The study is devoted to the problem of analysis and forecasting of the effectiveness of the results of enterprises to ensure production and economic reserves to intensify innovation and investment development in the context of monitoring the state of their economic potential. It is the basis for the formation of endogenous and exogenous capabilities of the enterprise, aimed at achieving targeted results in each area of its activities. Creating favorable conditions for economic growth of enterprises based on the intensification of innovation and investment development requires the effective implementation of production programs using the financial component of economic potential.

Based on the analysis of methodological tools for evaluating the activities of a mining and processing enterprise, formed a comprehensive methodology for quantitative and qualitative assessment of actual and projected values of performance indicators of the enterprise. It is based on determining the statistical probability of achieving a positive level of the indicator, the probability of its falling into a given interval of deviation from the recommended allowable values and an integrated assessment of the financial component of economic potential.

Approbation of the developed technique is carried out within the limits of the express analysis of effective indicators of efficiency of activity of mining and processing enterprises. The results showed that with high reliability of the forecast (more than 0.85), the recommended values of the level of margin to achieve the desired efficiency are in the range of 8÷10 %. Within a sufficient level of reliability of the forecast (not less than 0.75), the recommended values of this margin are 10÷24 %. In this case, the integrated indicator of the assessment of the financial component should be more than 0.3

Keywords: efficiency, innovation and investment development, economic potential, financial component of economic potential

FORECASTING THE EFFECTIVENESS OF THE ENTERPRISE TO INTENSIFY INNOVATION AND INVESTMENT DEVELOPMENT, TAKING INTO ACCOUNT THE FINANCIAL COMPONENT OF ECONOMIC POTENTIAL

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1. Introduction

The stable position of the enterprise in a competitive environment is determined by its economic potential, which forms the basis for ensuring the level of efficiency for this period and in the future. The degree of use of potential depends on the overall strategy of the enterprise, the main principle of which is: to produce competitive products and strengthen its competitive position in commodity markets.

The tools of enterprise management can be represented in scientific works, branched out in different functional areas of activity. This is how the economic potential is formed, the main components of which can be considered: production, personnel, innovation and investment, financial, organizational and managerial, marketing and sales potential.

It should be noted, that there is no single approach to defining this category. Summarizing the different approaches, it can be noted, that the economic potential is the ability of an enterprise to provide effective results based on meeting the needs of consumers, taking into account the influence of external and internal factors. Economic potential should form endogenous and exogenous opportunities of the enter-

prise for achievement of target results in each sphere, and also conditions for the further development.

The components of economic potential are a source of competitive advantage, and the indicators that characterize them reflect the problems and strengths in all areas of the enterprise. Considerable attention in the programs of strategic development of enterprises of various branches is paid to innovative activity. The introduction of innovations provides opportunities to obtain synergetic effects and solve most technical and technological, environmental and organizational and managerial problems of the enterprise.

At many enterprises there is a problem that inhibits the implementation of innovations. It is associated with insufficient investment. A significant part, even of own innovative developments of the enterprises, sometimes remains only in plans. It is obvious that all innovative measures, which are planned for the strategic perspective, must be implemented in a timely manner, to determine their positive effect and impact on the results of production and economic activities of the enterprise.

Commodity enterprises around the world are significantly influenced by the external environment. There are rapid changes in market conditions, political and economic factors, so companies cannot focus on current benefits.

The main promising areas of development of mining enterprises include investing in innovative technologies not only production but also artificial intelligence, which allows to increase the efficiency of planning and management decisions. This provides an opportunity to gain new, sustainable competitive advantages in the long run.

Carrying out of research in the direction of forecasting of efficiency of activity of modern MPP and definition of level sufficiency of a financial component of economic potential is actual. Its results are useful for practical application in the direction of determining changes in the efficiency and opportunities for financial support of innovation and investment development of enterprises.

2. Analysis of literary data and statement of the problem

[1] presents a wide range of components of the economic potential of the enterprise as a set of subsystems, including: personnel, production, financial and investment, innovation, information, organizational and managerial, competitive, marketing and business potential. This study aims to determine the content of the components in accordance with a number of functional aspects of the enterprise. The essence of economic potential and its components is reflected, but there is no focus on a comprehensive approach to solving this issue. It is advisable to consider the peculiarities of the formation of individual components of economic potential in accordance with the conditions of the enterprise and the relationship between them in the implementation process.

Research on the formation of evaluation methods and strengthening economic potential is important. In [2], taking into account the formation of the relevant components, a model for assessing the economic potential of the enterprise is proposed, which provides an opportunity to control the effectiveness of the objectives and groups of indicators. It would be advisable to consider the formation and conditions for achieving the desired efficiency of the enterprise on the selected evaluation indicator.

In [3] the issue of strengthening the economic potential of the enterprise through the application of the planning system and the formed interconnected stages is considered. The author of [4] formed a classification of these methods, which allows a thorough assessment of the economic potential of the enterprise depending on the characteristics of the influence of external and internal factors and the tasks to be solved. These works do not define which components have a significant impact on the efficiency of modern enterprises and how to use them to improve performance results.

For a more in-depth study of the structural components of economic potential and their improvement in order to obtain the desired results in solving each specific problem, separate components are considered. Thus, the authors of the article [5] explore the important issue of analyzing the factors of innovation potential of the enterprise, which are key in terms of innovation (at the micro level) and their impact on the economy (at the macro level). It should be noted, that it is important to ask questions about the development of innovation in the enterprise. Innovation is determined by the amount of investment in the development and implementation of innovations and the effectiveness of the results obtained. Therefore, it is important to monitor the dynamics of performance indicators of the enterprise under the influence of changes in the parameters of innovation. Any innovative development provides opportunities to improve certain technical and economic indicators and influence the overall results of the enterprise.

In [6] it is proposed to assess the development of the innovative potential of the enterprise, based on the index method, according to the system of indicators. This article recommends that companies develop a plan for financing innovation and implementing a customer relationship management system. Emphasis is placed on innovative development in the direction of sales organization. However, the paper does not cover the further mechanism and marginal capabilities of enterprises to finance innovations.

The task for the modern development of mining enterprises is to strengthen the innovation and investment component of economic potential in the direction of greater receptivity to innovation. In this aspect, the work [7] identifies external and internal factors that hinder the development of innovation. Examining the activities of Ukrainian enterprises, it should be noted, that an important external factor for them are certain restrictions on funding, which are due to "high risks, high costs for development and implementation of innovations" [7], and companies lack their own funds.

Internal factors include a certain wear of technological equipment (replacement of equipment did not take place at all operations and stages of the production process), the lack of a modern operational base for development [7]. However, in addition to identifying the factors that inhibit innovative development, it is advisable to consider the possibility of practical implementation of innovations through the development of methodological tools for planning their financial support.

Priority in modern enterprises is given to strategic aspects of innovation and investment activities. It is important to make the optimal choice of funding sources, strategies, areas of investment. To overcome these difficulties, forecasting of performance indicators at the enterprise is used. This approach is used in [8, 9]. In order to strengthen investment activity, the study [8] proposed a method of forecasting indicators to increase the financial stability of the enterprise depending on the phases of its life cycle. An important task is solved in [9] to study the relationship between sales of the enterprise with the level of innovation. The proposed model provides forecasting of the enterprise performance in the

implementation of innovation strategies. It should be noted, that these works do not take into account the methodological approaches to determining the risks in forecasting the results of the enterprise, as well as the conditions for achieving the desired level of evaluation.

In general, scientists pay special attention to the formation, evaluation, management of economic potential of the enterprise and its components, the choice of investment, the intensification of innovation. To solve the problem of improving the result indicators and ensuring the competitiveness of the enterprise in the strategic perspective, one should use the opportunities to intensify innovative development. All this allows us to say that it is advisable to apply a comprehensive approach to forecasting the efficiency of the enterprise in terms of improving innovation. At the same time, it is important to take into account the possibilities of the financial component of the economic potential, formed at enterprises in the specified period, to determine the actual and marginal levels of risks and on their basis to establish the level of achievement for enterprises.

3. Research aim and tasks

The aim of the study is to develop methodological tools for forecasting the effectiveness of mining and processing enterprises, taking into account the integrated assessment of the financial component of economic potential to enhance innovative development.

To achieve this goal, the following tasks were set:
– to develop a comprehensive methodology for quantitative and qualitative assessment of performance indicators of the enterprise;
– to determine the maximum capacity of enterprises to achieve the desired efficiency;
– to assess the level of the financial component of the economic potential of the mining and processing enterprise to determine its investment opportunities for innovative development.

4. Research materials and methods

In the study, the solution of strategic development problems is considered on the example of the activities of mining and processing plants (MPP) of the Kryvyi Rih basin, which are one of the leading enterprises of the mining industry of Ukraine, providing its export potential

The analysis of different spheres of MPP operation showed that some enterprises do not implement innovative measures at all, others – in insufficient volumes. Often this situation is due to insufficient financial resources for the implementation of complex, large-scale innovation projects, but the long-term results and the level of stability of competitive positions of the enterprise depend largely on the development of innovation and investment.

There should be noted the lack of an established mechanism for financing all areas of innovation. In general, in 2013–2019, the indicators of financial stability, liquidity and solvency of most MPPs deteriorated. The dynamics did not change in 2020, so it is advisable for the management of enterprises to determine the reserves and funding for innovation in the strategic perspective.

For the period up to 2020, mining and processing enterprises have planned to implement a number of innovative measures. Among them: production of concentrate from oxidized quartzites, expansion of cyclic-current technologies in quarries, introduction of a combined method of development of iron ore deposits. These measures should help increase the efficiency of MPP.

It should be noted, that in recent years (2017–2020) only in the private joint-stock company (PJSC) "Central MPP" (Ukraine) innovative design developments (2019) and implemented innovative measures (2020) were carried out. No innovative research was conducted at other mining and processing enterprises. To increase the efficiency of iron ore MPP in the strategic perspective, it is necessary to predict the possibilities of their innovation and investment development, taking into account the financial component of economic potential as a basis for investment formation.

Each following year, for the period under review, the resulting performance indicators of mining and processing enterprises deteriorated. The main reasons are the low technical level of production and increased resource costs, which leads to higher production costs. There was a need to develop a comprehensive methodology of actual and projected values of performance indicators of the enterprise to ensure its innovation and investment development.

One of the main tasks of managing the economic potential of the enterprise is to choose the optimal plan or program of production. When building economic and mathematical models of enterprise performance, forecasting methods are the most common and are used by scientists to solve these problems [10–13]. It should be noted, that the process of forecasting the efficiency of the enterprise, taking into account the need to intensify its innovation and investment development, can be carried out on the basis of the method of determining the statistical probability of achieving a certain positive result. In this case, the probability of occurrence of a certain event can be determined by an objective method, which consists in calculating the frequency, with which a certain event occurred in retrospect. The reflection of financial performance indicators in the past retrospective presents discrete dynamic series that can level change trends in time over these indicators, which requires a clear presentation of the dynamics of these changes.

Since the use of the classical method of determining the statistical probability in relation to the evaluation of results does not sufficiently take into account the degree of risk in relation to changes of indicators trends, it is possible to present their dynamics in the form of piecewise linear approximation. In this case, when modeling the dynamics of efficiency indicators, it is advisable to use linear equations at minimum retrospective intervals to find the points of intersection of lines using the software application Microsoft Excel. These lines will reflect the set levels of forecast indicators, which will take into account changes in the nature of their trends when calculating the values of statistical probability.

Given the changing market situation and the impact of the stochastic nature of production processes in the mining industry, forecasting the results of production and economic activities of the enterprise should be based on the characteristics of dynamic series and the law of large numbers [11].

At the final stages, the results of forecasting the effectiveness of MPP are considered in conjunction with an integrated assessment of the financial component of its economic potential, taking into account the provision of investment opportunities to enhance innovation.

5. The results of the study to intensify the innovation and investment development of mining and processing enterprises

5. 1. Development of a comprehensive methodology for quantitative and qualitative assessment of performance efficiency indicators of the enterprise

The activity of modern enterprises depends on the influence of environmental factors, which causes changes in various aspects of their internal potential. The solutions of development problems for the future are connected with an efficiency increase of activity of the enterprise on the basis of use of the advanced achievements of scientific and technical progress, rational use of labor, fuel and energy resources and maintenance of financial capacity.

At the same time, it should be emphasized, that there are complex relationships between the components of the economic potential of the enterprise and, in order to understand and take them into account when forming a new strategy, it is advisable to carefully interpret their interdependencies. To ensure effective innovation and investment development, the interdependence of this component with the financial component of the economic potential of the enterprise should be investigated.

In this context, it is important to systematize the innovative problems of the enterprise, which is presented in [14]. The first group consists of problems related to the use of the existing innovation and investment potential of the enterprise and can be eliminated by solving certain production and economic problems in the current periods of economic activity of the enterprise. The second group of problems depends on a number of factors and causes of objective and subjective nature. In essence, a correct interpretation of the problems of the first group is the basis that allows the company to establish the level of need to intensify its innovation activities and determine the feasibility of developing innovation and investment programs for future development. Undoubtedly, at this stage there is a need to predict the effectiveness of the enterprise to intensify innovation and investment development on the basis of the financial component of economic potential. Of course, this task is quite complex and time consuming. The main difficulties are in the formation of appropriate tools for forecasting further trends in the economic system based on modeling the achievement of the desired levels of certain key financial and economic indicators of the enterprise. An important point here is the development of methodological approaches to modeling the forecast values of indicators, approaches and criteria for assessing the level of reliability of forecasting and the probability of achieving positive results in general. At the same time, it is necessary to take into account certain characteristic features of production and economic processes in time and space, which relate to enterprises for mining and processing of minerals and production of raw materials for metallurgical production.

At the same time, the main reasons for mining and processing enterprises to be in a state of crisis are the inconsistency of their production mechanism with the modern conditions of constant transformations of the iron ore market. The reasons for this condition are very different. Among them is the level of inconsistency of technology and equipment with modern trends in scientific and technological progress in the industry, product quality to consumer needs, the ratio of market prices and production costs.

Since the financial component of economic potential largely ensures the development of innovation, investment and production potential, for the practical implementation of the tasks of forecasting performance, it is advisable to conduct an analytical study of a number of indicators. Among them: sales volume; enterprise assets; net profit; equity; current financial investments; cost; long-term liabilities and collateral; current liabilities and collateral; return on equity.

These indicators largely reflect the state of the financial and production sphere of the enterprise and affect the possibilities of its innovation and investment development. Along with the study of accounting indicators at the enterprise, it is advisable to pay significant attention to management with detailing costs by structural units and types of products. This makes it possible to manage costs and ensure the profitability of production in the implementation of innovation and investment solutions. It is important here to identify production reserves, which can be not only in the main structural units of the enterprise, but also in the supply, marketing and ancillary and service shops.

According to the results of research, we can propose a method for determining the efficiency of the economic potential of the iron ore enterprise for modern business conditions, which is based on the criteria of maximizing the economic effect ($E \rightarrow$max) while limiting:

$$V_b < V_p \pm \Delta V < V_{max}, \qquad (1)$$

where V_b – volume of break-even production of certain types of iron ore products (IOP); V_p – projected average value of production, which corresponds to the demand for certain types of IOP; $\pm \Delta V$ – deviation from the predicted average values of production volumes (calculation of this value is based on the use of time series and the law of large numbers); V_{max} – maximum volume of production of the main types of OIP, due to the production capacity of the enterprise.

Based on the analysis of the available tools for evaluating the activities of the enterprise, it is necessary to form a comprehensive methodology for quantitative and qualitative assessment of performance indicators of the enterprise. It is based on determining the probability of their falling into a given interval, taking into account the probability of deviation from the recommended allowable values and integrated assessment of the financial component of economic potential as a prerequisite for innovative development of the enterprise. The method performs:

1) forecasting the results of the enterprise performance on the basis of determining the statistical probability of achieving a given (positive) level of the indicator [14];

2) modeling of the forecasted values of performance indicators of the enterprise on the basis of the variance approach in the context of maximum possibilities of the manager (investor/entrepreneur) [10];

3) integrated assessment and forecasting of key indicators of the financial component of economic potential.

The method of calculating the values of statistical probability in relation to predicting the achievement of a given (positive) level of a certain indicator is illustrated below by the example of using piecewise-linear approximation of trends in its dynamics. Accordingly, the regression equation $y=ax+b$ is given, where y is the value of the predicted level of the enterprise activity indicator; a, b – coefficients of the regression equation; x is the coordinate on the abscissa axis of the ordinal numbers of the time retrospective period. In this coordinate, the line of the regression equation intersects with the line that sets the desired level of the value of the performance of the enterprise.

Step I.
1. If the initial values of the discrete dynamic series of the indicator are positive values relative to its desired level ($y=c$), the coordinates of the first intersection of the corresponding lines of regression equations, in which the value of the indicator is less than this given level, is calculated by the formulas:

$$x_{11} = (c - b_{11}) / a_{11}, \qquad (2)$$

$$x_{12} = (c - b_{12}) / a_{12}. \qquad (3)$$

Then the interval, at which the values of this indicator will be observed, less than the specified desired level, is calculated by the formula:

$$\Delta x_1 = x_{12} - x_{11}. \qquad (4)$$

2. If the initial values of the discrete dynamic series of the indicator are negative values relative to its given desired level, the coordinate of the intersection of the corresponding line of the regression equation, at which the value of the indicator becomes greater than this given level, is calculated by the formula:

$$x_{11}^* = (c - b_{11}^*) / a_{11}^*. \qquad (5)$$

The interval, at which the values of this indicator will be observed, even less than the specified desired level, is calculated by the formula:

$$\Delta x_1^* = x_{11}^* - 0,5. \qquad (6)$$

Step II.
1. If there are values in the middle of the discrete dynamic series of the indicator that are less than the value of its desired level, the coordinates of the intersection of the corresponding lines of regression equations, in which the value of the indicator is less than this level, is calculated by the formulas:

$$x_{i1} = (c - b_{i1}) / a_{i1}, \qquad (7)$$

$$x_{i2} = (c - b_{i2}) / a_{i2}. \qquad (8)$$

The interval, at which the values of this indicator will be observed, less than the specified desired level, is calculated by the formula:

$$\Delta x_i = x_{i2} - x_{i1} . \qquad (9)$$

Step III.
1. If the $n-1$ value of the discrete dynamic series of the indicator is less than the value of its desired level, and the n-th value is greater, then the coordinates of the intersection of the corresponding lines of regression equations, in which the value of the indicator is less than this level, is calculated by the formulas:

$$x_{n-1} = (c - b_{n-1}) / a_{n-1}, \qquad (10)$$

$$x_n = (c - b_n) / a_n. \qquad (11)$$

The interval, at which the values of this indicator will be observed, less than the specified desired level, is calculated by the formula:

$$\Delta x_{n-1} = x_n - x_{n-1}. \qquad (12)$$

2. If the n-th value of the discrete dynamic series of the indicator is less than the value of its desired level, the coordinates of the last segment on the abscissa axis of the ordinal numbers of the time retrospective period, in which the value of the indicator is less than the given level, is calculated by the formulas:

$$x_n^* = (c - b_n^*) / a_n^* , \qquad (13)$$

$$x_{n+0.5}^* = n + 0.5 . \qquad (14)$$

And the interval, at which the values of this indicator will be observed, less than the specified desired level, is calculated by the formula:

$$\Delta x_n^* = x_{n+0.5}^* - x_n^*. \qquad (15)$$

Step VI.
The value of the statistical probability of achieving a given (positive) level of the indicator is calculated by the formula:

$$p_{cm} = 1 - \sum_{i=1}^{n} \Delta x_i / n. \qquad (16)$$

The following is an example of using the proposed methodological approach based on determining the profitability of the three mining and processing plants of Kryvbas for the period 2013–2019 [15–17]. Forecast estimates are designed for a medium-term period of up to three years. The determination of quantitative values of the indicator is performed for at least five years [18]. The sample of source information should be at least twice the selected forecast period.

Product profitability is considered to be one of the key indicators of enterprise efficiency, which can be used in comparative assessments of generalized results of activities in retrospect. The initial data are given in Table 1.

Table 1

Profitability indicators of Kryvbas mining and processing plants for the period 2013—2019

Indicators	Retrospective period years						
	2013	2014	2015	2016	2017	2018	2019
PJSC «Northern MPP»							
Product profitability, share un	0.672	0.209	–0.118	0.374	0.678	0.616	0.498
PJSC «Central MPP»							
Product profitability, share un	0.536	0.145	0.165	0.694	0.476	0.331	0.185
PJSC «Ingulets MPP»							
Product profitability, share un	1.102	0.190	–0.535	–0.010	0.791	0.488	0.524

The results of the application of linear equations in modeling trends in the dynamics of profitability of products of these enterprises using the method of piecewise linear approximation at minimum intervals of the retrospective period are as follows.

Linear equations for the product profitability of PJSC "Northern MPP":
1) 2013–2014: $y=-0.4632x+1.1355$;
2) 2014–2015: $y=-0.3273x+0.8635$;
3) 2015–2016: $y=0.4923x-1.5951$;

4) 2016–2017: $y=0.3042x-0.8427$;
5) 2017–2018: $y=-0.0623x+0.9899$;
6) 2018–2019: $y=-0.118x+1.3239$.

Linear equations for the product profitability of PJSC "Central MPP":
1) 2013–2014: $y=-0.3903x+0.926$;
2) 2014–2015: $y=0.0202x+0.105$;
3) 2015–2016: $y=0.5283x-1.4194$;
4) 2016–2017: $y=-0.2179x+1.5653$;
5) 2017–2018: $y=-0.1445x+1.1985$;
6) 2018–2019: $y=-0.1462x+1.2087$.

Linear equations for the product profitability of PJSC "Ingulets MPP":
1) 2013–2014: $y=-0.9127x+2.015$;
2) 2014–2015: $y=-0.7251x+1.6398$;
3) 2015–2016: $y=0.5258x-2.113$;
4) 2016–2017: $y=0.801x-3.2136$;
5) 2017–2018: $y=-0.3031x+2.3068$;
6) 2018–2019: $y=0.0359x+0.2728$.

Fig. 1 shows a graphical interpretation of the dynamics of the profitability of products at these enterprises using the method of piecewise linear approximation.
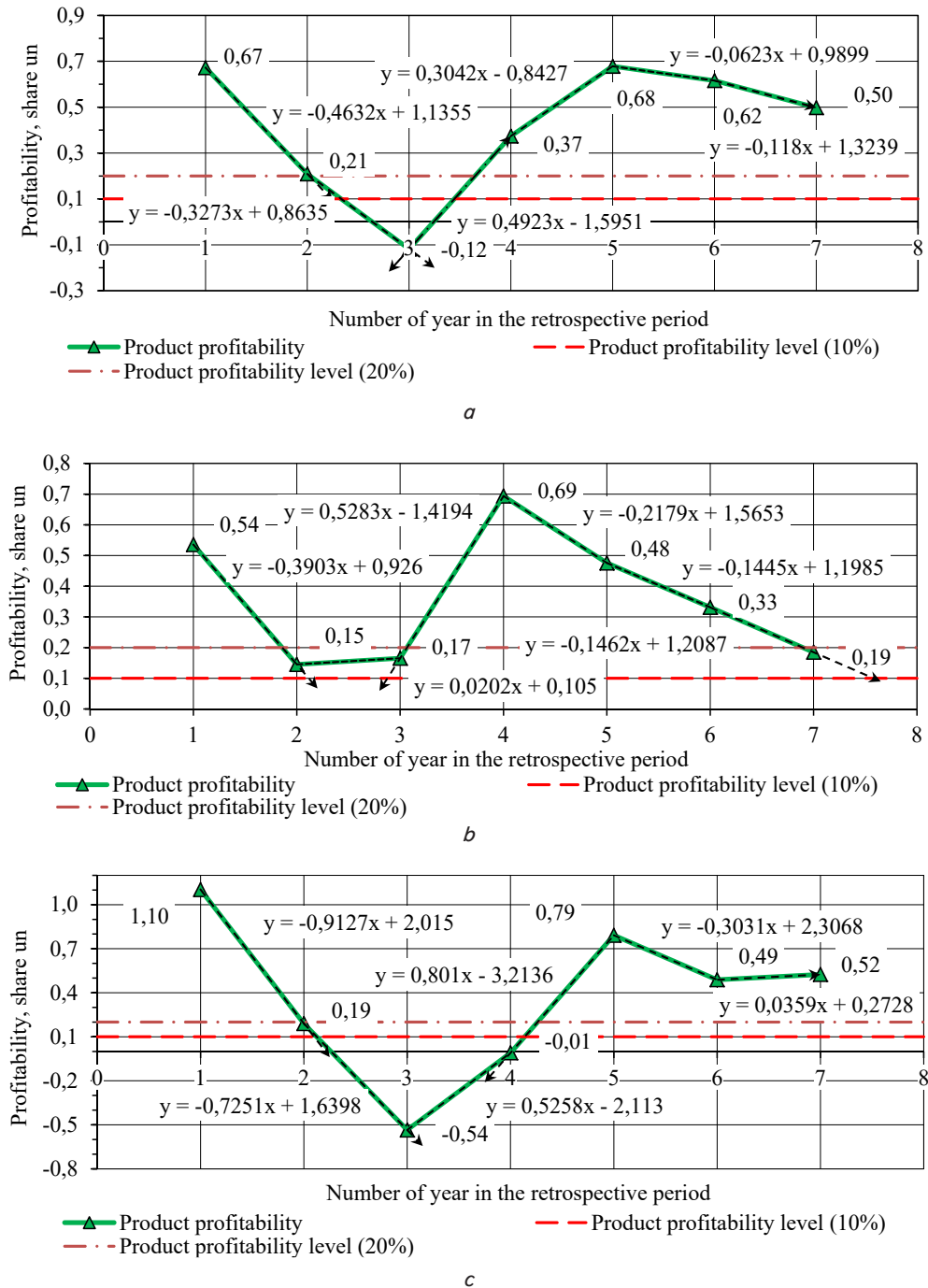

a

b

c

Fig. 1. Graphic interpretation of the profitability dynamics of products using the method of piecewise linear approximation for:
a – PJSC «Northern MPP»; *b* – PJSC «Central MPP»; in PJSC «Ingulets MPP»

By means of the lines of equations, constructed in these intervals, points of their intersection with control lines of the set minimum admissible positive levels of the forecasted indicator of efficiency of the enterprise are found. These points cut off the segments, on which the efficiency in the dynamics takes values less than these specified levels. The ratio of the sum of the lengths of these segments and the total line length of the retrospective period is a quantitative estimate of the statistical probability of achieving the desired positive efficiency. The calculations use formulas (2)–(16), which allows to take into account changes in trends in the dynamics of efficiency in forecasting their levels in the future based on the statistical probability of achieving the desired positive result.

The following is a method of modeling the predicted values of performance indicators of the enterprise on the basis of the variance approach in the context of the marginal capabilities of the manager (investor/entrepreneur). Accordingly, the evaluation criteria and parameters of mathematical planning models are selected on the basis of boundary theorems of probability theory, where the reliability $P(x)$, which means the probability of achieving a value (x) that is not less than a predetermined parameter x_p:

$$(x \geq x_p) = 1 - F(x_p). \tag{17}$$

In accordance with the above, the assessment of the predicted values of the results of enterprises, taking into account the intervals of deviations of the random discrete value from its predicted average value, is carried out according to the method, the essence of which is as follows.

1. The values of the random variable X, observed in n independent studies with mathematical expectation $M(X)$ and variance σ_x^2, are considered as random variables $X1, X2,..., Xn$ with the same mathematical expectations and variances. However, it should be borne in mind that, first of all, the risks for the manager (investor/entrepreneur) are associated with adverse performance. If we take into account the positive deviations from the expected value, they will show higher values of risk in the calculations, which is not logical. These circumstances were investigated in [19], where it was proved that "Chebyshev's inequality should be strengthened by such a numerical characteristic of the degree of risk as a seven-square deviation." Therefore, when modeling performance indicators, only negative deviations from their predicted averages should be taken into account. In such cases, semivariation $(SV(X))$ can be taken as a risk assessment [10].

Therefore, as a criterion for estimating the intervals of deviations of a random discrete quantity from its predicted average value, it is expedient to accept the Chebyshev inequality [13], where on the basis of a partial case the following expression can be written:

$$P\{|X - M(X)| \leq \delta\} > 1 - \frac{SV(X)}{\delta^2 n}, \tag{18}$$

where δ – predetermined deviation of a random variable; n – number of pairwise independent quantities.

2. A table of the distribution law of a discrete random variable X is compiled, which is the initial data for modeling the intervals of deviations of a random discrete quantity X from its predicted average value.

The initial data for modeling the intervals of deviations of a random discrete quantity X from its predicted average value are given in the form of Table 2.

Table 2

Initial data for modeling the intervals of deviations of a random discrete quantity X from its predicted average value

T_1	t_1	t_2	...	t_n
X_1	x_1	x_2	...	x_n

3. The calculation of deviations of the indicator as a random discrete quantity X from its predicted average value is based on a stochastic model, which is a function that characterizes the reliability (probability of not exceeding a given level of deviation of a random variable):

$$P(\delta) = 1 - \frac{SV(X)}{\delta^2 n}, \tag{19}$$

for this purpose the numerical characteristics of this model are calculated:

3. 1. The arithmetic mean of the indicator X:

$$\bar{X} = \sum_{i=1}^{n} \frac{X_i}{n}. \tag{20}$$

3. 2. Variance of the indicator X:

$$SV(X) = \sum_{i=1}^{n} \frac{(X_i - \bar{X})^2}{n}, \tag{21}$$

where X_i are taken for adverse deviations from the expected value of the indicator.

4. In order to ensure the desired reliability of the forecast, the interval or point values of the probability of not exceeding the specified level of deviation of the indicator are set.

5. To determine the extent, to which the average predicted values of the indicator relative to the risk have decreased, the deviations of the random variable in absolute and relative units are calculated.

5. 1. Negative deviations of a random variable in absolute units are calculated by the formula:

$$\delta = \frac{SSV(X)}{\sqrt{(1 - p_f)n}}, \tag{22}$$

where p_f – forecast probability.

5. 2. The deviation of the random variable as a percentage is calculated by the formula:

$$\delta_\% = \frac{\delta}{\bar{X}} \cdot 100\% . \tag{23}$$

6. For the given interval of probability of the forecast, the numerical values of the interval of the random variable are calculated taking into account its probable deviation in the negative direction:

$$\bar{X} - \delta . \tag{24}$$

The results f calculations of the predicted values of profitability of products with the given probability of the fore-

cast for the studied MPP, based on the data of their financial statements, are given in Table 3.

Table 3

The results of calculations of the predicted values of profitability of the Kryvbas MPP

Forecast probability (p_f), share un.	Projected values of product profitability taking into account the probable deviation in the negative direction $\left(\overline{X}-\delta\right)$, share un		
	PJSC «Northern MPP»	PJSC «Central MPP»	PJSC «Ingulets MPP»
0.675	0.283	0.313	0.162
0.7	0.277	0.311	0.153
0.725	0.271	0.309	0.144
0.75	0.264	0.306	0.133
0.775	0.255	0.303	0.121
0.8	0.246	0.300	0.106
0.825	0.234	0.296	0.088
0.85	0.219	0.290	0.066
0.875	0.200	0.283	0.037
0.9	0.174	0.274	−0.001
0.925	0.136	0.261	−0.058
0.95	0.073	0.238	−0.153
0.9625	0.019	0.219	−0.233
0.975	0.071	0.187	−0.367

Based on the data in Table 3, the dependences of the predicted values of the efficiency of the PJSC "Northern MPP", PJSC "Central MPP", PJSC "Ingulets MPP" enterprises using the method of piecewise linear approximation and variance approach in the context of the marginal capabilities of the manager (investor/entrepreneur) with the given forecast probability are constructed (Fig. 2).
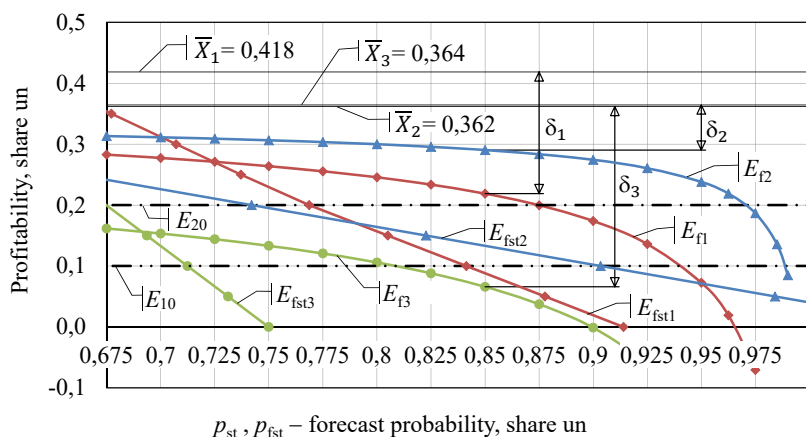

Fig. 2. Forecasting the efficiency of the PJSC "Northern MPP", PJSC "Central MPP", PJSC "Ingulets MPP" enterprises using the method of piecewise linear approximation and variance approach in the context of the marginal capabilities of the manager (investor/entrepreneur) with the given forecast probability. Note: 1, 2, 3 — indices of the PJSC "Northern MPP", PJSC "Central MPP", PJSC "Ingulets MPP" enterprises respectively; E10, E20 — control levels of product profitability of 10 % and 20 %, respectively; Efst1, Efst2, Efst3 — predicted values of product profitability taking into account the statistical probability of achieving a positive result; Ef1, Ef2, Ef3 —projected values of product profitability, taking into account the maximum capabilities of the manager

Based on the results of calculations of forecasting the efficiency of the PJSC "Northern MPP", PJSC "Central MPP", PJSC "Ingulets MPP" enterprises and their graphical interpretation, which is presented in Fig. 4, statistical probabilities (p_{st}) of achievement of a positive level of efficiency ((E_{fst}=10 % and 20 %) by the enterprises on the basis of application of the piecewise linear approximation method are defined.

For PJSC "Northern MPP":

1) For achieving the efficiency level of 20 % − $p_{st}(E_{20})$≤0.769;
2) For achieving the efficiency level of 10 % − $p_{st}(E_{10})$≤0.841.

For PJSC «Central MPP»:

1) For achieving the efficiency level of 20 % − $p_{st}(E_{20})$≤0.742;
2) For achieving the efficiency level of 10 % − $p_{st}(E_{10})$≤0.903.

For PJSC «Ingulets MPP»:

1) For achieving the efficiency level of 20 % − $p_{st}(E_{20})$≤0.675;
2) For achieving the efficiency level of 10 % − $p_{st}(E_{10})$≤0.712.

The results of the analysis allow us to draw a conclusion about the relatively satisfactory estimates of the projected values of efficiency of all enterprises. However, it should be noted, that PJSC Ingulets MPP has the worst estimates of the projected efficiency.

Regarding the assessment of the marginal capabilities of the manager (investor/entrepreneur) in forecasting the efficiency of the enterprises, provided the forecast probability as p_f≥85 %, the probability of achieving positive levels of efficiency by the enterprises as E_f=10 % and 20 % is determined.

For PJSC «Northern MPP»:

1) For achieving the efficiency level of 20 % − $p_f(E_{20})$≤0.875;
2) For achieving the efficiency level of 10 % − $p_f(E_{10})$≤0.941.

For PJSC «Central MPP»:

1) For achieving the efficiency level of 20 % − $p_f(E_{20})$≤0.971;
2) For achieving the efficiency level of 10 % − $p_f(E_{10})$≤0.989.

For PJSC «Ingulets MPP»:

1) For achieving the efficiency level of 20 % − $p_f(E_{20})$≤0.5;
2) For achieving the efficiency level of 10 % − $p_f(E_{10})$≤0.809.

The results of the calculations show that the risk limits for achieving positive levels of efficiency for PJSC "Ingulets MPP" are less than the desired reliability of the forecast as p_f ≥85 %.

5. 2. Determining the level of margin to achieve the desired efficiency of enterprises

Numerical data of the graphical interpretation (Fig. 2) make it possible to determine the level of margin of achievement of the desired efficiency by enterprises (LMADE). This indicator is defined as the difference between the quantitative values of the risk limits (limit probabilities of achieving the predicted result (APrR) and the quantitative values of risk (statistical probabilities of achieving a positive result APR). These values are calculated by the method of statistical probability, attributed to the quantitative values of the risk limits (limit probabilities of APrR). It should be borne in mind, that reducing the value of the controlled desired positive level of efficiency may lead to a decrease in LMADE. However, this does not indicate a negative

trend, as there is a shift in the values of E_{pr} in the range of the interval of greater reliability of the forecast.

Provided the forecast probability as $p_{pr} \geq 85$ %, we have.

For PJSC «Northern MPP»:

1) For achieving the efficiency level of 20 %: LMADE= =(0.875−0.769)/0.875=0.1211 (12.11 %);

2) For achieving the efficiency level of 10 %: LMADE= =(0.941−0.841)/0.941=0.1063 (10.63 %).

For PJSC «Central MPP»:

1) For achieving the efficiency level of 20 %: LMADE= =(0.971−0.742)/0.971=0.2358 (23.58 %);

2) For achieving the efficiency level of 10 %: LMADE= =(0.989−0.903)/0.989=0.087 (8.7 %).

According to the results of preliminary calculations, it should be noted, that PJSC Ingulets MPP, at $p_{pr} \geq 85$ %, does not have sufficient LMADE.

5. 3. Assessing the level of the financial component of economic potential to determine the investment opportunities of mining and processing enterprises

An important point in determining the investment opportunities to enhance the innovative development of enterprises is to assess the level of the financial component of their economic potential. To do this, it is necessary to calculate the value of local indicators and integrated indicator for assessing the financial component of the economic potential of the enterprise in the context of monitoring its investment opportunities to enhance innovation development (I_{afcep}). Selected local indicators characterize the financial results of the enterprise. Return on equity is considered the most important indicator, which focuses on the results of all activities of the enterprise. The absolute liquidity coefficient characterizes the ratio of the most liquid part of assets and current liabilities, which is important for mining and processing enterprises. If the value of the indicator is higher than the normative (0.2), the company can invest part of the funds not only in production activities, but also in financial investments, i.e. innovative development. The coefficient of financial stability reflects the level of financial risks. The coefficient of autonomy shows the share of assets of the enterprise, which can be financed from its own financial resources. The results of the calculations are given in Table 4.

Fig. 3, 4 show the dynamics of return on equity and integrated indicator for assessing the financial component of the economic potential of enterprises. The integrated indicator is calculated by the formula: $I_{afcep} = \dfrac{1}{2^4} \prod_{i=1}^{4} (1+x_i)$

where x_i – i-th local indicator of assessment of the financial component of economic potential (Table 4); n – number of local indicators for assessing the financial component of the economic potential of enterprises.

The integrated indicator is estimated in fractions of a unit, where the desired reference value is 1. According to the formula for calculating I_{afcep}, provided that all indicators correspond to the standard, i.e. $x_i=1$, the product of sums $(1+x_i)$ must be divided by 2^n, where $n=4$.

From the analysis of the dynamics of the I_{afcep} indicator of the enterprises it can be concluded, that at the desired value of this indicator ($I_{afcep} \geq 1$) for the analyzed period none of the enterprises reached this level. However, with the values of $I_{afcep} \approx 0.3$, the enterprises of PJSC "Northern MPP" and PJSC "Central MPP" had the value of the product profitability indicator as 37.4 % (2016 – Table 1) and 16.5 %, respectively – Table 1 and return on equity – 12.0 % (2016 – Table 4, Fig. 3) and 11.0 % (2015 – Table 4, Fig. 3), respectively.

Therefore, conducting the rapid analysis using the proposed methodological approaches allows:

1) to explore their limitations in achieving the desired efficiency of economic results;

2) to monitor its investment capacity for innovative development.

Table 4

Local indicators and integrated indicator for assessing the financial component of the economic potential of the Kryvbas MPP

| Indicator	Retrospective period years						
	2013	2014	2015	2016	2017	2018	2019
PJSC «Northern MPP»							
1. Return on equity, share un	0.277	0.066	−0.051	0.120	0.326	0.268	0.277
2. Absolute liquidity coefficient, share un	0.008	0.031	0.005	0.010	0.003	0.005	0.003
3. Financial stability coefficient, share un	2.772	2.605	4.226	3.728	1.015	1.195	1.605
4. Autonomy coefficient (financial independence), share un	0.735	0.723	0.809	0.788	0.504	0.544	0.616
5. I_{afcep}, share un.	0.476	0.288	0.107	0.275	0.737	0.656	0.518
PJSC «Central MPP»							
1. Return on equity, share un	0.234	0.139	0.110	0.372	0.383	0.283	0.203
2. Absolute liquidity coefficient, share un	0.252	0.062	0.459	0.037	0.069	0.022	0.016
3. Financial stability coefficient, share un	6.021	5.382	5.397	0.896	0.990	1.040	0.699
4. Autonomy coefficient (financial independence), share un	0.858	0.843	0.844	0.472	0.498	0.510	0.411
5. I_{afcep}, share un.	0.515	0.280	0.305	0.745	0.858	0.595	0.462
PJSC «Ingulets MPP»							
1. Return on equity, share un	0.270	0.084	−0.364	−0.008	0.397	0.294	0.306
2. Absolute liquidity coefficient, share un	0.003	0.005	0.004	0.000	0.001	0.001	0.003
3. Financial stability coefficient, share un	2.397	0.603	0.356	0.284	0.416	0.448	0.576
4. Autonomy coefficient (financial independence), share un	0.706	0.376	0.262	0.221	0.294	0.309	0.366
5. I_{afcep}, share un.	0.560	0.348	−0.243	0.124	0.635	0.538	0.667
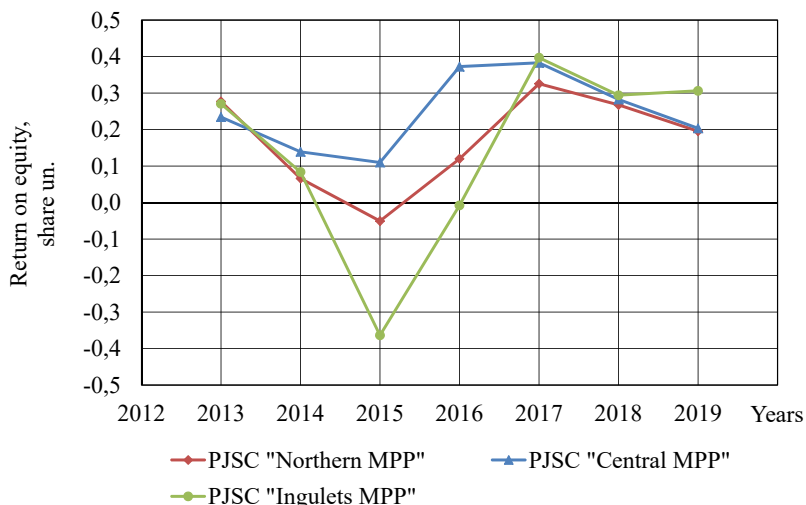
Fig. 3. Dynamics of return on equity of the mining and processing plants for the period 2013—2019
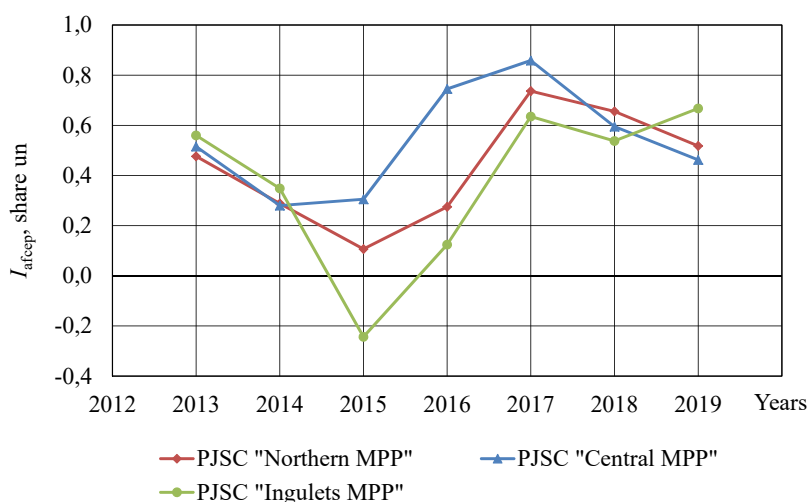

Fig. 4. Dynamics of I_{afcep} of the mining and processing plants for the period 2013—2019

6. Discussion of the results of the application of the comprehensive methodology for quantitative and qualitative assessment of the enterprise efficiency indicators

The application of the proposed methodological tools on the example of MPP allowed to establish the following regularities:

1) changes in the statistical probability of achieving a positive level of efficiency depends on the corresponding changes in its specified threshold value. The characteristic of change of the numerical value of probability is caused by changes in tendencies of dynamics of the indicator of efficiency (Fig. 1);

2) quantitative values of risk limits (limit probabilities of APR) in the given intervals of reliability at modeling of the forecasted values of efficiency indicators exceed the corresponding quantitative values of risk (statistical probability of APrR) (Fig. 2).

The disadvantage of the proposed tool for forecasting efficiency indicators can be considered a violation of the law (2) within the low and high values of fore-

cast reliability (p_{pr}>0.99 – PJSC "CMPP"; p_{pr}<0.69 – PJSC "InMPP"; p_{pr}<0.71 – PJSC "NoMPP"). However, this shortcoming can be considered insignificant, as the study should be conducted within the values of the interval of the forecast reliability p_{pr}=0.85÷0.95 (Fig. 2).

The peculiarity of the proposed methodological tools is that the forecasting of resulting performance efficiency indicators of the enterprise with the intensification of innovation and investment development is based on estimates of the maximum capabilities of top management, taking into account the financial component of economic potential. Here the following economic categories are divided into a single subsystem: "efficiency", "innovation and investment development", "financial and economic potential" and "risk" as an objective-subjective category. This allowed to form a comprehensive methodology for quantitative and qualitative assessment of actual and projected values of resulting financial and economic indicators of the efficiency of the enterprise to ensure its innovation and investment development.

At such statement for modeling of dynamics of the efficiency indicators on the basis of data of the express analysis of the enterprise functioning according to the data of the retrospective period we have:

First: the method of piecewise linear approximation is used. This, in contrast to studies [10], where it is proposed to calculate the probability of undesirable consequences on the basis of statistical data, allows to take into account the regularities of changes in the dynamics of the efficiency indicator (Fig. 1).

Secondly, the risk limits are taken into account when forecasting the efficiency indicators on the basis of the variance approach, where semi-variation and seven-square deviation are accepted as risk assessment (21), (22). Thus, forecasting of the efficiency indicators taking into account risk is carried out on the basis of limit theorems of the theory of probabilities of the law of large numbers that gives the chance to investigate them with sufficient reliability as random variables with an arbitrary law of distribution.

Third: the integrated multiplicative model is used to assess the financial component of the economic potential of the mining and processing plant, as its indicators are resulting ones of its activity efficiency, and therefore should be considered as a basis for innovation and investment development of the enterprise (Table 4, Fig. 4).

The study of forecasts of the probability of achieving the desired efficiency and the values of the integrated indicator for assessing the financial component of the economic potential of the enterprises allows to increase the level of economic justification of their investment capacity to enhance innovation under uncertainty.

The approbation of the developed technique is carried out within the limits of the express analysis of actual and

forecasted resulting indicators of the activity efficiency of the mining and processing enterprises of Kryvbas (Fig. 2). The calculations of the predicted values of the margin level to achieve the desired efficiency showed that this indicator takes place according to certain conditions at PJSC "Northern MPP" and PJSC "Central MPP". The results of the analysis for PJSC "Ingulets MPP" showed that this company does not have a sufficient level of margin to achieve the desired efficiency at $p_{pr} \geq 85$ %. It should be noted, that this MPP needs to strengthen the financial component of economic potential in order to intensify innovation and investment activities for the development of various functional areas and increase export supplies of a concentrate of the new Premium Class.

Forecasting of the efficiency indicators of the mining and processing enterprises is performed for the medium term (up to three years). This led to the choice of the dynamics of the calculated indicators – 7 years. This restriction meets the conditions for sampling the inital information, which should be twice the forecast period.

In the future, it is advisable to study the interaction of all components of the economic potential of the enterprise to improve the functional areas, develop appropriate strategies and implement innovation and investment opportunities to ensure sustainable competitive advantages.

7. Conclusions

1. An important step towards intensifying innovation activity is to ensure the process of its financing. This emphasizes the importance of constant adaptation of enterprises to changing conditions, based on modeling and forecasting future trends in efficiency in the context of intensifying innovation and investment development, taking into account the financial component of economic potential. Accordingly, the comprehensive methodology for quantitative and qualitative assessment of actual and projected values of effective financial and economic indicators of enterprise efficiency to ensure its innovation and investment development has been developed. This technique differs from the classical approach in that it allows to take into account estimates of the levels of the projected indicator.

2. When forecasting the results of the enterprise by presenting the dynamics of the indicator by piecewise linear approximation, it is possible to clarify the value of the forecast probability for different values of the profitability indicator. At lower values of the indicator, segments of shorter length are cut off and the ratio of these segments to the total length of the retrospective period will provide lower values of the forecast probability. Quantitative values of the forecasted indicator are calculated in the set interval of reliability of the forecast. To determine the final values of this indicator, they are evaluated taking into account the negative deviations. This allows us to investigate with sufficient reliability the performance indicators of the enterprise as random variables with an arbitrary distribution law.

3. The results of economic and mathematical modeling of the predicted values of efficiency allowed to establish the margin level LMADE for enterprises as the difference between the quantitative values of risk limits and the corresponding quantitative values of risk These values are calculated by the method of statistical probability, related to the quantitative values of the risk limits (limit probabilities of APrR). In particular, the calculations showed that the more difficult situation in terms of the forecast of achieving a positive result (ensuring the reliability of the forecast ≥ 85 %) is demonstrated by the company PJSC "Ingulets MPP", which does not have a proper LMADE.

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