterprises.

Separating the security of economic and information interests as a component that is one of the first to respond to the degree of implementation of innovative developments and technologies in the current period improves the quality of all economic security of the enterprise.

As a result of testing the indicator is an indicator of the state of security of economic and information interests, determined by formula (3), the hypothesis that the presence of a time indicator indicates prognostic properties was confirmed. Therefore, the experimentally confirmed proposed indicator (S_i) at the second stage of verification adequately evaluated the operations of all limited classes (Fig. 3). The experiments confirmed the efficiency of the proposed indicator, which allows to recommend it to experts – practitioners to select an evaluation criterion from a variety of indicators offered by researchers as criteria for assessing the economic security of the enterprise and its individual components.

On the basis of the revealed trends (Fig. 4) calculations of an indicator (Si) are carried out (Table 5). The obtained data allow to state that Ukrainian mining enterprises significantly lag behind the leading enterprises of the industry in the implementation of innovative developments and technologies. A high level of automation of production processes, information and transport infrastructure is required, as well as the interest of management, change of corporate culture, training of new staff.

As a limitation of this study should be mentioned the difficulties for an individual enterprise in obtaining complete and timely information about the amount of IT capital of other enterprises in the industry, in fact, competing enterprises. And this is a necessary condition for benchmarking analysis and the establishment of a threshold value of the security indicator of economic and information interests. This study should be deepened in the direction of further improving the definition of the threshold value of the share of IT capital in the amount of fixed assets and intangible assets of the enterprise.

7. Conclusions

1. A procedure for ensuring the security of economic and information interests of the enterprise, taking into account innovative technological trends, combining operational and strategic levels. It is substantiated that the use of robotic and unmanned equipment, digital technologies minimize the degree of inconsistency of the internal characteristics of the enterprise to environmental trends. Due to this, the security parameters of the enterprise in the current period are ensured. It is substantiated that the value of IT capital is an indicator that reflects the degree of implementation of developments and technologies in the enterprise that meet innovative technological trends. It is determined that one of the first to react to the change of this value is such a component of economic security as the security of economic and information interests of the enterprise. It is proposed to use the indicator of the ratio of IT capital to the amount of fixed assets and intangible assets as an indicator of the security of economic and information interests of the enterprise. At the same time, the introduction of innovative developments and technologies will generate a cumulative effect of improving the economic security of the enterprise by ensuring its parameters and improving the security of economic and information interests of the enterprise.

2. Verification of the indicator of assessment of the state of security of economic and information interests of the enterprise is carried out. It was found that it has prognostic capabilities, as well as the ability to evaluate equally effective operations. On the basis of the verified indicator the state of safety of economic and information interests of mining enterprises is estimated. The value obtained at PJSC "Northern GOK" is equal to 1, which corresponds to a very high state of safety. It was found that at other enterprises the safety condition is equal to 0 and is characterized as catastrophic. Therefore, to ensure security, these enterprises need urgent management action aimed at increasing the amount of IT capital.

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