In a monography written a new solution and theoretical generalization of the problem, which is to build methodological principles, approaches and conceptual tools of analysis, mathematical modeling and management of investment activities on coal mines. The system of factors affecting the investment processes on coal mines expanded and analyzed. Determined the relationship between these factors, the volume of investment and profit of the mine. The system of economic and mathematical models built. It allows to obtain important information for making investment decisions on coal mines, which includes: defining the investments that mine can do from their own means and determining profits in case the implementation of any project. The problem of optimal distribution of investments in coal mine for 12 th kinds solved, the solution allows to maximize profits by identifying the mine on the types of investments.

Born in 1951 in the city of Dnipro. I received higher education in the specialty "Automation and telemechanics" at the mining institute of the city of Dnipro and after twenty years of of break return to my “alma mater”. It is an active work in the field of microeconomics and I have a hundred publications on this topic.

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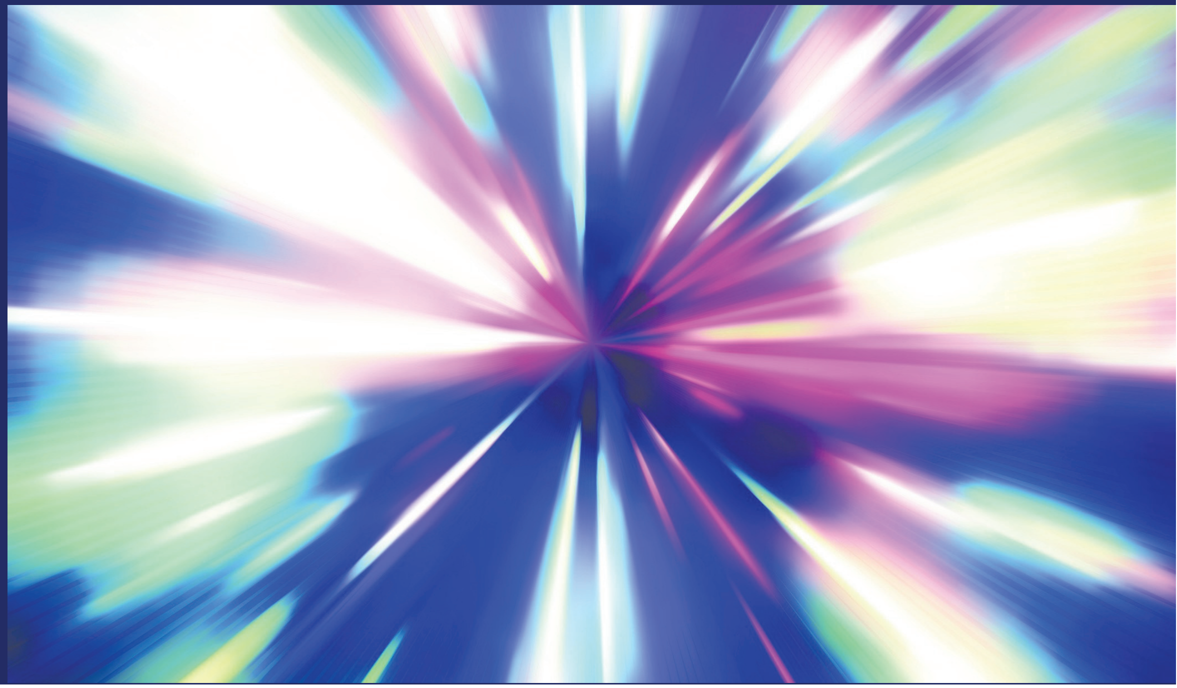
Neural Model of Investment

Pistunov, Churikanova



Ihor Pistunov
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Optimization of the neural model of investment

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Introduction

Investment activity in the coal industry should be strengthened in connection with the decision of the Ukrainian Government regarding the possible privatization of the entire coal mining industry. Obviously, for investors it will be interesting to calculate the amount needed for profitable activity of the mine. But investors' resources are limited. Therefore, in the period of limited investment resources, the efficiency of their rational use becomes the forefront. To solve such problems, an improved methodology for optimal distribution of limited investment resources is needed, which is tailor-made for the coal mining industry, taking into account those features that may have an impact on the efficiency of investments. This testifies to the urgency of the problems posed and solved in the dissertation research

The study of the management of investment activities is devoted to the study of a large number of domestic and foreign scholars [1-41, 50, 57, 67], but their research does not exhaust the whole complex of issues related to this problem.

All of the above-mentioned scholars have done their job in determining the qualitative factors that influence the profitable activity of the coal mine. By this time, there was no development that could accurately calculate the investment needs of a specific coal mining enterprise in all existing investment directions. Thus, the calculation of investment needs is an urgent need of the present, and why this work is devoted.

To solve this problem, scientific research was carried out in the following directions:

- Identify the main types and directions of investment, determine the objectives of investment activity in coal mining enterprises;
- Systematize and disclose the economic composition of the principles laid down in the basis of evaluation of the effectiveness of the investment project;
- to study the mathematical apparatus of neural networks in order to improve the formation of investment needs in coal mining enterprises;
- Systematize factors that influence investment activity in coal mining enterprises;

- To conduct a study of the numerical indicators of the work of coal mines in Ukraine;
- Identify statistically significant factors that influence the efficiency of investment activities of coal mines;
- Develop an economic and mathematical model for creating optimal investment plans for coal mining enterprises, an economic and mathematical model for determining the profit of a coal-mining enterprise from the implementation of investment projects and a method for creating optimal investment plans in order to maximize the profit of a coal mining enterprise based on the application of neural networks.

Chapter 1
Theoretical bases of management of investment processes at a coal mining enterprise

1.1. Characteristics of the coal mining enterprise as an investment object

According to the Law of Ukraine on investment activity N 1561-XII of 09/18/91, investments are all types of property and intellectual property that are invested in objects of entrepreneurial activity and other kinds of activity, resulting in the creation of profit (income) or the social effect is achieved [1]

Objects of investment activity can be any property, including fixed assets and working capital in all branches and spheres of economy, securities, target money deposits, scientific and technical products, intellectual property, other objects of ownership, as well as property rights.

Investors are the subjects of investment activity, which make decisions on investing their own, borrowed and attracted property and intellectual property in investment objects. Investors can act as depositors, lenders, buyers, and also act as any member of investment activity.

Investment activity can be carried out at the expense of:

- - own financial resources of the investor (profit, depreciation, reimbursement of losses from accidents, natural disasters, monetary accumulation and savings of citizens, legal entities, etc.);
- - borrowed funds of the investor (bond loans, bank and budget loans);
- - borrowed funds of the investor (funds received from the sale of shares, share and other contributions of citizens and legal entities); budget investment allocations;
- - free of charge and charitable donations, donations of organizations, enterprises and citizens [1].

Investments in the coal mining industry have played and will play a significant role in its development. Having a well-planned investment policy is a key to maintaining the industry's capacity at an appropriate level. Investments in the mine have a direct and indirect impact on all its components. But investment resources always have the property of limitation, so most of the mines in Ukraine are able to fully provide their investment plans with cash resources. Therefore, any mine is constantly faced with the choice of the most optimal investment directions in order to maximize profits, therefore, the problem of choosing these areas and calculating the expected economic effect is always relevant.

At the coal mining enterprise, as well as in any other, investing is an investment of capital in order to generate income in the future, which compensates the investor for postponed consumption of the expected growth of the general level of prices and the uncertainty of obtaining future income (risk) [2].

The purpose of investing is to find and determine such an investment method, which would provide the desired level of profitability and minimal risk [3].

Sources of financing of investment projects of the coal mining industry can be:

- funds of the state budget, provided in corresponding financial plans for state enterprises;

- own funds of the enterprise consisting of a part of profit and amortization deductions;

- bank loans (long-term and short-term);

- borrowed funds received from other enterprises under certain conditions [4].

Taking into account the investment attractiveness of the majority of coal mining enterprises, the state budget funds (including funds from state investment and innovation funds) and the own funds of coal mining enterprises are accepted as the main sources of financing of the industry. Other sources of investment (private domestic and foreign investments, local budget funds, foreign loans, etc.) because of investment unattractiveness played and will play a secondary role in the future [4].

In order to increase profits, it is necessary to develop a mechanism for the introduction of methods for generating production costs on the basis of process-normative planning, accounting, costing and control of costs in the places of origin and centers of responsibility at all stages of the reproductive cycle (design, capital construction, coal engineering, coal mining, coal extraction); actively and skillfully engage in the investment sphere of commercial private capital, saving the population in favorable for investors effective investment objects that give an investment profit with guaranteed receipt in clearly defined terms. In order to increase extrabudgetary investment resources, it is expedient to lease previously built surface and underground buildings, as well as the construction of stopped enterprises and industries, unfinished construction objects and, from the funds received, to form an industry guarantee investment fund. At the same time, it is necessary to increase the role of profit among the investment resources of coal-mining enterprises [5].

To increase the investment attractiveness of coal mines available in the state register of Ukraine, it is possible if potentially increase the profitability, as well as the competitiveness of manufactured commodities and demand for it. In crisis conditions, the current transition of coal mining enterprises to multi-product production is the most effective measure in conditions of not yet stable energy market [6].

In 2007, the first stage of denationalization of mines was virtually completed. Among them there are 28 enterprises with a total industrial reserves of 1.7 billion tons of coal and a total production capacity of 29.5 million tons per year. In 2008, the share of these enterprises in the total gross Ukrainian production was 43% [7].

A significant role in the development of the coal mining industry can be played by private investment. As an example of the positive impact of private investment, the mine Krasnoarmiiska-Zapadnaya №1 can be considered. In 2000, this mine was privatized and privatized. Since then, the mine had no public investment, but only private. Coal production has grown noticeably from 1.2 to 6 million tons.

By type of investment are divided into [8]:

– investing in financial assets;
– investing in non-financial assets;
– investment in tangible assets;
– investing in intangible assets.

It is possible to distinguish two types of portfolios of securities: an individual and a portfolio of the enterprise.

An enterprise can attract cash from the issuance of securities (passive transactions) and invest in cash in securities of other issuers (active operations) in order to obtain additional profit or to maintain and increase capital [9].

In fact, a very small percentage of the total investment resources of the mines invest in financial assets, although this type of investment is not profitable for the industry. This is due to the limited investment resources, the presence of more priority areas of investment and the lack of positive experience in investing in financial assets.

Investing in non-financial assets means investing in precious stones, precious metals, collectibles. This kind of investment is not typical of the coal mining industry and is practically not practiced at all.

The most priority investment in the mine is investment in tangible assets, which includes investment in industrial buildings, structures, machinery, equipment, construction of residential and other premises. The material base of a coal-mining enterprise always requires cash investments, so when investing in investment plans, investment in tangible assets is classically becoming the first place.

According to the Law of Ukraine "On Investment Activity", investments aimed at reproduction of fixed assets and the growth of inventories are made in the form of investments. Investment - is a monetary expression of the total cost of creating new, expansion, reconstruction, technical re-equipment of existing enterprises and renovation of fixed assets, the introduction of new technology in the manufacturing industries, construction of objects in all sectors of the social sphere and implementation of design and exploration. Thus, investment objects are production fixed assets, current assets (inventories), fixed non-productive assets, as well as expenses for the reproduction of fixed assets [9].

Although in an insufficient volume, but in the coal mining industry, investing in intangible assets takes place. This type of investment at the mine means investing in knowledge, retraining of staff, health care, research and development. Research, development and introduction of innovations at a coal mining enterprise have a direct impact on the growth of technical and economic indicators of the work of mines, but the investment in this area is not enough. Investing in research and development is directly related to the fact that a certain volume of material investments is planned, for example the purchase of new equipment. The real situation in the industry is that the technical re-equipment of mines and related investments in personnel training, research and development are relatively slow. In Donetsk region together with the National Academy of Sciences of Ukraine a program of scientific and technical development of the Donetsk region up to 2020 was developed, one of the key points of which is the introduction of highly profitable innovative and investment projects capable of sustainable development, rapid return on investments and accumulation of own capital, to put the beginning of progressive changes in the structure of production and trends in its development [10].

According to the classification of investments by investment objects, investments are divided into real and financial ones.

In modern Ukraine, the fundamental changes in economic and, especially, investment relations are accompanied by a rethinking of the essence of many economic categories, and in the first place such as "investment activity", "investment", etc. As in the orientation of the economy to market and economic relations are expressed in the relevant categories and require a clear definition and effective management [13].

By definition, which is presented in the Law of Ukraine "On Investment Activity" and which most researchers agree, "investment activity" - this is a set of practical actions of citizens, legal entities and the state for the implementation of investments [1].

The multifaceted basis of investment activity, in particular the category of "investments", has defined a wide range of their forms.

Among the small number of classification of investments in forms it is necessary to highlight their characteristics, which are given in the works IO Blanca [14] and AA Transplants [9].

In general, in the context of rising prices in the world of energy resources, it should be more rationally applied to the coal mining industry. The coal reserves are not exhausted and can serve Ukraine for another century. Therefore, it is necessary to pay attention to the mine as an investment object. Thus, the creation of optimal investment plans at unprofitable mines can serve their recovery, since the construction of new mines is much more expensive for the state. If it is possible to attract investments to every unprofitable mine, its restoration will cost ten times cheaper than building a new one, which may take at least 10 years.

Over the past decade, radical economic transformations have dramatically changed the character of the functioning of Ukrainian coal-mining enterprises. They have virtually complete economic independence, the movement of goods and prices are increasingly subject to market requirements. The mining of state-owned mines has begun. Along with state investment in the industry also appeared private. Much attention is paid to the integrated economic analysis of mines when making investment decisions.

1.2. Economic analysis of the coal mining enterprise in determining the main directions of investment

As a rule, a comprehensive economic analysis of organizations includes an analysis of economic processes, their socio-economic efficiency, and the final economic and financial results of activities that are formed under the influence of objective and subjective factors. A characteristic feature of economic analysis is not only the identification of trends and patterns of the functioning and development of organizations, reserves, lost opportunities, but also the development of practical proposals and recommendations for improving their activities. It is expedient, especially in coal mining enterprises, to consider economic analysis in terms of a systemic approach. One can distinguish the following most important principles of the system approach (system analysis) [15]:

1) the decision-making process begins with the identification of the most important problems and the precise formulation of the specific objectives of the system;

2) when considering the problem as a whole, all the consequences and interconnections of each private decision should be identified;

3) it is necessary to identify and explore possible alternatives to solving the problem and achieving the goal;

4) the goals of individual subsystems must be coordinated with the goals of the whole system;

5) in the process of analysis it is expedient to switch from abstract to concrete (from the wording - to the quantitative estimates);

6) it is necessary to identify the links between the elements of the system, to investigate their interaction.

Compliance with the above principles of enterprise analysis is a prerequisite for creating effective investment projects.

The purpose of implementing one or another investment project is to restructure it in order to improve the efficiency of the operation. When deciding on a restructuring, as well as on investing, an analysis of the object under study is mandatory.

Thus, it is necessary to analyze the financial condition of the enterprise, the structure of capital and the level of its maneuverability. This will make it possible to establish the investment attractiveness of an object, since the value of an enterprise is determined not only (and not how much) the value of the property, as foreseen by the corporatization project, but also the prospects for its development, the maneuverability of capital in the event of a change in market conditions. It is also necessary to analyze the assets of enterprises in terms of efficiency of their structure, business activity, efficiency of the use of financial resources. In particular, the analysis of the structure of assets of coal enterprises indicates that, in addition to objective reasons related to changes in mining and geological conditions and technical development lag through these changes, the very role of low profitability of enterprises plays a very irrational use of available resources: the amount of shortage and damage, as well as other expenses for which the enterprise has not determined the source of coverage. Thus, for some in a number of enterprises, 5-10 times exceeds the sum of all production stocks [16].

To a certain extent, the effectiveness of investment projects supporting the capacity of mines is the relationship between the share of changes in the value of innovation and the share of increase in mine capacity and labor productivity: the ratio of growth of specific capital investments to reduce the cost of coal mining and to change the concentration of mining robots and payback periods. These relationships are necessary to determine the essence of the behavior of the mine as a system and characterize the function of the mine movement system and its phase space. On the basis of iterative comparisons of investment project variants and numerical comparisons of cost indicators and results of these costs, as well as assessing the possible consequences, a specific mine policy is being developed [17].

In the coal mining industry, as in any other field, there is a common desire to match the needs and possibilities of their satisfaction. For example, the volume of production is related to the volume of stocks; the use of the latter - with the availability of manpower, the provision of means of labor. Production output should be consistent with the needs of the market. In turn, the degree of satisfaction of the market directly depends on the solvency of the enterprise. Such an interconnection implies a balance. Compliance with the theory and practice of reproduction of a cumulative social product determines the content of the balance method.

Analysis of the balance sheets of coal mining enterprises shows that despite the sharp change in the mining and geological conditions, the mines do not use intangible assets (licenses, patents, know-how), which allow to reduce the cost and increase profits. Mining enterprises practically do not participate in the financial market: they do not form financial assets that give interest income, do not use attraction of long-term borrowed funds for investment projects by issuing long-term debt obligations, do not use modern forms of settlements (for example, domiciliation of bills), which allow reducing receivables. All this also reduces the efficiency of the use of financial resources [16].

One of the most important indicators of the efficiency of the mine is the volume of assets, which shows the amount of use of fixed assets for the production of one unit of production.

A distinctive feature of the mining industry is the high level of capital intensity of production. High resource availability and low profitability lead to the fact that the costs of forming the main production facilities are covered by own means, while the lifetime of most of the fixed assets is inextricably linked with the life of the mine [16]. Thus, the majority of mines have a low technical level of fixed assets, therefore the real investment needs of an individual enterprise are very high.

Many of the authors [18, 19, 20, 21, 22] believe that the specifics of coal production, which is expressed by the high degree of concentration of labor and other productive resources in the unit of mined minerals, does not find its adequate reflection in the corresponding methods of technical and economic influence . This is due to the fact that the share of these costs in their overall structure significantly exceeds similar indicators of other industries, and their minimization is complicated in the existing methods of extraction of minerals. Already, enterprises of the coal industry are in unequal economic conditions compared to other industries [23].

Ability to increase and stabilize the mine in terms of extraction is determined by the "level of development of production capacity". It is important that the higher the value of this indicator, the less capital investment is needed for the mine in order to increase its production capacity, and therefore the smaller amount of investment needs to be invested. Studies [24, 25] prove that "the level of development of production capacity" should be not less than 90%.

The main areas of investment in the mine are determined by its investment policy. If the definition of the term "investment policy" is briefly described, then this is a set of measures that determine the direction and amount of investment at the set time. The investment policy of a coal-mining enterprise has its own goal of reproduction (simple or extended).

The directions and volumes of investment in a coal mining enterprise are determined by such parameters as the nature of reproduction and its general condition, including economic and non-economic aspects.

Due to the fact that the resources of any minefield are limited and eventually fully developed, there is a need for the development of new plots, which in turn leads to the aggravation of investment policy.

Also, one of the features is the high volume of passive fixed assets in the form of mining workings.

It is generally accepted to assess the state of the mine by the coefficient of economic reliability [26]. Prospective mines capable of maintaining production capacity have a coefficient of economic reliability of 1.2 to 1.5. In case of maintenance of the coefficient of economic reliability at such a level, the amount of necessary investment may be insignificant, but if the capacity of the mine will increase, there will be a need for additional capital investments.

In addition, it is very important to take into account the uncertainty and, most importantly, the level of costs to improve the parameters that determine the level of economic viability of the mine and its investment attractiveness. Economic reliability is a consequence (and inert) of some decisions, because it is more important to evaluate the solutions themselves, that is, their individual vectors [27].

In addition, for mines as a mining company, the value of residual mineral reserves is of paramount importance. Accordingly, the index of economic reliability consists of three elements: the indicator of technological reliability, the indicator of economic level and the index of geological reliability. Simultaneous evaluation of the three main components of the mine avoids the one-sidedness inherent in the use of one indicator, even sufficiently wide, such as, for example, cost or profitability. Experience shows that the wells in one respect of mines are not necessarily safe in general. For example, a mine with a high degree of mechanization may have few stocks, or a high cost of coal mining [4].

Thus, based on the foregoing, we conclude that the economic analysis of the mine as an investment object requires consideration of a certain selection of factors, but the analysis will not be complete and reliable, if not to evaluate all factors, using different approaches:

– integrated approach;
– an integration approach aimed at researching the interconnection between factors;
– marketing approach;
– functional approach;
– subject approach;
– dynamic approach;
– playback approach;
– process approach;
– normative approach;
– quantitative approach.

To solve such an extended task, it is necessary to use a powerful economic and mathematical apparatus, which, in addition to a certain selection of financial and economic indicators, would include a factor of time as a necessary parameter for improving the accuracy of the analysis.

1.3. Theoretical approaches to determining the efficiency of investments in a coal mining enterprise

The problem of increasing the efficiency of capital investments has always been and remains one of the most important economic problems. Since the Soviet Union, many issues have been devoted to this problem, in which different perspectives were considered, and various official methodological and regulatory documents were developed.

Ukrainian economist Goyko AF in his paper "Methods of assessing the effectiveness of investments and priority areas for their implementation," believes that the former methods for evaluating capital investments and new technology were developed mainly for the conditions of a costly economy and a free lending system. And such indicators of the assessment of the efficiency of capital investments, as the coefficient of efficiency and the payback period, had their disadvantages. In their calculation, often used values that can not be compared: the profit was taken into account in the future value, and investment - in the current. The payback rate was determined, as a rule, based on the balance profit, rather than from the cash flow, which includes the amount of net profit and depreciation. Regarding the normative coefficients of economic efficiency, they were asked in a directive, without sufficient justification and without taking into account the time factor [34].

In place of the old methods of calculating the investment efficiency that was used during a planned economy, the methods of calculating the economic efficiency of investments that were used in industrialized countries were borrowed at the initial stage of the Ukrainian economy restructuring.

International practice of evaluating the efficiency of investments is based on the concept of estimating the value of money in time. To compare different projects or variants of one project and choose the best of them is recommended using the following key indicators [35, 36, 37]:

– present Value - PV;
– net Present Value (Net Present Value) - NPV (analogous to the NDP in the Soviet methodology for evaluating the effectiveness of investment projects);
– profitability Index (PI); internal rate of return (IRR);
– modified Internal Rate of Return (MIRR);
– payback Period - PP;
– discounted payback period (DPP);

the rate of return on investment (ARR).

If NPV is positive for the given discount rate (NPV> 0), then the project can be considered effective and consider the issue of its acceptance or further analysis. The higher the value of NPV, the more effective the project. If NPV <0, then the project is considered ineffective.

To determine the NPV you can apply a modified method. The use of the modified NPV is based on the ratio of disbursed IP investments spent with total disposable cash inflows. In this case, the NPV is calculated for a constant discount rate.

The use of none of the listed indicators is insufficient to make a decision on project implementation. The decision to invest the project should be taken taking into account all the considered indicators and interests of the participants of the investment project [38]. In each case, it is necessary to focus on the criteria that, in the opinion of the project management, are more important or to take into account the additional objective and subjective factors.

Some Ukrainian scholars and economists consider Western methods to be benchmarks and suggest copying them for Ukraine's conditions. To calculate the economic efficiency of investments, the recommended methodology as a whole or some of its components in its work is offered by such Ukrainian and Russian economists as Bocharov V. Ya., Voronov K., Gridchina MV, Savchuk V. P., Fedorenko V G., Vilensky P.L., Livshits V.N., Orlova ER, Smolyak S.A. etc. [39, 40, 41, 42, 43, 44].

For example, E.M. Chetyrkin believes that the measure of the efficiency of investments is the NPV [45].

But, despite the fact that the methods of evaluations of investment processes, the conditions of their application and requirements for their initial information are determined and worked out by international practice of developed countries, one should not rely on their versatility and perfection. Many Ukrainian economists and scientists believe that they are unsuitable for use without thorough study of specific conditions and taking into account the specifics of socioeconomic processes characteristic of Ukrainian society.

Yes, P.A. Orlov, taking into account the specifics of our economy, in his article "Determining the Effectiveness of Real Investments" [46] according to the specifics of our economy, instead of literary translation of NPV "net present value", uses the term "net current result" or "project revenue".

He believes that the formula of the net current result (income) of a real investment project, taking into account the cost estimation of the accompanying social and environmental benefits, is more convenient and clearer:

$$NPV = \sum_{i=0}^{T} (П_t + A_t + E_t - H_t + Л_t)(1+i)^{-t} - K_{\Sigma},$$

where T – the duration of the calculation period, years; $П_t$ – profit from project implementation for the year t; A_t – depreciation for renovation in a year t; H_t – profit tax for the year t; t – year, the results and costs of which are equal to the calculated; K_{Σ} – total capital investments for the project implementation, are given up to the initial time; E_t – cost estimate of the associated social, environmental and economic benefits received during the year t; $Л_t$ – liquidation surplus or sales revenue from disposal of fixed assets in year t with the exception of sales costs; i – discount rate in units of unit.

Efficiency of expenses on increase of labor productivity will characterize coefficient:

$$E_З=P_З/P_м.$$

Therefore, in the opinion of the author, in the methods of determining the effectiveness of investments, capital investments, new technology, rationalization proposals and other measures aimed at increasing social productivity, it is important to emphasize the fact that it is advisable to select the best options not for the indicator com comparative economic efficiency E, and by the indicator of the DN or indicator E3. The limited resources of society, which it can direct to increase labor productivity, requires the introduction of regulatory factors that would determine the minimum allowable level of efficiency of labor replacement costs. The role of such a norm was fulfilled by that time, the normative coefficient of comparative economic efficiency of En. In the transition to the definition of efficiency on the E3 indicator, it will be necessary to introduce the Ezn standard, which should characterize the minimum permissible level of efficiency of the costs of substituting the workforce.

The task of selecting a project for investment is extremely important for a potential investor. In the issue of evaluating the investment project, there are still a number of discussion issues. Still actual development of the strictest definitions of the concepts used and the scope of applicability. The importance of decision making in the sphere of investment calls for the improvement of existing methods.

In the work of Bilenko VZ the indicator "internal rate of profitability of the project" is analyzed in relation to the indicator "induced rate of profitability". The project is evaluated by the entity implementing the project. There are two types of projects - single and multiple use. Each type has its own profitability indicator.

Estimates are built from the point of view of the economic environment in which the firm operates [50].

For a one-time project Bilenko V.Z. suggests using the Induced Rate of Profitability of a Project (INP) as an indicator of project efficiency and an internal rate of return (GNP) for a replicated investment project:

1. Induced rate of return.

So, the induced rate of profitability of the project is called the value

$$\mu(\rho) := \sup\{x \in R_+ | \Phi^\rho(x) > 0\}, \quad (1.1)$$

where: $\Phi^\rho(x)$ – yield function; R_+ – vector of financial flows; ρ – deposit rate; x – analytical borrowing rate.

It is generally accepted that supremum in an empty set is considered to be equal $-\infty$; on the other hand, if all the semicircle is positive R_+, then $\mu(\rho) = +\infty$.

This definition applies to any project. The term "induced" is underlined by the fact that the indicator (1.1) depends on the deposit rate ρ, induced by it. If the value is not favorable, then such a project is deliberately unprofitable and it makes no sense to consider it; in this case $\mu(\rho) = -\infty$. Otherwise, for an investment project a ($a_0 < 0$) value μ finite; it is the root (only) of the equation $\Phi^\rho(x) = 0$, $x > 0$, and the function $\Phi^\rho(x)$ positive (project profitable) at $x < \mu(\rho)$ and negative (project is unprofitable) at $x > \mu(\rho)$. Therefore, the concept introduced has a clear meaningful meaning: INP $\mu(\rho)$ – This is the maximum amount of the borrowing rate (at this value ρ deposit rates), in which the project is profitable (brings a positive income).

Although theoretically, the analytical borrowing rate across the entire hemisphere is considered here R_+, but its real possible values lie in the area $x \geq \rho$. Then if $\mu < \rho$ ($\Phi^\rho(\rho) < 0$), the project is ineffective and should be discarded from it; otherwise, provided $\mu \geq \rho \Leftrightarrow \Phi^\rho(\rho) \geq 0$, the project is called effective.

Internal Rate of Return (GNP) of the duplicate (investment) project a in (ρ,σ) - environment is the pace (indicator) of revenue growth for a portfolio of projects

$$\wp = \{a, \rho.\sigma\}:$$

$$\nu := \lim_{T\to\infty} V(T)^{1/T},$$

wherte ν – internal rate of return; T – investment horizon; $V(T)$ – income.

This definition is complete; it includes three fundamentally different situations:

1) $P_a(\rho) \le 0$ – in this case, the project is not effective, and the portfolio has a growth rate $\nu = \rho$, achieved by simple deposit;

2) $P_a(\rho) > 0$ – the project is effective, here are two cases:

2a) $P_a(\rho) > 0 \forall x \in [\rho, \sigma]$ – it's the opposite of degeneration, then $\nu = \infty$;

2б) equation $P_a(x) = 0$ has at least one root; this case is the main one, there is also a polynomial P_a which is equal to the smallest root α , in the range $(\rho, \sigma]$.

Suprun S.D. proposed an approach in which the project evaluation process is considered as a set of interconnected elements. Thus, on the basis of a generalized indicator, there is an opportunity to make a final decision on the effectiveness of the analyzed project [54].

Yes, the project is divided into two main indicators – a criterion $F_1 (x_1, \ldots, x_5)$ – based on discount estimates; F_2 (x_6, x_7) – based on accounting estimates:

$f(x_1)$ – pure reduced effect (NPV);

$f(x_2)$ – return on investment (PI);

$f(x_3)$ – Internal Rate of Return (IRR);

$f(x_4)$ – Modified Internal Rate of Return (MIRR);

$f(x_5)$ – discount payback period (DPP);

$f(x_6)$ – payback period of investments (PP);

$f(x_7)$ – коефіцієнт ефективності інвестицій (*ARR*).

At this level of analytical work it is also important to find out the relationship and contradiction between the criteria considered.

So, depending on the criteria for the effectiveness of the investment project chosen as the main company, diametrically opposed conclusions can be drawn.

Consequently, by conducting this research, we can conclude that the evaluation of the effectiveness of investment projects is a generalized methodology without taking into account the characteristics of the enterprise and the possibilities of its optimization [55].

The coal mining industry receives most of its investments in the form of public funds. The state provides funds for technical re-equipment of mines according to business plans of coal mining enterprises [56].

Recently such business plans were prepared in accordance with the guidelines [57]. But today a new method of technical re-equipment of mines is proposed [58], the final version of which [59] is based on the following basic principles, such as:

- firstly, unlike the previous practice, the economic efficiency of technical re-equipment of mines should be evaluated not by conditional indicators, but by a real change in the final financial results of the work of mines taking into account all factors;
- second, investments in the technical re-equipment of mines should be paid off by means of the abolition or reduction of subsidies - state support for the partial covering of expenses on the cost of production, as well as by paying taxes and special deductions from the profit of enterprises, which as a result of re-equipment become profitable.

Chapter 2
Theoretical principles of management of factors determining the investment activity in a coal mining enterprise

2.1. Conceptual provisions for determining the optimal investment plans for a coal mining enterprise

Management of investment activity at coal mining enterprises has its peculiarities in comparison with the classically known methods and methods of investment management at other enterprises. Even in the middle of the industry, at each individual mine, the specifics and nature of investment processes can vary significantly. This is due to the fact that the efficiency of the coal mining enterprise is influenced by a large number of factors, among which geological conditions occupy a significant place, which determine the necessity of investing in the renovation of the mine fund. It is from the geological factors that the investment in the purchase of one or another equipment, buildings, carrying out the necessary research and development, training of personnel depends. Therefore, the application of classical investment management techniques at the mine is not effective, because it does not take into account the specifics of its work.

All of the above methods of evaluating the effectiveness of investment projects do not allow for optimization. Do not take into account the peculiarities of the functioning of the enterprise. Their essence is only to choose the project with the best indicators according to the established criteria. The assessment of the effectiveness of investment projects should be adjusted to take into account changes in input factors that are typical for the coal mining industry, that is, the level of profit required for the investment project.

An important task in managing investments in a coal mining enterprise is to establish a link between factors that affect the level of profit. Coal Mine is a complex economic system, whose investment effectiveness is influenced by a large number of indicators. In order to construct economic and mathematical models of investment activity management, it is necessary to select a number of the most influential factors that determine the amount of investment and optimality of investment distribution.

At the current stage of economic development, such a concept as investment activity is inextricably linked with innovation processes. It is from innovations that the achievement of high and stable rates of economic growth depends. The development of only extensive factors in the coal mining industry does not provide accelerated renewal of fixed assets, product quality and competitiveness.

The legislation of Ukraine defines innovation activity as "one of the forms of investment activity undertaken for the purpose of implementing NTPs in production and social sphere" [62].

Innovations are designed to address the following issues in the coal mining industry:

1. Issue of a new product, or a known product of a new quality.
2. The introduction of a new, still unknown in a particular field of production method.
3. Penetration into a new market - known or unknown.
4. Receiving new sources of raw materials or semi-finished products.
5. Organizational restructuring, in particular the creation of a monopoly or its liquidation [63].

At present, such conditions as the exhaustion of natural resources and the complication of extraction processes, the stiff competitive conditions, etc., have developed in the coal mining industry. In this regard, the release of new technologies and products becomes a decisive factor in the growth of production efficiency and, consequently, its profitability.

Innovation and investment activities are very closely interconnected, and they have a direct impact on each other. When making decisions on the creation of investment projects, investors consider the activity of coalmining enterprises in terms of performance indicators by various factors in order to improve these factors through innovations.

Thus, the quality of innovation depends on the amount of investment - the more effective the innovation, the less in the future, the mine will need investment. After the introduction of new technologies at the enterprise, savings are started when using different factors of production, because the introduction of innovations allows them to be used more rationally. The same applies to limited natural resources.

As a rule, innovations are designed to increase the profits of an enterprise, which is obtained through the production of better and more competitive products. The value of profit, in turn, depends on the size of the revenue expected from innovation, start-up costs, the level of profitability from innovation for a certain period of time, the cost of innovation, the amount of discounting of future income and expenses.

But, unfortunately, at this time, investment in the introduction of innovation is not a common phenomenon in the coal mining industry, although the needs of enterprises in Ukraine for coal mining in them are very high. Most Ukrainian mines do not have the money to purchase innovative equipment, technologies, etc. Therefore, for most coal-mining enterprises, investment processes far outweighs innovation.

At this time, there are many methods for determining the commercial and budgetary efficiency of investment in the real economy. It uses indicators such as net discounted income, profitability index, internal rate of return, payback period, other indicators reflecting the interest of the participants or the specifics of the project.

Analysis of the essence of the listed indicators shows that on the basis of them it is possible to state the profitability of the project, but it is impossible to determine ways of improving the mechanism of the investment process, since they state the level of efficiency of capital investments without identifying the factors that determine the achieved level of efficiency.

Therefore, there is a need to deepen theoretical developments regarding the essence of the investment and innovation process and identify the factors that should be regulated by managerial decisions in order to increase the efficiency of innovation processes at enterprises, in the region and in the country as a whole [64].

Thus, the definition of factors that affect the investment processes in enterprises is one of the most important issues, its solution to increase the efficiency of the latter.

In analyzing the factors affecting the overall effectiveness of the investment project, it is impossible to use general factors for industrial enterprises. The coal mining industry has its own peculiarities both in economic and technical terms, and therefore requires the establishment of its set of indicators for the management of investment processes.

Thus, the classification of factors that determine the investment situation in the industrial complex is to justify such approaches, which will ensure the consideration of both purely sectoral and territorial changes and their mutual influence. At the same time, it is necessary to keep in mind the traditional factors that determine the course of the investment process and, in fact, the consequences of market reform of the whole system of economic relations in the whole region, and not only in the investment sphere.

In the literature, the economic status of an object is usually described using a system of indicators. Deviation from the normal state is determined by measuring the values of the indicators and their deviations from some standards or standards. Therefore, the task of assessing the investment potential of an enterprise is essentially in determining the appropriate set of indicators and the establishment of reference values.

As shown by the analysis of domestic and foreign literature, the state of sectoral complexes can be described by several dozen (and maybe more) groups of indicators that take into account the influence of both internal (intersectoral) and external (economic and legal environment) factors of economic growth. But the use of a very large number of indicators can complicate both the computational process itself and the interpretation of results. Therefore, there is a need to develop the most rigorous framework for the applicability of factors affecting the investment processes of the coal mining industry.

One of the main features of the coal mining industry is that the production of a product at coal-mining enterprises does not occur in the production process, but only isolated from the natural environment.

The product obtains only in one link - mining operations, the function of other parts of the mine is to save the system, they do not create other products at all and do not change the product obtained from the "mining" section. Thus, the mine can be considered as a complex economic system, and mine reserves can be attributed both to the economic and geological categories. In this connection, recently it is proposed to assess the state and level of investment attractiveness of mines on the criterion of economic reliability, which synthesizes three elements: the indicator of technological reliability, the coefficient of economic level and the index of geological reliability. Such a complex indicator more fully characterizes the mine than any individual (cost, productivity, profitability, etc.). The index of economic reliability can be attributed to a separate production process and to the mine as a whole [26].

The evaluation of the mine on the criterion of economic reliability avoids the one-sidedness inherent in the use of one indicator, even if rather synthetic, such as, in particular, the cost price of coal mining or profitability in the case when the mine is profitable. Inadequate also purely technical characteristics, such as the power of the enterprise, the state of fixed assets, residual geological reserves. Experience shows that the prosperity of one of these indicators of the mine as a whole does not necessarily belong to the number of well-off in general. Thus, large residual reserves may be in the mine and with unfavorable mining and geological conditions, and with high cost of coal mining. Physical content of the proposed indicators is uneven and this fact allows for their joint use to get more complete than when using any one indicator, the assessment. The indicator of geological resources characterizes the general background of the mine as a subject of nature use. It is clear that a mine with small reserves (with a small value of the index of geological resources) is a hopeless enterprise, even if two other factors in it are high, but when dealing with, for example, the issue of the order of closure of mines, it may not fall into the category first of all, as would happen only through small residual stocks. The indicator of technological reliability potentially characterizes the level of investment that may be needed for further work of the mine. The small value of this coefficient indicates the need for a large amount of investment to support and even more to increase the capacity of the mine [65].

2.2. Theoretical approaches to the management of investment factors in a coal mining enterprise

Resource management can be considered as the most effective mechanism for improving the efficiency of mines through internal reserves. It is this approach that underlies the productivity of labor, that is, the result we receive as a consequence of what we invest. If the relation between contribution and result increases, the economic results increase. Actually, the optimality of the use of virtually all types of productive resources is embodied here: labor, financial, material, technological, energy and natural. Consequently, the evaluation of the activity of the mine as a system with stochastic nature can be made only with allowance for probable categories of initial parameters [66].

Virtually every decision to change the parameters of the mine can be attributed to both simple and extended playback. And since it is anticipated that the problem will be solved in relation to the distribution of investments between different mines, the issue of the involvement of individual works on capacity maintenance or reconstruction goes to the background, giving way to the overall effect of optimal spending of production resource limits.

Optimization of the parameters related to the maintenance of the capacity of a separate mine, largely depended on the past from the original mining and geological information. However, in our time we can state that the parameters of nature are already sufficiently studied and evaluated quantitatively. Among them are the main ones, according to which mine fields are distinguished from the position of rent payments. But the optimal parameters of the mine, set for any set of derivative data, will always be locally-optimal. The effectiveness of planning a separate mine or group of mines can be evaluated not by one, but by several indicators. Here as indicators is not considered a criterion in terms of assessing decisions that are taken, but pre-selected output parameters that have a certain degree of economic reliability. Thus, for example, the level of costs for coal mining, the minimum losses of detected economically efficient stocks, the maximum reliability of the technological schemes of the mine, which can be achieved under the given conditions, can be used [67].

Such economists as OI Amosha VI Sally, O.V. Trifonova, OI Symonenko, offer a system of indicators, which include 9 factors that have an impact on the investment attractiveness of the mine [68]:

1. General availability of coal reserves. The necessity and importance of this indicator is due to the fact that mines with small reserves are not attractive to investors. Provision of coal reserves, expressed in tones, not comparable with other indicators and not enough informative.

2. Specific gravity of stocks in reservoirs with relatively more favorable conditions. Coal mine, according to its characteristics and conditions of extraction, is more or less favorable. This concerns, in the first place, the thickness of the beds, their structure, ash content, the content of sulfur, as well as the properties of the enclosed rocks.

3. Specific gravity of the layers (in area) with the sustained power.

Plates of coal mines have, as a rule, unevenness in the area: there are thinning of layers, small tectonic disturbances, etc., which considerably complicate the conditions of operation and often lead to the need for additional mining workings. Obviously, the more such violations, the less attractive the mine is regarding investing.

4. The capacity of the layers developed. This indicator is one of the most important, it directly affects the volume of production and largely determines the conditions of extraction in the lava, including the possibility of using modern cutting equipment.

5. Maximum depth of development (vertically). The impossibility of extraction of minerals leads to the displacement of the workplace from the extraction of coal (a clearing face) in space and, in particular, leads to an increase in the depth of

development with direct and indirect negative consequences for the coal mines arising from it.

6. The capacity of the main parts of the mine - the coefficient of technological reliability. If we consider the sequence of processes for extracting coal from lava to loading in railway cars, one can distinguish the following processes: clearing works, preparatory works, underground transport, lifting on the trunks, technological complex of the surface, ventilation of the mine.

7. Capacity of the mine. The capacity of the mine shows the "degree of size" of the enterprise. It is desirable to increase the capacity of the mine to certain limits, because on other equal terms it increases the efficiency of its operation.

8. The complexity of the underground economy. The development of the mine in time and space leads to the complication of underground economy - an expanding network of mining work with a gradual increase in their total length.

9. The average annual production of the last 5 years. This indicator characterizes the development of the production capacity of the mine and the actual amount of extraction.

A special place in the policy of disclosing internal reserves of enterprises should be allocated to the improvement of product quality. This will allow, with relatively small additional costs, to significantly increase the cost of its implementation and competitiveness. It is precisely the correct investment policy that determines the factors that influence its efficiency, will improve the technology of coal mining, introduce advanced mining equipment, thereby improving the quality.

The technology of coal mining, its evaluation depends on several parameters, among the main - the depth of occurrence and the angle of the slope of the coal seam.

Coal is extracted by open or closed methods, the cost depends on it. The open method in Ukraine produces almost 40% of coal - Dnipro buro-coal basin. The most economically advantageous type of fuel is open-mined coal and its production is constantly growing.

The price of coal is influenced by its vintage composition and quality. Coal is divided into stone, brown, coking, energy. In Ukraine, coal is 2/3 of all stocks.

To characterize the technological properties of fossil fuels, a complex of research methods, combined with the term "technical analysis", has been developed. After this analysis, the price of coal is set. It is significant that low quality coal is sold cheaply and does not bring the company big profits. But the quality of coal can be influenced by increasing the efficiency of its extraction, and this requires new equipment and related developments, which in turn requires specific investment. Consequently, the quality of coal, which in energy, mainly affects the heat of combustion, directly depends on its price.

Coal, for example, has very little effect on the cost of production, but significantly affects the price of coal by raising it from brown coal to anthracite and coking coal [4].

In addition to coal, its price is also influenced by a number of other factors:

- the importance of anchoring to enterprises that consume coal;
- the transport role, namely - the costs of its transportation.

But the real situation on the coal market in Ukraine is such that very often the purchase of low quality coal is carried out at prices well above the prices set for high quality coal.

At the same time there is an annual rise in fuel prices, while the quality of coal does not improve, and sometimes it deteriorates.

Thus, the price of coal is not an objective factor in analyzing the work of a coal mining enterprise.

According to the calculations made for mines that sell ordinary coal or enrich a small part of it, the addition of coal production by the enrichment process at relatively low costs will significantly reduce or even overcome the loss-making of mines due to increased revenues from the sale of enrichment products at higher prices. Also, the reconstruction of the mine fund should be considered as a more important investment destination [69].

Qualitative characteristics of coal and investments by type aimed at the reconstruction of the mine fund are one of the most important factors influencing the efficiency of the investment activity of the mines.

The analysis shows that for most coal mines, the main innovation-investment processes are connected with the improvement of the main technological part of the mine - the treatment works. This does not mean that the state of mining, transport or lifting does not affect the efficiency of production. It is about concentration of forces and means for the most effective working out of reserves of fields of mines.

From the accepted innovative decisions regarding the number of lava in the mine field, the type of excavation technology, mining type and the quality of the rock mass will depend on the system of mining economy [70].

Development of an investment project - one of the main stages of the economic activity of the enterprise, which connects the interests of science, technology, construction, technology, production and sales of products.

Development of an investment project has a decisive influence on the rate of economic growth, organizational and technical development of the enterprise, the quality and competitiveness of products.

As noted in most studies, a special place in the classification of productive resources used in the process of supporting the capacity of mines, takes financial resources. This is explained, above all, by the fact that if the use of other types of resources (electricity, materials) is largely determined by their essence, then financial resources, in contrast to them, are not used for the extraction of coal in its (pure) form, but transformed into other resources (wages - labor resources, procurement of materials - material resources, etc.), thereby capitalizing. This feature determines the scarcity that characterizes the financial resources and puts great responsibility on the design structures and officials, whose sphere of competence includes decision making and the definition of ways of investing in the technological links of the mining enterprises [23].

The process of managing the implementation of investment projects can be more effective if we structure the factors that have an impact on the deviations of the actual performance indicators of the investment project from the estimated values in the business plan.

To identify factors that have an impact on the performance indicators of an investment project, many different factors need to be taken into account.

Classification of factors influencing the efficiency of the investment project in the course of its operational activities, allows us to make a general conclusion about the deviation of the actual indicator of net income from its estimated value as a whole for the entire life cycle of the investment project, and for each year of its implementation. This information is then used for a detailed analysis of the factors that have an impact on the deviation of the actual indicators from their estimated values and the development of management decisions aimed at eliminating the negative factors.

Similarly, an analysis of the deviation of the actual performance indicators of the investment project from their estimated values in accordance with the investment and financial activity plays a similar role.

For example, the deviation of actual performance from project values to operating activity may be the result of the impact of technical, organizational, structural and inter-sectoral factors.

While the factors of organization of production, labor and management are more influenced by the deviation of the actual indicators of the investment project from the estimated ones in accordance with the investment activity. These include mistakes in designing, disruptions in the construction of the facility, failures by suppliers of terms of supplies of materials, component equipment, repair of defects in construction, etc.

An analysis of literary sources on identifying factors that have an impact on investment activity has revealed many indicators proposed by Ukrainian and Russian economists as priority. Factors belong to those or other directions. The whole set of these factors is summarized in Table. 2.1.

With regard to the assessment of the efficiency of investment activity management at coal mining enterprises, several different criteria (as well as factors of investment activity) have been identified by several different authors (Table 2.2).

Table 2.1

Factors that have an impact on the investment activity of coal mining enterprises

№	*Factors by groups*
1	Technical factors.
2	Factors of the organization of production, labor and management.
3	Factors of structure and volume of production
4	Sectoral and inter-sectoral factors
	By types of resources
1	Financial resources
2	Material resources
3	Technological resources
4	Energy resources
5	Natural resources
	Detail by groups and resource types
1	Indicator of economic reliability - indicator of technological reliability; - coefficient of economic level; - geological reliability index.
2	Coal cost recovery.
3	Minimum cost of detected cost-effective stocks
4	The maximum reliability of the technological schemes of the mine
5	Total supply of coal reserves
6	Specific gravity of stocks in reservoirs with relatively more favorable conditions
7	Specific gravity of layers with sustained power
8	The capacity of the layers developed
9	Angle of falling layers
10	Maximum depth of development

№	*Factors by groups*
11	The capacity of the main parts of the mine
12	Mine power
13	The complexity of an underground economy
14	Average annual production
15	Profit level
16	Characteristics of coal / coal grade
17	The price of coal
18	Number of lows in the mine field
19	Type of pull-out equipment
20	Type of extraction

Source: [4,5,6,7,11,17,20,22,23,26,27,28,29,67,68]

Taking into account all of the foregoing, it is proposed to conduct a classification of technical and economic factors, not only by type of activity, but also by groups and directions. For this purpose, the following classification of factors by groups and directions can be carried out [70]:

1. Technical factors.
2. Factors in the organization of production, labor and management.
3. Factors of structure and volume of production.
4. Sectoral and inter-sectoral factors.

1. Technical factors. The scientific and technical level of production and production includes enhancing the progressiveness and quality of products and equipment used, the degree of automation and mechanization of production, technical and energy labor, and the progressiveness of the technologies used. In this regard, all technical factors are classified in the following directions:

- technological processes;
- mechanization and automation of technological processes;
- introduction of computing equipment;

- change of technical characteristics of the manufactured product;
- expansion of scale and improvement of applied technology;
- other factors that increase the level of production.

Table 2.2

Criteria for assessing the effectiveness of investment activity management at coal mining enterprises

№	Criteria
1.	Indicator of economic reliability - indicator of technological reliability; - coefficient of economic level; - geological reliability index.
2.	Net discounted income
3.	Income Index
4.	Internal rate of return
5.	Payback period
6.	Profitability index
7.	Cost of coal mining
8.	Profitability
9.	Power of the enterprise
10.	The state of fixed assets
11.	Residual geological reserves

Source: [4,5,6,7,11,17,20,22,23,67,68]

2. The process of incorporating technological factors into the formation of competitive innovation and investment strategies may be the following steps [71]:

   I - coordination of technological opportunities with the needs that exist in society;

II - development of economically grounded innovation strategies and determination of profit from innovations. The determinants of this are the solvency of potential customers and their ability to pay a price that would generate profit;

III - analysis of technological variability, which will help predict the dynamics of technologies in the future;

IV - selection, evaluation and implementation of innovative technological solutions.

The main task of the coal industry at present is a significant improvement in the technical and economic performance of mines with increasing coal mining. One of the ways of solving this problem is the introduction of technological innovations in the process of developing coal seams.

2. Organizational factors have an impact on changing the level of specialization, co-operation, reducing the production cycle, ensuring the rhythm of production, the development of the skills of manufacturers. The following areas are identified at the level of organizational factors that have an impact on the efficiency of investment projects:

- improvement of management and reduction of costs;
- improvement of production organization;
- improvement of organization and standardization of labor;
- reduction of production losses from marriage;
- improvement of the use of fixed assets;
- improvement of material and technical supply;
- reduction of transport costs;
- other factors that increase the level of organization, work and management.

An important role in the coal mine management system, in particular, in the procedures of in-house planning, is played by innovations. The planning process is a complex set of scientific and practical activities of economists-managers. The level of its organization at domestic enterprises significantly influences the progress of the development of planned indicators. In essence, it is a method of optimizing the production activities of staff. In order to improve planning effectiveness, the following measures can be implemented [71]:

- improvement of the planning methodology;
- development of normative base;
- improvement of professional level;
- widespread use of computer technology in planning and management;
- development and use of business plans at the enterprise.

3. Factors of structure and volume of production. Ensuring the production of material resources - equipment, facilities, etc.

Investments in construction and equipment are the main area of investment in coal mining enterprises. It is these investments that have the largest share in the total investment share and most influence the overall development of the enterprise, maintaining its capacities.

Investments in equipment have a direct impact on the development of the enterprise, therefore, the analysis of investment projects in coal mining enterprises in this direction should be given the greatest attention. After analyzing the level of investment in equipment in time and in terms of the amount of invested money, it is possible to draw conclusions and make recommendations on the appropriateness of such investment. It is also very important to analyze the investment activity of coal mining enterprises of Ukraine in this area in order to capture experience and take it into account when creating their own investment plans.

Thus, there is a need to create an additional classification for investment in equipment. According to the order of the Ministry of Coal Industry of Ukraine (Order No. 12-r of March 17, 2009), methodological recommendations for the selection of stationary equipment for the technical re-equipment of coal mining enterprises were developed and approved [72]:

1. lifting devices (surface and underground): lifting machines (the basic part, couplings, braking systems, separate units and elements of a mechanical part); gearboxes; electric motors; control, protection and control equipment (triggers, thyristor converters, reversors, control cabinets, etc.); lifting vessels (skips, cages,

counterbalances, trolleys, bodys); ropes (main, balancing, braking, conductor); trailer and suspension devices; parachuting devices for cages and balances; pulleys damping and deflecting (multi-channel installations); reinforcement of the trunk (rail conductors, box-boxes, ropes, shootings); signaling and communication equipment; boot devices; copper constructions (metal, reinforced concrete, etc.).

2. Ventilation units for the main fan: fans (housings, housings, suction devices, impellers, guides, head wafers with bearings, couplings, etc.); control, protection and control equipment (thyristor converters, reversors, control cabinets, etc.); electric motors (drive, accelerating); reversing and switching devices (lays, cybers, their drives);

3. Compressor units: compressors (piston, screw, turbochargers); equipment of the compressor installation (suction filters, coolers, air collectors, cooling systems (cooling towers, pumps)); control, protection and control equipment; pipelines of pneumatic networks;

4. Drainage installations: pump units (pumps, electric motors); drainage pipelines; stop valves; control, protection and control equipment;

5. transport facilities: main belt conveyors (drive stations, electric motors, gearboxes, tensioning, unloading and terminal stations, feeders); cable and monorail roads; circular rollers; shunting equipment (pushers, stoppers, trolley exchange systems).

6. degassing: degassing plants; thermal power plants: boilers; boiler equipment (pumps, economizers, smoke exhausts, heat exchangers, water treatment equipment, etc.); calorifiers (sections for calorific); the heating system;

7. technical complex of the surface of the mine: equipment for concentrating plants (screens, feeders, belt conveyors, winches, elevators, cyclones, coal mines, suction machines, bunkers, etc .;

8. Electrical installations:

surface installations:

- surface substations (transformers, switchgears, high-voltage cells, short-circuiting switches, separators, etc.),

- power lines (air, cable),

- Electricity accounting equipment;

underground installations:

- underground substations (transformers, switchgears, high-voltage cells, switching and protection devices);

- power lines (cable).

Sectoral and inter-sectoral factors. They are more expressive and definite, more closely connected with the future business. In the process of strategic planning, the industry is considered as a set of enterprises, products which according to consumer qualities and uses can be interchangeable. The analysis of sectoral factors is aimed at [73]:

- estimate the size of the industry;

- identify the main forces competing in the industry;

- to assess the degree of intensity of competition;

- Identify key success factors in the industry.

The subject of sectoral analysis are the following factors:

- consumers (market volumes and characteristics, market growth rates, seasonality and cyclicality of demand, product differentiation, consumer sensitivity to prices, consumers' ability to dictate their prices);

- suppliers (quantity, intensity of competition, availability of substitute materials, level of vertical integration with suppliers, the ability of suppliers to dictate their prices);

- competitors (the main forces competing in the industry, the division of the market among them, the intensity of competition, the possibility of emergence of fundamentally new product substitutes, the main competitive advantages in the industry);

- barriers to entering the industry (volume of initial investment, availability of sources of raw materials and sales channels, convertibility of assets, protection by the state, consumer affiliation, etc.);

- technology (the speed of change in production technology in the industry, the impact of technological changes on product quality and price, the possibility of gaining benefits from the introduction of new technologies, the possibility of emergence of fundamentally new technologies in the industry, etc.).

The analysis of these factors allows us to clarify a number of fundamentally important branch activities:

- What trend (ups or downs) is inherent in this industry?
- What is the degree of competition in the industry?
- to what stage of the life cycle is the main products of the industry?
- How are the tastes and the orientation of consumers changing?

The factors taken into account when analyzing the investment activity of an enterprise are proposed to be classified as follows:

- investment activity;
- financial activity.

As for the investment activity of the enterprise, it is advisable to subdivide the investment according to the classical scheme, taking as a basis the multifactorial model for determining the effectiveness of investment projects, which in turn should also be classified by type [11]:

- material investments;
- financial investments;
- intangible investments.

Such a classification will allow a more detailed assessment of the negative and positive effects of factors on the overall effectiveness of the investment project.

But the details of these factors can not be applied on a general basis, since the coal mining industry has undoubtedly its own special investment directions.

Thus, tangible investments are subdivided into:

1. investments in equipment, which in turn are classified by type:

a) equipment:

- lifting installations;
- ventilator installations;

- compressor installations;
- drainage installations;
- transport facilities;
- degassing;
- thermal power plants;
- technical complex of the surface of the mine;
- electrical installations.

b) other capital investments:
- buildings;
- supplies of materials.

2. financial investments:

and. portfolio of securities.

3. intangible investments:
- training of personnel;
- research and development.

It is also necessary to take into account the technical factors of products produced as indicators that have a direct impact on the volume of income, and also take into account the geological conditions of extraction. So, for the coal mining industry, the main technical factors of the product being produced are [74, 75]:
- average ash content of coal;
- average sulfur content of coal;
- medium humidity.As the main economic factors to be taught when creating effective investment plans, it is proposed to use the following:

1. Volume of production (extraction).
2. Profit.

Geological factors have a direct impact on the operation of the coal mining enterprise, namely: the cost and price of products produced, profits, production volumes, the need for a certain type of excavation technology and mining technology, the complexity of underground economy in general, and others. All this affects the investment level of the mine and characterizes it in terms of attractiveness as an investment object for private investors. Thus, geological factors are an important element in the analysis and management of investment activities of coal mining enterprises.

So, with regard to geological factors, when developing the economic-mathematical model of investment management in coal mining enterprises, it is proposed to select the following:

1. Residual industrial reserves.
2. Average geological thickness of the beds.
3. Maximum depth of development.
4. Length of mining workings.
5. Angle of falling layers.
6. Project capacity of the mine.

A prerequisite for the application of all of the above factors is the time factor. This means that each factor should be considered in the light of changes in its dynamics over the years in order to be able to assess the impact of a factor on the overall performance of the investment project. Moreover, it is necessary to take into account the positive and negative experience of introducing investment projects not only in one object, but in as many examples as possible. Conducting this kind of analysis is possible with the use of well-known statistical methods. However, given the large number of variables and the need for a study of the relationship between these variables, it is necessary to find a perfect mathematical machine that could simultaneously process the entire sample under study, to find the regularity between the studied variables, taking into account the time factor. With such a statement of the problem, the application of neural network technology will be optimal. Unlike all known statistical methods of analysis, they are able to find regularities in the case of a large number of variables, to take into account the time factor and make predictions with a probability of 0.99 percent.

In solving the problem of creating an effective investment plan for a coal mining enterprise, the question becomes not only about determining the effectiveness of an investment project at given levels and directions of investment, but, taking into account the conditions of investment resource constraints, the question of how much investment it is necessary to invest by type of investment to achieve maximum economic effect. Such an approach is a prerequisite for the planning of investments in coal mining enterprises.

In selecting factors, the following criteria were taken into account:

- Simplification of the system of economic indicators. The factors that are included in the system are not large in number, which simplifies the computational processes. But, due to the selected factors, it is possible to assess the efficiency of investment processes in coal mining enterprises.

- Classification of investments by types most characteristic for the coal mining industry. The main direction of investing in mines is investing in equipment, so this type of investment is expanded by additional types of equipment in the number of 9 destinations.

- Simplification of technical factors. Technical factors are the technical characteristics of coal as a reflection of the efficiency of the functioning of the technical base in general.

- Consideration of the minimum selection of the most influential for the investment activity of the mine geological factors.

2.3. Quantitative analysis and determination of statistically significant factors that influence the efficiency of investment activity of coal mines

Management of investment activity in coal mining enterprises is an issue that involves a lot of factors, because the coal mine is primarily a complex economic system, all of which are closely interconnected. But the main link of the coal mining enterprise is the one in which the coal mining process takes place. It is precisely with the process of coal mining that investment management processes are linked.

Today, the mining fund of most coal-mining enterprises is in a state of decline and needs a major reconstruction, and therefore, significant investment investments.

In the Strategy for the Development of the Coal Industry by 2030, the reconstruction is considered as the main measure of improving the structure of the mine fund of Ukraine. At the same time, it is understood that the purpose of the reconstruction is to increase the capacity of the mine and improve the technical and economic results of the enterprise. The same idea lies in the policy of financing the industry according to sources of income and areas of use. First of all, it is carried out due to the need to support the existing and create new production capacities for coal mining in the volumes sufficient to meet the "Energy Strategy of the needs of the economy for the future up to 2030". Secondly, due to the need to increase the economic efficiency of the operation of coal mines first and foremost through their technical re-equipment in order to ensure self-development and reduce the needs of enterprises in state subsidies [76].

The existing investment scheme, in fact, puts coal mines under conditions of survival [77]. But the prospect of attracting additional investments, whether public or private, is not available in most mines. Therefore, at this time, the issue of improving the efficiency of management of investment processes at its own expense is relevant.

One of the most important features of the coal industry is the unfavorable structure of fixed assets, among which mining operations and specialized buildings and structures on the surface are predominantly prevailing, that is, passive fixed assets. They occupy 75-77% of the total cost of fixed assets, which generates a high inertia of the mine fund, complicates the operating conditions and thereby worsens the economic performance of the mine. For this reason, in order to implement measures for simple reproduction, which also reduces the efficiency of coal mining enterprises, the contradiction can be eliminated only in one way: the simple reproduction must include elements, primarily associated with the use of scientific and technological progress that enables the extinguishing emerging negative trends. In particular, one of such means is to increase the concentration of production by increasing the pressure on the treatment blasting.

Thus, in the coal industry there is an objectively doomed trend of increasing capital intensity of simple reproduction [70]. Therefore, in this situation, it is expedient to create investment plans for coal mining enterprises to address issues related to investing in equipment. Thus, it is necessary to conduct a study on the effect of the volume of investment on one or another type of equipment on the efficiency of the mine and on the characteristics of coal.

In connection with the development of coal basins, the transition to mechanized coal mining, the deterioration of mining and geological conditions of extraction, qualitative characteristics of almost all coal basins in the process of exploitation deteriorate. The general deterioration of the quality of solid fuel is determined by the aggregate result due to an increase in ballast in it. Quite clearly, the nature of the change in the quality of solid fuel has become evident in recent decades in the Donetsk and Lviv-Volyn coal basins [78].

Thus, the coal industry of Ukraine has been operating over the last 30 years under the restricted reproduction scheme, but this does not exclude the possibility that individual companies may operate under the extended reproduction scheme. The main factors that determined the low efficiency of the operation of the industry over the last ten years have affected the profitableness of most mines, such as:

- factors of an objective nature, connected with: complication of natural-geological conditions and the development of reserves, increase in depth and complication of the conditions of occurrence of coal seams, high methane formation of layers and enclosed rocks, deterioration of the quality of reserves and etc.;

- factors related to the general economic conditions and difficulties of the transition period: high level of non-payment and increase of mutual debts between suppliers and consumers of coal, barter calculations, inter-industry disproportions of prices, imperfection of the system of crediting of coal mining enterprises, decrease of living standards of miners and increase of social tension in coal mining enterprises ;

- factors related to subjectivity in management decisions that are taken at both the state and sectoral levels with a sharp reduction in the volume of support for coalmining enterprises, inappropriate spending of state support funds, unacceptably low capital investment in reproduction production, low utilization rates production capacities, "shadow" operations, etc .;

- Regional factors: lack of sufficient leverage on the regional level to influence the current situation and development of the industry, the neglect of the social sphere in mining towns [4].

In tabl. 2.3, 2.4, 2.5 shows the main financial performance of mines, technical and economic characteristics of coal and geological factors. The investment activity of coal mining enterprises is shown in Annex A. The data are presented for 7 years from 2003 to 2009.

Table 2.3

Financial and economic indicators of the coal-mining enterprises of Ukraine

MINE	*Year*	*Net profit thousand UAH.*	*Production volume, thousand tons*
Pavlogradugol OJSC	**2003**	300980,00	6780,00
	2004	347034,00	6821,26
	2005	108103,00	7786,47
	2006	2210,00	10432,68
	2007	2598,00	11172,39
	2008	40689,00	13732,00
	2009	52089,00	14163,00
OJSC Novo Dzerzhinskaya	**2003**	1245,00	84,08
	2004	80,00	82,61
	2005	3236,00	84,48
	2006	5263,00	69,78
	2007	4203,00	110,11
	2008	3226,00	70
	2009	4568,00	63
OJSC mine "Nadiya"	**2003**	987,00	484,50
	2004	1123,00	453,22
	2005	1234,00	367,3
	2006	1382,00	366,72
	2007	1382,00	326,32
	2008	1480,00	253,00
	2009	813,00	250,00

MINE	Year	Net profit thousand UAH.	Production volume, thousand tons
CJSC "Removgullya"	2003	1016,00	425,81
	2004	1112,00	380,94
	2005	1086,5	392,23
	2006	1572,60	412,54
	2007	1357,00	381,91
	2008	1430,00	332,00
	2009	1674,00	330,00
OJSC "Lisichanskugol"	2003	6543,00	60,76
	2004	8711,00	62,16
	2005	29102,00	156,78
	2006	12618,00	254,85
	2007	44626,00	448,00
	2008	29102,00	445,00
	2009	111787,00	640,00
OJSC Krasnodonugol	2003	15679,00	4109,09
	2004	12890,00	4442,80
	2005	50676,00	6296,81
	2006	54063,00	6714,89
	2007	88730,00	7399,04
	2008	50676,00	6181,00
	2009	142903,00	5377,00
OJSC 60 years of Soviet Ukraine	2003	230,00	5,76
	2004	201,00	10,74
	2005	24227,00	9,28
	2006	8717,00	0,30
	2007	6605,00	0,10
OJSC Belarechenskaya Mine	2003	18000,00	66,33
	2004	21305,00	620,05
	2005	11166,00	572,80
	2006	24552,00	671,12
	2007	17159,00	595,31
	2008	92063,00	524,12
	2009	140933,00	508,02
AP them O.F. Zasyadko	2003	110543,00	1164,71
	2004	159420,00	1183,15
	2005	145970,00	1377,15
	2006	157000,00	1250,00
	2007	165874,00	1177,11
	2008	157489,00	1354,25

MINE	*Year*	*Net profit thousand UAH.*	*Production volume, thousand tons*
	2009	189745,00	1554,01
***OJSC AI* Gayoviy**	**2003**	9600,00	158,45
	2004	12170,00	304,74
	2005	13254,00	355,87
	2006	12456,00	388,46
	2007	14252,00	381,79
	2008	13254,00	375,29
	2009	14578,00	398,32
OJSC Komsomolets Donbassa	**2003**	18600,00	2034,75
	2004	23706,00	2210,83
	2005	3586,00	2733,19
	2006	36758,00	3414,73
	2007	70519,00	3663,78
	2008	3586,00	3985,25
	2009	76049,00	4189,02
OJSC "Krasnoarmeyskaya Zapadnaya №1"	**2003**	120400,00	5197,62
	2004	53157,00	5392,74
	2005	325749,00	9915,88
	2006	84072,00	6242,55
	2007	53523,00	6140,91
	2008	325749,00	5087,00
	2009	22335,00	5447,00
Open Society "Dobropillyuyu branch"	**2003**	56932,00	1512,50
	2004	90678,00	1695,67
	2005	79000,00	1439,39
	2006	87000,00	1247,34
	2007	95144,00	1213,05
	2008	94568,00	1359,04
	2009	97864,00	1283,12
JSC "Zhdanivska"	**2003**	11700,00	71,5
	2004	26000,00	101,50
	2005	45678,00	90,32
	2006	2872,00	88,4
	2007	3421,00	241,4
	2008	3985,00	268,8
	2009	4102,00	244,05

Source: calculated for [79-98]

Based on the data presented in Table. 2.3. The volume of production, which is one of the main indicators characterizing the capacity of a coal-mining enterprise, is about 50% of the studied mines having a tendency of gradual growth (Figure 2.2).

At such coal mining enterprises as the mine OJSC "Nadiya" OJSC "them". 60 years of Soviet Ukraine ", OJSC" Belorechenskaya ", AP" them. O.F. Zasyadko ", Open Society" them. AI Gayovoy ", OJSC Krasnoarmeyskaya-Zapadnaya №1, OJSC" Dobropillyugol ", there is a decrease in coal production volumes in 2007.

Among the main reasons for the reduction of production volumes can be set:

- considerable moral and physical depreciation of fixed assets (since about two thirds of domestic mines operate over 30 years, another quarter - more than 50, 20% of mines - in general, over 70);
- significant complexity of mining operations;
- accidents and accidents;
- change in the structural distribution of the mine fund in the form of ownership, which takes place in Ukraine;
- and other.

In terms of profit, it can be noted that in 2006, compared to previous years, profits for such coal mining enterprises as Pavlogradugol OJSC, OJSC Lisichanskugol, OJSC named after them. 60 years of Soviet Ukraine ", OJSC named after them. AI Hayovoy ", JSC" Krasnoarmeyskaya-zapadnaya №1 ", JSC" Zhdanivska ".

The following factors could affect the decrease in profits at enterprises:

untimely and incomplete calculations for coal;

- the discrepancy of prices for coal products to the costs of its production;
- the lag of the coal industry from the general pace of reforming property relations in the state;
- payables;
- arrears of wages and social welfare. payments;
- low wages and pensions;
- lack of funds for the restoration of production.

Investigation of the profit index gives grounds to state the growth of the expenditure part in many coal-mining enterprises.

In the analysis of the main activities, it should be noted that the amount of costs affected by two indicators: the volume of output and cost. With an increase in output, an increase in sales will occur, which in turn affects the increase in revenue, and if you reduce the cost, then the costs will be reduced, which will allow you to find reserves for profit growth. It should also be noted that costs are subdivided into:

- Total expenditures,
- Administrative expenses,
- expenses on sales of products.

The increase in material costs is largely influenced by auxiliary materials, which can be divided into two groups:

1) materials deducted at cost as soon as they are put into production;
2) long-use materials, which are accounted for as expenses of future periods.

One of the main factors influencing the increase in the cost of these materials is the decline in output and increase in cost. A very important reason, which causes an increase in the cost of supporting materials, is the availability of a partial reproduction facility, which contributes to the expansion of the repair service of the enterprise, the growth of the number of repair workers and, consequently, the growth of material costs. The main reasons that lead to increased costs:

- Mining of mines;
- relative increase in the volume of preparatory work;
- incompleteness of removal of materials from repatriated mines.

Cost of 1 ton of commodity coal is UAH 387.9, and its average wholesale price is UAH 275.6. The cost per tonne of commodity coal output increased by more than 2% compared to the corresponding period of the last year, while its price has practically remained unchanged, while the gap between cost and price has increased by 8% [87].

The actions of the monopolists in the coal market and in the supply of mine equipment hinder the development of market processes, prevent coal producers from reaching the necessary level of self-sufficiency and create barriers to third-party investment in the industry. Yes, prices for major types of mining equipment continue to grow. On the other hand, because of the imbalance of income and expenses on coal enterprises, depreciation costs are practically not formed as a source of reproduction of fixed assets [67].

As can be seen from the volume of investments in mines, a significant share in the total amount of funds allocated for investing takes investment in equipment, in the second place - investments in construction works. This situation is natural for the coal mining industry, because the main load in the process of extraction is the equipment that is rapidly wearing out. At the same time, for most mines, there has long been no complete reconstruction of the mine fund. Thus, a significant part of the allocated investments is spent on repair or purchase of the supported equipment, which in turn in the near future will lead to the need for new investment investments. It is better to update the mine fund for the purchase of new equipment, which will be an effective solution in terms of various aspects of the operation of the mine, but, as a rule, coal-mining enterprises in Ukraine do not have the money to do this. If we investigate the tendency of investing in equipment in mines of Ukraine according to Annex A, then there is a gradual increase in the amount of investment investments for different types of equipment. But, if you look at this situation from a global point of view, then the prices for equipment have a gradual tendency to increase every year. Hence it turns out that the increase due to investment injecting equipment is not really the case. Currently, most mines of Ukraine are capable of maintaining their capacities at the achieved level only at the expense of great efforts. In order to develop the industry and increase production volumes, significant investment investments in the field of equipment are required.

Recently, due to the significant increase in allocated state funds for capital construction (from UAH 310 million in 2002 to UAH 553 million in 2005), the physical volumes of work in mines do not actually increase. The main problems that negatively affect the work of the mining complex are due to the late and not fully financed construction, low wages, lack of own working capital (Figure 2.4).

The analysis of the efficiency of the work of mines, first of all, must identify economically insolvent enterprises.

The competitiveness of coal is directly related to its quality. The quality of products depends largely on the economic performance of not only coal industry enterprises, but also of other sectors of the economy. Thus, reducing the coke's ash by 1% reduces its cost of casting iron by 2.5%, limestone by 2%, and increases the productivity of blast furnaces by 2.5%. Reducing the ash content of coal also contributes to the improvement of their petrographic composition and coking component, which in turn increases the physical and mechanical properties of coke. An increase in moisture in coking coal by 1% increases the cost of heat for coking, reduces the productivity of coke ovens by 3-4%, accelerates the wear of furnace masonry. At high humidity the transportability of coal deteriorates, and in winter conditions it is frozen. Moisture also negatively affects the technology of coal processing. The most harmful impurity in the coal is sulfur. When burning coal, much of the sulfur compounds are converted into sulfur dioxide (sulfur dioxide), which adversely affects human health, poisons the atmosphere, causes corrosion of metals. Sulfur reduces the economic value of technological fuel, impairs the quality of final processing products. Reduction of sulfur in coke by 0,1% reduces the cost of coke for the smelting of pig iron and increases the productivity of blast furnaces by 1-1,5% [97]. Characteristics of coal mined in mines of Ukraine are given in Table. 2.4.

In Ukraine, coal deposits of fossils are concentrated in the Donetsk, Lviv-Volyn and Dnipro basins. According to geological reserves of fossil coal, Ukraine ranks first in Europe. Explored reserves of coal in Ukraine amounted to 34.0 billion tons. or about 50 billion tons (as of 1998). Forecast reserves are about 120 billion tons. In the structure of balance stocks, all grades from brown coal to high metamorphosed anthracite are given [99].

The share of coal grades is (%) [99]:

storm (B) - 6,6;

long-flown (D) - 22,4;

gas (T) - 36.1;

gas-greasy (GZH) - 4,1%;

fat (G) - 4.7%;

coking (K) - 3,1%;

Leaky Speaker (OS) -3.3%;

Song (P) - 8.4;

Anthracite (A) - 11.3%.

Table 2.4

The main average indicators of the technical characteristics of coal mines in Ukraine

MINE	Characteristics of coal		
	Average ash content,%	Average moisture,%	Average sulfur content,%
Pavlogradugol OJSC	9,2	3,4	2,8
OJSC "Novodzerzhynsk"	10	2,2	1,9
Mine Hope OJSC	24,9	5	2,9
CJSC "Removgullya"	9,8	7	2,1
OJSC "Lisichanskugol"	18	9	1,8
ВАТ «Краснодонвугілля»	12	3	2,9
OJSC "them" 60 years of Soviet Ukraine »	32	10	3
OJSC "Mine Belorechensk"	12	10	1,9
AP "them" O.F. Zasyadko »	35	2,8	2,5
OJSC "named A.I. Gayoviy "	28	7,2	2,4
OJSC Komsomolets Donbassa	20	3	2,5
OJSC "Krasnoarmeyskaya Zapadnaya №1"	15	2,7	1,8
Open Society "Dobropillyugol"	24,5	3,2	2,9
JSC "Zhdanivska"	33	8	2,2

Source: calculated for 79-98

Due to insufficient volumes of capital investments in the coal industry, Ukraine has the oldest mine-mine fund among the CIS countries, and its accelerated aging has led to the formation of a negative balance of production capacities. The decline in their volume has become a constant trend, which is already catastrophic.

During the period of 1991-2005, the production capacity of coal mining enterprises decreased from 192.8 to 91.5 million tons per year or almost 2.1 times. At the same time, only 85% of production capacity is used recently [90].

Almost 96% of mines have been operating without reconstruction for more than 20 years. Due to the slow restructuring of the industry, there is a significant number of small and medium-sized lossy, unpredictable mines. In some mines, coal production is decreasing.

Geological factors that characterize the working conditions of coal mining enterprises of Ukraine are given in Table. 2.5.

In order to characterize the intensity of the development of coal mining in time, the statistics are presented for comparison with each other, resulting in a system of absolute and relative indicators of dynamics [100]. In order to characterize the intensity of development over the long time average values are calculated: average absolute growth, average growth factor, average growth rate, average growth rate (Table 2.6).

The investment activity of mines in the areas of investment is carried out roughly in the same proportional volumes (Annex A). Insignificant amounts of investments are invested in the direction of intangible investments (training, research and development). Somewhat larger investment investments take place in financial investments. Stable high amounts of investment are made into such types of investment as tangible investments, namely: the largest amount of money is invested in equipment and facilities. This situation with regard to the volume of investment by type of investment is classical for the entire coal mining industry. Limited investment resources determine the direction of their investment. So, without investing in the main means of the mine, it will not be able to maintain its capacities, so this direction is always the first priority. In the conditions of privatization of coal mining enterprises of

Ukraine, the following investment direction appeared, such as investment in shares, the total volume of which is increasing proportionally to the increase in the number of privatized enterprises. As for other areas of investment, in the absence of investment resources, their share remains stable low.

Table 2.5

Geological factors

MINE	Геологічні фактори					
	Residual industrial stocks million tons.	Average geological thickness of the beds	Maximum depth of development, m.	Length of mining works, km	Angle of falling layers	Production capacity (project), million tons per year
Pavlogradugol OJSC	1370	0,9	600	878,7	6	1,2
OJSC "Novodzerzhynsk"	58,6	0,95	580	52,4	29	0,43
Mine Hope OJSC	18	1,13	610	37	12	0,17
CJSC "Removgullya"	400	1,1	900	541,3	13	3,54
OJSC "Lisichanskugol"	179,7	1,2	620	285	17	0,6
OJSC Krasnodonugol	379,9	0,9	600	510,6	10	5,7
OJSC "them" 60 years of Soviet Ukraine »	86	1,4	1018	90,5	19	0,6
OJSC "Mine Belorechensk"	20	1,36	500	42,3	4	0,45
AP "them" O.F. Zasyadko »	97,4	1,5	1270	128,9	11,5	1,5
OJSC "named A.I. Gayoviy "	16	1,8	975	42	60	0,52
OJSC Komsomolets Donbassa	133,6	1,1	810	137,3	4	2,1
OJSC "Krasnoarmeyskaya Zapadnaya №1"	109,5	2,15	720	107	4	2,1
Open Society "Dobropillyugol"	471,6	1,8	860	375,9	8	5,2
JSC "Zhdanivska"	23,1	1,42	671	62,8	20	0,78

Source: calculated for [79-98]

Table 2.6

Average indicators of development dynamics in mines

Шахта	Growth factor (basic)	Growth factor (chain)	Growth rate (baseline)	Growth rate (chain)
Pavlogradugol OJSC	1,21	1,15	0,21	0,15
OJSC "Novodzerzhynsk"	0,96	0,97	–0,04	–0,03
Mine Hope OJSC	0,95	0,99	–0,05	–0,01
CJSC "Removgullya"	0,92	0,98	–0,08	–0,02
OJSC "Lisichanskugol"	2,55	1,72	1,55	0,72
OJSC Krasnodonugol	1,42	1,19	0,42	0,19
OJSC "them" 60 years of Soviet Ukraine »	1,11	0,88	0,11	–0,12
OJSC "Mine Belorechensk"	9,41	3,83	8,41	2,83
AP "them" O.F. Zasyadko »	1,09	1,03	0,09	0,03
OJSC "named A.I. Gayoviy "	2,21	1,40	1,21	0,40
OJSC Komsomolets Donbassa	1,37	1,19	0,37	0,19
OJSC "Krasnoarmeyskaya Zapadnaya №1"	1,57	1,27	0,57	0,27
Open Society "Dobropillyugol"	1,06	1,02	0,06	0,02
JSC "Zhdanivska"	0,89	0,99	–0,11	–0,01

Source: calculated for tabl. 2.3

The average increase in coal production in all mines is almost in the approximately identical numerical range, with the exception of the mine "Novodzerzhinskaya" and OJSC "Mine Nadia" where there is no increase in coal production on average for four years. But in OJSC "Belorechenskaya mine", on the contrary, there is a noticeable leap in increasing coal production. As the analysis of periodicals for 2004 shows, in the period of the "Belorechenskaya" mine during this period there was active assistance of the regional state administration of the Luhansk region to promote private capital, which means the restoration of the mine fund and, consequently, an increase in coal mining volumes.

The lack of precise relations between the economic processes of the coal industry leads to the need to identify clear dependencies in order to further optimize the industry, that is, we come to the need to identify the clear relationship between the main economic indicators of the work of mines, the main technical characteristics of coal and types of investment [101, 102, 103].

One of the factors that affects the company's profit growth is investment in fl uence. Such a situation may indicate a rational use of the profits of mines and the development of the enterprise as a whole. But, given the fact that the mine is a multi-lateral economic system, it is not objectively to draw conclusions about the effectiveness of investments only in relation to the level of profit received. Mine profits can often be accompanied by a decline in production capacity, and vice versa, may indicate inefficiency and lack of investment. This situation once again proves that the coal mining industry needs active investment and skillful use of investment resources.

As already mentioned in this paper, the technical characteristics of coal are a reflection of the material and technical base of coal mining enterprises. The brand of coal, the basis of which is its technical characteristics, directly affects its price, and, consequently, the profit of the enterprise. Thus, the brand of coal depends to some extent on the volumes and directions of investment.

In order to determine whether there is a relationship between such technical characteristics of coal, such as average ash content, average humidity, average sulfur content, and volumes of investment in coal mining enterprises, these factors were analyzed graphically, taking into account the average annual volume of investment in each of the 14 - of the explored coal mining enterprises and indicators of technical characteristics of coal.

This technical characteristic of coal, such as moisture, is inversely proportional to the level of investment, which means that the more investments are made in maintenance of capacities and in the development of the coal-mining enterprise, the better quality of coal is due to the reduction of moisture in it. The lack of some reciprocal investment dependence on the level of coal moisture may indicate that the investment projects implemented at the mine were not sufficiently effective (no priority investment areas were identified) or the presence of adverse geological conditions.

With regard to such technical characteristics of coal as "the content of sulfur", then it is determined by the points in direct dependence on the level of investment and in the reverse. The current situation in this case may also be somewhat related to the geological conditions, as in general, the quality of fuel quality deteriorates in the niches of the mine fields of Ukraine. Due to investments, the quality of the extracted coal can undoubtedly increase, for example, if additional funds are spent on coal enrichment or on equipment that during production can affect quality. But the funds allocated for the purchase of this equipment are often lacking, and therefore the investments that were not received to the required extent are not effective, hence the presence of a directly proportional relationship between the quality of coal and the level of investment. Investments are, but they can not influence the quality of coal. The same can be said about any other technical characteristics of coal. For example, the link between investment and the technical characteristics of coal "ash content" has approximately the same trend.

The influence of geological factors on investments in 14 mines is analyzed in Fig. 2.11. The relationship between investments and geological characteristics is reflected more or less on the schedule. The increase in the geological factor is reflected by the rise of the investment line later, after the lifting of the geological factors. But in the graph for not all points there is a pattern that indicates other external factors.

Thus, it is impossible to create a clear linear dependence between the variables under study, therefore, the analysis of dependencies between these factors and the application of them in the construction of economic and mathematical models requires the use of nonlinear methods.

Analysis by graphic methods is very vivid and definitely giving reason to make certain conclusions according to the objects under investigation, but this method is not effective for establishing dependencies. A dedicated system of factors that are considered the most important in managing investments in a coal mining enterprise is analyzed graphically and the presence of a connection between all vectors to one degree or another is revealed, but in order to provide this connection of numerical values, it is necessary to apply methods of mathematical analysis , namely - correlation.

Consequently, the purpose of the correlation analysis is to establish the relationship between investments invested in coal mining enterprises, whereby investments are maximally classified by type in order to determine the impact of each of them on the profit of the enterprise. The goal is also to obtain, as a result of the analysis, the significance of the impact of investment in income, the volume of extraction, the cost of coal mining enterprises and on the price of manufactured products.

As has been researched in many papers by leading Ukrainian scholars such as AI Amosha [5], O.S. Galushko [16], BLL Reichel [26], VI Sally [67], O.V. Trifonova [23] et al., Geological factors and technical characteristics of the produced products have a significant impact on the profit of coal-mining enterprises and on the volume of investment. The problem of insufficient investment required to improve the quality of coal and increase production is widely covered in the works of the aforementioned authors, which underscores the unequivocal link between investments and geological factors. But to provide this connection, the numerical value with the help of correlation analysis methods does not seem possible. This situation is due to the fact that in the sample of the survey data from 14 coal mining enterprises of Ukraine the dynamics of changes in volumes of investments, profits, production volumes, etc. are given. for 7 years for each of the mines, and as for the dynamics of changes in geological factors, its indicators do not change annually. The average values of indicators of geological factors remain unchanged for several years. Thus, the annual change in investment volumes in the initial sample of data is compared with the constant value of the average indicators of geological factors in the mines, which, in turn, does not allow for obtaining significant correlation coefficients between these indicators. One of the reasons for the lack of a correlation between geological factors, profit, volume of production and volumes of investment is also a feature of the functioning of Ukraine's coal mines, which is due to the critical shortage of investment resources, the almost practical lack of experience in introducing investment programs aimed at applying at each link of the mine the corresponding equipment taking into account the geological conditions of extraction, which in turn increased the quality of the extracted coal, and thus its price and profit of the ears mining enterprises.

For example, the nature of coal mining in general and the type of winch technology, in particular, depends on the thickness of the layers. And this directly affects the cost of production and, as a consequence, profits. As the depth of development increases, the complexity of coal production increases, and along with this, there is a need for additional research, and a deepening of knowledge of personnel and procurement of additional equipment. The length of the mining operations requires the construction of additional structures and the use of additional equipment. In Ukraine, the following tendency was observed (Table 2.5): mines with the largest length of mining operations are joint-stock companies (OJSC Pavlogradugol, OJSC Komsomolets Donbassa, OJSC Dobropillyugol). Also, mines with the largest extent of mining work have the largest amount of mining and, consequently, greater than other profits.

Unfortunately, very small amounts of investment are invested in research, development, and proper training. The real situation in the industry is such that most of the mines are characterized by a lack of capital construction and physical volumes of increased work. However, there is an annual increase in equipment [104, 105].

Taking into account all the above-mentioned aspects, we conclude that it is inappropriate to apply correlation analysis methods to identify the links between the geological factors of the operation of coal mining enterprises and income, profits, production volumes and costs.

Thus, we arrive at a definition of the correlation between the financial and economic indicators of the work of the mines of Ukraine and the volume of investment in them.

Calculations of the correlation coefficients were performed using the Excel Correlation function [105, 107, 108, 110, 111, 112, 113].

For correlation analysis, a statistical sample of 14 Ukrainian coal enterprises in seven years was taken (Table 2.3, 2.4, 2.5). Using correlation analysis, the relationship between the following indicators is investigated: volumes of investments by types (material, intangible, financial investments); profit; income.

As a result of investing in equipment, profits yielded high correlation coefficients, indicating the existence of a connection between these variables. Other capital investments according to the obtained correlation coefficient have a strong influence on the profit of coal-mining enterprises.

With regard to the impact on the profits of coal mining enterprises in the portfolio of securities and intangible investments, a low correlation coefficient is obtained, which proves the lack of a strong link between these indicators. This situation may be due to the fact that investing in these areas is not a priority for the coal mining industry and is not performed on a regular basis or on a large scale. For example, the impact of investments in intangible investments can not be estimated immediately in accordance with the financial results of the year. Payback for such investments is a long process involving several stages, which usually does not last for one year. For such purposes, methods of nonparametric statistics are used [109]. This could lead to low correlation coefficients on the economic performance of the mine.

Also, low correlation coefficients were obtained in relation to production volumes.

The low correlation coefficient was obtained in connection with investments in the portfolio of securities and intangible investments in the profit of mines.

Despite the fact that a satisfactory level of correlation coefficient for all types of investment was not obtained, we can not say that there is no complete connection between the variables under study. Therefore, it is necessary to determine the significance of the obtained coefficients by obtaining the boundaries of a reliable interval, which enters separately the investigated coefficient [110].

Validation of significance is done using Excel spreadsheets.

To build a reliable interval, the reliability level is 95%, the number of observations corresponds to the sample size in the mines and equals 98.

In the first stage, the calculation of the z-transform Fisher using the help of Fisher's function in the section "Statistical Functions of EXCEL Spreadsheets".

On the second one - the probability is calculated that corresponds to the normal distribution using the Normstrof function.

In the third stage Fischer's error calculated from the correlation coefficient.

If the value of the correlation coefficient, which is closer to 1, indicates a strong correlation between the variables, in this case the negative value of the correlation coefficient indicates the feedback between the pairs being studied.

In the fourth stage, the Maximum and Minimum Expected Fisher Value from the correlation coefficient is determined by adding and subtracting the corresponding error obtained in the previous step by the Fisher coefficient value.

On the fifth one - the maximum and minimum expected values of the correlation coefficient are calculated, which will be the boundaries of the reliable interval for the investigated coefficients. The calculation is performed using the "Fisher -Head" function to the maximum and the least expected values of the Fisher coefficient.

In the sixth stage, the error of the received results is deducted from the maximum and the minimum expected values of the correlation coefficient of the initial correlation coefficient.

Thus, based on the calculations of the six stages according to the formulas (2.1-2.4), we obtain the following bounds of the reliable interval (in brackets the upper and lower bounds of the reliable interval are given respectively):

for investment in the securities portfolio the following positive reliable interval for relations was obtained:

portfolio of securities - volume of production (0,2- 0,6);

portfolio of securities - profit (0,1- 0,5);

for the intangible investments the following positive reliable interval for relations was obtained:

intangible investments - volume of extraction (0.2- 0.6);

intangible investments - profit (0,2- 0,6).

The purpose of the correlation analysis with the subsequent establishment of the limits of a reliable interval is to determine the system of indicators that have an impact on the investment processes of coal mining enterprises. Thus, looking at the set of coefficients obtained, the question arises of the relationship between variables with which values of the correlation coefficient is considered significant. In order to get an answer to this question, a calculation was made using the tables of the critical values of the Student's t-criterion. After the calculations came the conclusions that can be considered if the value of the correlation coefficient is greater than or equal to 0,3 - between the variables is the relationship.

Chapter 3

Models of determination of investment volume and optimization of distribution of investments in coal mining enterprise

3.1. The mechanism of distribution of investments in the coal mining enterprise

3.1.1. Theoretical basis of modeling by neural networks

Management of investment activity at coal mining enterprises with the use of economic and mathematical modeling was started back in the 70's. But the mathematical apparatus of those times was not able to take into account the large number of parameters and constraints in the construction of economic and mathematical models. Nowadays, with the help of the use of modern computational techniques, solving of multicriteria economic problems is quite possible.

The only technological process of coal mining is a set of a series of successive stages. Almost every stage is closely connected with others, together they constitute the only indissoluble coal mining process [114].

Therefore, the directions of investment should take into account all stages of the coal mining industry. The model should be configured to make multivariate solutions. To facilitate calculations and their analysis, these restructuring measures can be classified according to any indication.

As the main economic indicator is taken: at the level of the coal company - the value of its net discounted income (net of taxes and other deductions) received by it, and at the state level, the balance of expenses and revenues of the state directly related to the implementation of these restructuring measures [115].

In developing the model, it should also be taken into account the fact that it is a working mine, which provides for the implementation of an investment project aimed at increasing the volume of coal production.

The coal industry proved to be unprofitable. And as a result of this - a reduction and almost complete cessation of investments, non-payment to suppliers, low productivity, aging of basic production assets, many months of wage arrears, etc. Budget opportunities in terms of providing large grants to loss-making enterprises are practically exhausted [116].

In this regard, it should be noted that mines are mostly unprofitable, so the calculated cash flow from the mining business during the period of investment attraction can be considered an effect from the implementation of the investment project. Thus, the total profit received by the enterprise will be a profit from the implementation of the investment project.

In the simulation, it is also necessary to take into account the fact that in the process of increasing the capacity of the operating company, the funds aimed at expanding production include investments for the purchase of new and replacement of worn out equipment, underground mining and other construction works, as well as funds for replenishment of reversible assets of the enterprise providing an increase in the volume of coal mining.

Various options are used to characterize and evaluate the investment project in various aspects in the process of drawing up feasibility studies, as well as a statement of the possible deviations of the various components (function-vectors) of the project spaces and their mapping, the statement of the regularities of these deviations, the justification of the tolerances of these deviations [4].

In the existing coal sector, the financing of fixed assets may be subject to the following tasks:

- increase in the capacity of the mine sector of the industry, which is achieved through the construction of new enterprises and the reconstruction of the operating mine fund;

- preservation of the mine fund's capacity, which is achieved through the new construction or reconstruction of an existing operating mine fund, with or without increasing the capacity of individual enterprises, and simultaneously leaving or closing individual enterprises. This case can be considered as a simple reproduction for the industry;

- Reduction of the mine fund's capacity, which occurs in connection with the decline in the capacity of individual enterprises [4].

An important point in constructing an economics-mathematical model is to obtain the values of optimized parameters in a given range, which will be a reflection of the change of managed parameters (investments) on the value of the target function (profit).

Unfortunately, classical techniques prove to be ineffective in many practical tasks. This is due to the fact that it is impossible to fully describe the reality with a small number of model parameters or the calculation of the model takes too much time and computing resources. In particular, consider the problems that arise when solving the problem of optimal allocation of investments.

In real-life, none of the functions is known exactly - only estimated or expected value of profit is known. In order to get rid of uncertainty, we are forced to fix the functions, while losing the accuracy of the description of the task.

In practice, in the analysis of risks, there are often problems associated with the observation of random variables. For such problems it is not possible to construct deterministic models, therefore, a fundamentally different, probabilistic approach is used. Parameters of probabilistic models are distributions of random variables, their mean values, variances, etc. As a rule, these parameters are initially unknown, and statistical methods used for the samples of the observed values (historical data) are used for their estimation.

We also note that statistical methods are well developed only for one-dimensional random variables. If we want to take into account several interconnected factors, then we will have to turn to the construction of a multidimensional statistical model. However, such models either foresee the distribution of Gauss's observations (which are not performed in practice), or are not theoretically substantiated. Thus, there is a need to use an improved mathematical device, which can be neural networks.

The use of neural networks provides the ability to model the state of an object, which is affected by an unlimited number of factors that determine the prognosis (diagnosis) for a particular object. In general, the neural network is an artificial analog of the human brain. Therefore, its main component components, which by analogy are called neurons, are capable of performing certain functions of processing the information that comes to them. Neurons are grouped into layers and have numerous interactions with any neurons of its own layer, as well as many other layers. The output of the neuron is the state of its activity.

Input signals arrive at the first layer neurons, which, after data processing, transmit information to the next layer, etc. The neurons of the last layer direct the information to the outputs of the network. Consequently, in the case of the use of the neural network, there is no need to have a clear idea of the structure of the object and the features of its internal connections. It is necessary only to show the network specific carriers of information or their aggregate, that is, examples in which certain inputs are compared to certain outputs of the system. Neural networks are capable of independently finding interconnections within the system, using for this purposes techniques of mathematical processing of the output sample, which represents an array of real experimental data. This process is called training neural network. The neural network in offline mode is looking for such a weight of connections between neurons, which would allow to get out of it the results are as much as those obtained in a real experiment. As a result, a certain mathematical model of the investigated object is created, which is difficult to clearly describe, due to the fact that it is "encoded" in the connections between the neurons of the network. However, the developed model works extremely efficiently and really simulates results that are very close to those that are obtained experimentally. In addition, the neural network is capable of approximating complex nonlinear functional dependencies in tasks of diagnostics, forecasting, identification, etc.

The use of such an approach will make it possible to create a prediction mechanism that is quite adequate to the objectives of scientific research in the field of investment activity management at coal mining enterprises, based on which probabilistic time estimates of the most common types of investment and their impact on the profit of coal mines in Ukraine will be. The obtained results allow to objectively objectivize the process of forecasting various changes in the state of indicators that determine the profitability of coal mining enterprises in Ukraine.

Thus, there is a need to use a mathematical apparatus that would be able to take into account all of the above requirements in improving the economic methods of forming investment needs for coal mining enterprises. Neural networks can become such a mathematical device because they have the following properties:

- do not depend on the properties of the input data, for them there is no requirement for a certain type of distribution of output data or the requirement for the linearity of the target functions, ie they are universal;
- networks are capable of modeling dependencies in the case of a large number of variables;
- unlike statistical studies, they do not require a large amount of data;
- accelerates the process of finding dependence at the expense of simultaneous processing of data by all neurons.

The use of neural network technology is appropriate in cases where the formalization of the solution is difficult or impossible at all. This technology is a very powerful simulation tool, because it is non-linear in nature. As has already been said, linear simulations have long been key in most areas, due to the fact that they have a large number of optimization methods. However, in order to solve the problem of risk analysis, the assumption of a linear separability of the source data in the vast majority of cases turns out to be incorrect. The neural network is used in the first place when the exact exact form of the connection between the input and the output is unknown. It's enough to know exactly that there is a connection between incoming and outgoing data. In this case, the dependence itself will be deduced in the learning process of the neural network.

Despite the fact that neural networks are capable of solving virtually any problem, in many cases, their use is not appropriate. For most tasks, the use of other mathematical models is more effective. Neural networks have been particularly well-proven in solving classifying, predicting, encoding and decoding information.

To manage the risks of neural networks use the most appropriate in the following areas:

- assessment of industrial risks;
- forecasting of the necessary stock of raw materials;
- optimal production planning;
- assessment of investment risks;
- analysis of organizational and economic stability of enterprises and prediction of bankruptcies;
- valuation of currency risks;
- forecasting quotes in the foreign exchange market;
- assessment of credit risks;
- forecast of lending efficiency;
- assessment of trade risks;
- research of the demand factor;
- forecasting and price analysis;
- forecasting sales [117].

Thus, we can conclude that, given the complexity of the mine as an economic system, the presence of a large number of factors having an impact on the efficiency of the investment activity of the coal mining enterprise and, most importantly, in the absence of a direct relationship between these factors, and therefore, uncertainty - the use of the mathematical apparatus of neural networks for the simulation of investment processes is an effective method for solving problems of this type.

Economic task statement. In the problem of investment distribution, the question remains as to which direction and in what volumes it is necessary to distribute investments, since the proper functioning of the whole enterprise depends on the correct distribution of investments.

Goal. Maximizing profits of a coal mining enterprise by optimal distribution of investment resources.

Incoming data. The theoretical, graphical and mathematical analysis of factors influencing the efficiency of investment activity of coal mining enterprises is carried out. The method of mathematical analysis has established the presence of direct or reciprocal influence between all factors, the same result was obtained after performing graphical and theoretical analysis. In the case of solving the classical problem with the use of factors, the tightness of the connection between which was investigated by methods of correlation analysis, as significant factors are taken values with the correlation coefficients closest to unity. But the coal industry and the mine, in particular, are a very complex economic system, the work of which is affected by many external factors, namely: market conditions, conditions for the formation of prices for coal, features of reproduction, much expensive equipment, geological conditions, etc. All these factors in aggregate cause a lack of a sufficiently large correlation coefficient. Consequently, the relationship between the factors is, which is reflected by the presence of positive correlation coefficients, but its increase is influenced by many third-party factors.

On the basis of the foregoing, the following are selected as data that will be involved in solving investment management tasks for coal mining enterprises:

financial indicators:

1. profit;
2. volume of production;

Investments by types that are invested in:

1. lifting installations;
2. ventilating installations;
3. compressor installations;
4. drainage installations;
5. transport facilities;
6. degassing;
7. heat power plants;
8. technical complex of the surface of the mine;
9. electrical installations;
10. other capital investments;
11. portfolio of securities;

12. intangible investments;

geological factors:

1. average ash content of coal,%;
2. average humidity of coal,%;
3. Average content of sulfur in coal,%;
4. Residual industrial reserves, million tons;
5. average geological thickness of the beds;
6. maximum development depth, m;
7. length of mining works, km;
8. angle of fall of layers;
9. production capacity (project), million tons per year.

Setting objectives. Management of investment activity in coal mining enterprises includes the solution of a great many issues, among the main ones are the following: maintaining the capacity of the mine through the purchase of any equipment; expansion of production; investment in research and development.

It is necessary to form a complex investment project, the realization of which will have a positive impact on the profit increase of coal mining enterprises. Investments are presented in 12 kinds most characteristic for coal mining enterprises of Ukraine:

A) material:

- lifting installations;
- ventilator installations;
- compressor installations;
- drainage installations;
- transport facilities;
- degassing;
- thermal power plants;
- technical complex of the surface of the mine;
- electrical installations;
- other capital investments;

B) financial:

- portfolio of securities;

B) Intangible:

- training, research and development.

Regarding the source of the project's investment, the task that is solved within the framework of this work involves increasing the efficiency of using the company's own funds. In an unstable economic situation in the country, private investors do not have to rely on coal-mining enterprises in terms of public investment, as a rule, they are not timely and are not sufficient to meet the financial needs of mines. Therefore, there is almost the only way - the survival of the enterprise at the expense of its own profits. As shown by the analysis of the profitability of coal mining enterprises considered in this paper, almost all of them receive a profit, although not high enough to make investments at their own expense and to intensively develop. Consequently, the issue of efficient placement and determination of the directions of investment of limited investment resources in order to achieve the greatest possible efficiency is an urgent task in the management of investments in coal mining enterprises. Thus, within the framework of the development of the economic-mathematical model of investment process management at coal mining enterprises, the source of financing of investment projects is considered own funds.

The effect of investing is estimated annually at the end of the fiscal year. This approach is also due to the results of the mathematical analysis carried out in the second section, which has established that the maximum economic effect of material and financial investments is achieved after the first year of investment. In the case of intangible investments, after determining the amount of investment and profit, it is necessary to set the payback periods for these investments. If an investment project involves an investment that is distributed over the years, then the definition of profit is executed as the total effect of the profit for each year of investment.

Solving the problem will answer the following questions:

1. What amount of coal mining company is able to allocate to investing?

2. What level of profit will be obtained by a coal mining enterprise in case of implementation of a particular investment project?

3. To what extent do you allocate between 12 types of investment investment funds in order to maximize profits?

Stages of solving the problem:

Stage 1. Development of an economic-mathematical model for determining the amount of investment in a coal-mining enterprise.

The purpose of the model is to determine the amount that a coal-mining enterprise can allocate to investing at its own expense.

Stage 2. Development of an economical and mathematical model for determining the profit of a coal mining enterprise depending on the volume of investments by means of neural networks.

The purpose of the model is to determine how the level of investment on the profit of a coal mining enterprise affects.

Stage 3. Development of a model for determining the optimal volumes of investment in a coal mining enterprise. Perform the distribution of investments by 12 types of investment, which will help maximize profits of the coal mining enterprise. The economic-mathematical model for determining the optimal investment volume combines the results of the models mentioned in the previous two stages.

Stage 4. Verification of the model of determination of optimal investment volumes using the classical methodology for evaluating the effectiveness of investment projects.

Mathematical formulation of the problem. According to the methodological principles of vector optimization, all technical solutions should be considered as variants of mine development. Thus, and methods of constructing an economic-mathematical model should have a set of options that meet the minimum loss or loss of effective stocks.

Any task associated with maintenance of power and, as a consequence, the choice of optimal parameters of this enterprise, is characterized by certain features, the main of which are as follows:

1. Target function in such tasks is usually more extreme.

2. Insufficient and incomplete information about the mine fund system makes it impossible to use accurate methods of analysis.

3. There is no possibility to formulate a universal criterion that would take into account all the features of the mine fund system [67].

At the stage of making a decision on the appropriateness of an investment project, there are two main questions:

1) what amount of investment will be optimal for a particular investment project at the given parameters of the enterprise - profit, volumes of production, geological factors;

2) which will receive the economic effect of a certain amount of investment, namely, the projected profit level.

To answer the above questions, it is necessary to construct a model by means of neural networks taking into account all the above-mentioned parameters [118-141].

The most acceptable in this case is the choice of a two-layer perceptron and an algorithm for the propagation of error as an educational.

This type of neural networks is well-researched and described in scientific literature and is discussed in detail in almost all textbooks on neural networks. Each network element builds a weighted sum of its inputs with a correction in the form of a term, and then skips this value of the internal activation through the activation function and, thus, obtains the output values of this element. Elements are arranged in a layer-through architecture with a direct signal transmission. Such a network can easily be interpreted as a non-linear model of input-output, in which the weights and thresholds are free model parameters. A similar network can simulate the functions of virtually any degree of complexity, and the number of layers and the number of elements in each layer determine the complexity of the function.

Determining the number of hidden layers and the number of elements in them is an important issue when designing. The number of input and output elements is determined by the terms of the task. Single-layer networks are significantly limited in their computational abilities. The larger the number of layers in the network, the more complex calculations it can do, but excessive increase in layers can lead to excessive complications of the computational process. In order for the network to be able to perform simulation, the number of weights of the neural network must not exceed the sample size [130].

At the expense of the linear calculation of linear combinations and nonlinear transformations, an approximation of an arbitrary multidimensional function is obtained by selecting the network parameters [124].

There are no feedback links in the multilayer perceptron. Such models are called direct distribution networks. They have no internal state and do not allow the development of dynamic systems to be simulated without additional techniques.

The multilayer perceptron can count the output vector Y for any input vector X, that is, give the value of some vector function $y = f(x)$. Consequently, the condition of any task that can be put into the perceptron must be a set of vectors $\{x^1 \ldots x^S\}$ з N_I components of each.

The solution to the problem will be the set of vectors $\{y^1 \ldots y^S\}$, each vector y^S with N_O components:

$$y^s = f(x^s),$$

where $s = 1..S$ – image number

The most commonly used functions of activating the formal neuron are:

- a rigid step;
- logistic function or sigmoid;
- hyperbolic tangent;
- the floor is a step.
- gradient methods (for example, the method of reverse error propagation);
- Quick calculation of the derivative accelerates training.

As an activation function, the selected sigmoid (3.1), Fig. 3.3, which is used very often for multilayer perceptrons and in other networks with continuous signals, because it has such positive properties as:

- smoothness
- continuity of function;
- the continuity of the first derivative, which allows you to teach the network.

$$sigm(NET) = \frac{1}{1 + e^{-NET}} \quad . \tag{3.1}$$

3.1.2. Determination of volumes of investing in a coal mining enterprise by means of neural networks

For the construction of the neural network, a statistical sample of 98 sets of data on mines was used, including 97 sets of data for 2003 - 2009, were used at the stage of training of the neural network, and data from the Open Society Palohradvugil for 2009, applied as data for testing of predictive properties networks (Table 2.3 - 2.5).

The task is to synthesize the network based on multilayer perceptron, which will form a link between types of investment activity of mines and their profitability. The model is needed for the analysis of the development of Ukraine's coal-mining enterprises for future periods, taking into account the volume of investment by type of investment.

To solve this problem a system of economic and technical factors was used.

Neural network construction was performed by means of MS Excel using the neuroexcel add-on [142].

As input data, the main financial and economic indicators were taken (Table 2.3), namely:

– volume of production, thousand tons. (X_1);

– profit (X_2), thousand UAH;

geological factors, including the main characteristic of the extracted coal, the impact of which on the investment activity of mines is analyzed in [103, 104, 105]:

- average ash content of coal, % (X_3);
- average humidity of coal, % (X_4);
- average sulfur content % (X_5);
- residual industrial stocks, mln tons. (X_6);
- average geological capacity of seams, m (X_7);
- maximum depth of development, m. (X_8);
- length of mining, km. (X_9);
- the angle of the fall of layers, degrees (X_{10});
- production capacity (project), million tons per year (X_{11}).

Output - volumes of material, financial and intangible investments in:

- lifting installations (Y_1);
- ventilator installations (Y_2);
- compressor installations (Y_3);
- drainage installations (Y_4);
- transport facilities (Y_5);
- degassing (Y_6);
- thermal power plants (Y_7);
- the technical complex of the surface of the mine (Y_8);
- electrical installations (Y_9);
- other capital investments (Y_{10});
- portfolio of securities (Y_{11});
- intangible investments (Y_{12}).

To solve this problem, a two-layered perceptron with architecture 11-3-12 was synthesized, the input of which was the value of financial and economic indicators of the enterprises and indicators of technical characteristics of coal, and the forecast of the output parameter was made - the volume of investments by type.

As activating functions are taken sigmoids (3.1). At each step of the calculation, weight and threshold sensitivity were adjusted according to the rule:

$$\Delta w_{ij} = \varepsilon(OUT - y)x_{ij}, \qquad (3.2)$$

where

OUT – value of the output calculated by the network;

ε – step learning step.

At each step, they were reduced ε in 1,5668.

To improve the adequacy of the model before the training of the perceptron input and output data (Table 2.3 - 2.5) were centered and normalized with the following rule:

- Updated standardization of incoming data:

$$x = \frac{X - m_X}{8\sigma_X} + \frac{1}{2}, \qquad (3.3)$$

where

m_X – average value X;

σ_X – mean square deviation X.

The resulting values belonged to the range from -4 to 4 with a probability of 0.99. In order to obtain data in the range from 0 to 1, assuming that the distribution law for the factors X and Y is normal, the transformation is performed according to the formulas:

- Updated standardization of incoming data:

$$y = \frac{Y - m_Y}{8\sigma_Y} + \frac{1}{2}, \qquad (3.4)$$

where

m_Y – average value Y;

σ_Y – mean square deviation Y.

The training error was calculated using the formula of the cumulative quadratic deviation between the desired (y) and the actual *OUT* output signals for all sets of the training set:

$$E = \frac{1}{2}\sum_{k=1}^{P}(y_k - OUT_k)^2 , \tag{3.5}$$

where

E – Total square error (training criterion),

P – number of examples in the training set,

y_k – desired output value

OUT - Actually received the output of the network,

k – is an example number.

A simple neural network is constructed. In order to get rid of unnecessary computational complications due to the alignment of the range of variables with the help of the NeuroExcel add-in, the re-processing of the input data is performed. The variant Mean / Variance, in which the data are converted into a dimensionless form of the average and the normalization of their dispersion, is chosen.

To determine the significance of the input parameters, the Boxcounting function, which determines the statistical significance of the inputs for the specified outputs, was used. In the results we find the most and least significant parameters, as well as those that have intermediate values. Reducing the number of inputs allows you to reduce the time spent learning the neural network or allows you to increase its nonlinear quality. Also, the removal of the most insignificant inputs, whose values are about 0 and positive, which is reflected in the value of the dispersion, which should be as far away as possible from the unit. Using the Boxcounting function calculates the calculated Median to Dispersion ratio:

Y_1=0,58/0,13=4,46;

Y_2=0,62/0,14=4,43;

Y_3=0,57/0,16=3,56;

Y_4=0,65/0,13=5;

Y_5=0,66/0,15=4,4;

Y_6=0,66/0,13=5;

Y_7=0,67/0,14=4,79;

Y_8=0,54/0,15=3,6;

Y_9=0,57/0,15=3,8;

Y_{10}=0,55/0,15=3,68;

Y_{11}=0,68/0,12=5,67;

Y_{12}=1,02/0,1=10,2;

The more this ratio, the better the model performs forecasting.

According to all indicators satisfactory values of the calculated coefficients were received, therefore all of them will participate in the construction of the model of the neural network.

The constructed dual layer neural network has architecture 11-3-12 (number of inputs - the number of neurons in the first layer - the number of outputs) and the following parameters:

- number of layers without input (Number of layer) = 2;
- number of inputs (Number of inputs) = 11;
- number of neurons in the first layer (Layer1, neurons) = 3;
- the order of nonlinearity of the first layer (order) = 1;
- Type of output function of the first layer (function) = sigmoid;
- number of neurons in the second layer (neurons) = 12;
- the order of nonlinearity of the second layer (order) = 1;
- Type of output function of the second layer (function) = linear.

The next step is to start Networking. The character of the test sample is set to Random, since for the approximation problems the most significant is the random choice of the test set. The following learning algorithm is established:

- initial error of elements (Initial delta) = 0,1;
- minimum error (Minimal delta) = 1 × 10-8;
- maximum error (Maximal delta) = 10;

- decrease step Nu (-) = 0,5;

- increment step Nu (+) = 1,2.

At the first step, the training was completed when it reached the number of 1000 epochs. The learning error 0.07 was received, which stabilized when the mark reached 886 epochs. Graphically, small deviations of the line of real data from data predicted by the network were obtained. In other words, the network produces the same set of data that was submitted at the input with a possible error of no more than 1%. If the network is not trained to make accurate predictions on the numerical values at which the training was conducted, it will lead to significant errors when forecasting on a new set of numerical values. Comparison of real and predicted by the network of values by volume of investment in other capital investments is presented on (Figure 3.1).

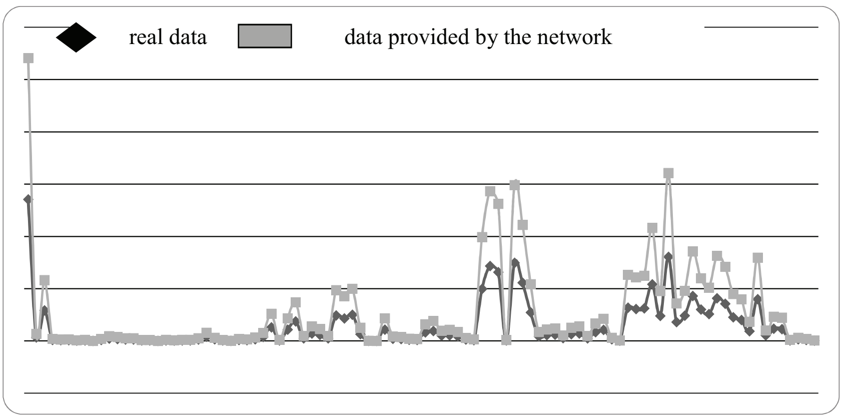

Fig. 3.1. **The result of training the neural network - a comparison of real data and network feedback**

The work of such a network is described by the formula (3.6):

$$OUT = sigm\left(\lambda_2 \sum_{j=1}^{3} \left(sigm\left(\lambda_1 \sum_{i=1}^{11} x_i w_{ij}^1\right) \cdot w_{jk}^2\right)\right), \tag{3.6}$$

where

$k = 1..2$

w_{ij}^{1} – weight coefficient of the i-th input of the neuron number j in the first layer (Table 3.1), w_{ij}^{2} - weight coefficient of j-th input of neuron number k in the second layer (Table 3.2), $OUT_к$ – the output signals of the neural network are standardized according to (3.4), which determine the volume of investment by type of investment:

- investments in lifting plants;
- investments in fan installations;
- investments in compressor plants;
- investments in drainage facilities;
- investments in transport facilities;
- investments in degassing;
- investments in thermal power plants;
- investments in the technical complex of the surface of the mine;
- investments in electrical installations;
- investments other capital investments;
- investments in the portfolio of securities;
- intangible investments.

λ_1 and λ_2 – coefficients of steepness of the sigmoids of the first and second layers, λ_1 and λ_2 was about 0.5.

The architecture of the synthesized neural network is presented in Fig. 3.2.

Thus, the total number of scales of the network 11-3-12 is 69. Based on the fact that the sample size is equal to 98, the neural network constructed is capable of doing simulations.

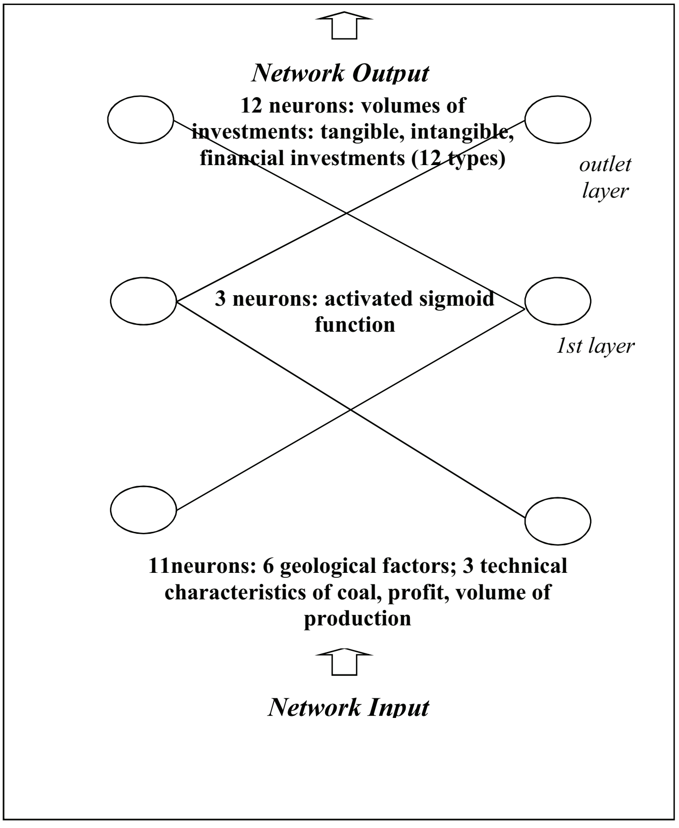

Fig. 3.2. **Neural Network Architecture 11-3-12**

Table 3.1

Values of weight coefficients w_{ij}^{1} first layer

Number of neuron	Entrance number										
	1	2	3	4	5	6	7	8	9	10	11
1	4,4	5,0	0,6	–0,3	2,8	4,2	0,6	2,1	2,5	2,4	0,2
2	0,3	4,8	2,9	0,2	2,5	0,5	3,1	1,3	2,8	3,5	3,5
3	4,5	4,9	4,5	3,4	–0,3	3,9	–0,3	4,8	3,1	1,2	2,2

Source: calculated for (3.6)

Table 3.2

Values of weight coefficients $w_{j\kappa}^2$ second layer

Number of neuron	Exit number											
	1	2	3	4	5	6	7	8	9	10	11	12
1	0,4	1,6	2,3	6,5	3,8	6,2	1,1	6,4	6,0	6,9	3,1	4,7
2	4,3	2,9	2,8	2,5	3,9	–0,5	4,0	2,5	3,5	6,6	2,4	1,5
3	2,0	5,3	4,0	–0,2	3,0	–0,1	4,4	1,3	3,9	0,2	4,2	2,0

Source: calculated for (3.6)

3.1.3. Determination of profits of coal mining enterprise from investments by means of neural networks

As in 3.1.2, a statistical sample of 98 sets of data on mines was used to construct the neural network, of which 97 data sets for 2003-2009 were used at the stage of training of the neural network, and data from OJSC "Palohradvugol" for 2009 The year is taken as data for testing the predictive properties of the network (Table 2.3-2.5 and Annex A). The purpose of this model of the neural network will be to determine the profit of mines, taking into account a certain level of investment by type of investment. Unlike the model developed in subsection 3.1.2, inputs here will be investments by type (material, financial, intangible):

- lifting installations (X_1);
- ventilator installations (X_2);
- compressor installations (X_3);
- drainage installations (X_4);
- transport facilities (X_5);
- degassing (X_6);
- thermal power plants (X_7);
- the technical complex of the surface of the mine (X_8);
- electrical installations (X_9);

- other capital investments (X_{10});
- portfolio of securitiesв (X_{11});
- intangible investments (X_{12});

and geological factors, including the main characteristics of the extracted coal:

- average ash content of coal, % (X_{13});
- average humidity of coal, % (X_{14});
- average sulfur content % (X_{15});
- residual industrial stocks, mln tons (X_{16});
- average geological capacity of seams, m (X_{17});
- maximum depth of development, m (X_{18});
- length of mining, km (X_{19});
- the angle of the fall of layers, degrees (X_{20});
- production capacity (project), million tons per year (X_{21}).

As input data the profits of the coal mining enterprise are taken:

- profit, thousand UAH. (Y);

To solve this problem, a two-layer perceptron was developed, the input of which was the value of investment volumes in accordance with the enterprises, geological factors and technical characteristics of coal, and made the forecast of the output parameter - profit. Neural network construction was performed according to the method used in section 3.1.2. As activating functions taken sigmoids.

At each step of the calculation, weight adjustment and threshold sensitivity were performed according to the rule (3.2). Before beginning the training of the perceptron, the input data were normalized by the rule (3.3). Error learning was calculated by (3.5).

To determine the significance of the inputs used for the given outputs, the ratio of Medium to Dispersion is calculated:

Y_1=1,67/0,13=12,8.

The satisfactory value of the calculated coefficient was obtained.

In the first stage, a two-layer neural network constructed with architecture 21-3-1 (the number of inputs - the number of neurons in the first layer - the number of outputs) and the following parameters:

- number of layers without input (Number of layer) = 2;
- number of inputs (Number of inputs) = 21;
- number of neurons in the first layer (Layer1, neurons) = 3;
- the order of nonlinearity of the first layer (order) = 1;
- Type of output function of the first layer (function) = sigmoid;
- the number of neurons in the second layer (neurons) = 1;
- the order of nonlinearity of the second layer (order) = 1;
- Type of output function of the second layer (function) = linear.

At the next step, networking begins. The character of the test sample is set to Random, since for the approximation problems the most significant is the random choice of the test set. The following learning algorithm is used:

- initial error of elements (Initial delta) = 0,1;
- minimum error (Minimal delta) = 1 × 10-8;
- maximum error (Maximal delta) = 10;
- decrease step Nu (-) = 0,5;
- increment step Nu (+) = 1,2.

In the first step, the training was completed when the number of 1000 epochs was reached. There was an error learning 0.01, which stabilized when the mark reached 728 epochs. Graphically, small deviations of the line of real data from the data calculated by the network were obtained. In other words, the network produces the same set of data that was submitted at the input with a possible error of no more than 1%. If the network is not trained to make accurate predictions on the numerical values at which the training was conducted, it will lead to significant errors in prediction on a new set of numerical data (Fig. 3.3).

The work of such a network is described by the formula (3.7):

$$OUT = sigm(\lambda_2 \sum_{j=1}^{3} (sigm(\lambda_1 \sum_{i=1}^{21} x_i w_{ij}) w_j)), \tag{3.7}$$

where w_{ij} – ваговий коефіцієнт *i*-го входу нейрона номер *j* у першому шарі (табл. 3.3), w_j – weight coefficient of j-th input of neuron of the second layer (Table 3.4), *OUT* – output signal of the neural network - standardized for (3.4) profits of the coal mining enterprise, λ_1 and λ_2 – the coefficients of steepness of the sigmoids of the first and second layers, λ1 and λ2 were approximately 0.5.

Thus, the total number of scales of the network 21-3-1 is 66. Proceeding from the fact that the sample size is equal to 98, a neuron-based neural network is capable of doing simulations.

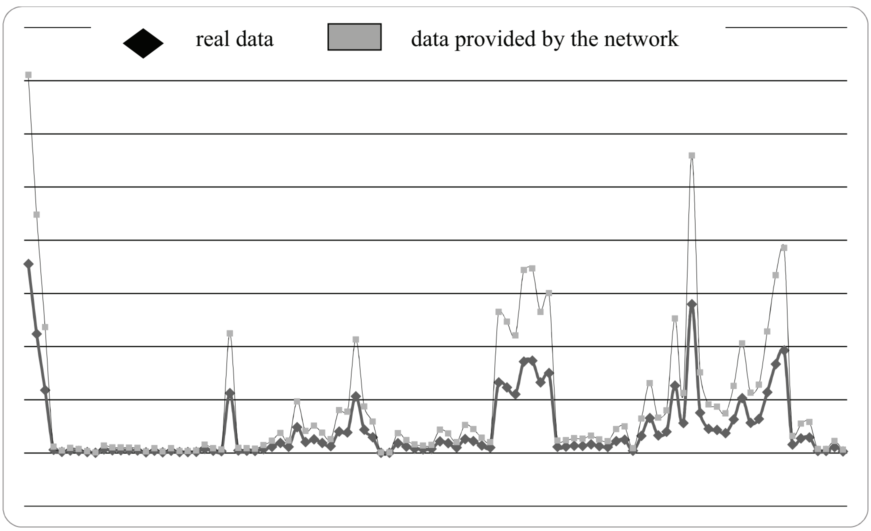

Fig. 3.3. **The result of training the neural network - a comparison of real data and network feedback**

Table 3.3

Values of weight coefficients w_{ij} first layer

Номер нейрону	Номер входу										
	1	2	3	4	5	6	7	8	9	10	11
1	1,7	5,1	1,9	4,2	4,2	2,6	3,1	0,9	0,2	2,5	5,2
2	5,2	1,1	5,9	2,9	6,2	–0,1	1,1	6,6	5,2	0,1	2,7
3	–0,5	1,0	6,8	3,7	3,4	3,4	0,6	0,9	5,0	3,6	3,1

Номер нейрону	Номер входу										
	12	13	14	15	16	17	18	19	20	21	
1	1,8	1,3	2,6	2,4	0,6	2,2	0,6	3,4	3,8	1,7	
2	3,3	3,8	1,9	0,2	0,1	0,2	5,5	0,4	2,4	0,7	
3	3,6	1,5	2,9	4,1	2,7	6,3	4,2	5,8	6,2	3,5	

Джерело: розраховано за (3.7)

Таблиця 3.4

Значення вагових коефіцієнтів w_j другого шару

Номер нейрону	Номер виходу
	1
1	1,1
2	0,1
3	4,2

Джерело: розраховано за (3.7)

3.1.4. Analysis of modeling properties of neural networks

In order to establish the modeling properties of the models developed in sections 3.1.2 and 3.1.3 of the neural networks, a quality assurance test on the test set is required.

At this stage, the generated primary model is further tested as a prognostic tool on a series of test data that were not included in the training sample. Therefore, the test set should be different from the training. To this end, data on the work of Pavlogradugol OJSC for 2009 (Table 2.3-2.5 and Annex A), which did not participate in teaching neural networks, were used.

In order to test the Neural Network "Determination of Investment Volume", developed in 3.1.2, inputs of the network were prepared, including the value of profit, volumes of production, technical factors and geological characteristics of coal produced by Pavlogradugol OJSC in 2009. With the help of the NeuroExcel add-in, based on the already trained neural network, the source data were simulated by the network, among which the volumes of investing in 12 types are given in Table. 3.5.

Table 3.5

Results of Neural Network Modeling "Determination of Investment Volume"

	Indexes															
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Real data	104,80	22,10	65,40	158,90	256,80	4,50	68,80	99,70	45,40	38,40	38,80	354,70	2,00	10,90	24,10	2,80
Data is calculate by network	104,70	22,54	64,30	158,85	256,60	4,40	68,20	97,60	45,28	36,50	39,20	354,72	1,94	10,80	24,01	3,00
Deviation	0,1	-0,44	1,1	0,05	0,2	0,1	0,6	2,1	0,12	1,9	-0,4	-0,02	0,06	0,1	0,09	-0,2

Source: calculated according to (3.6) based on Table. 2.3-2.5.

Marking:

1 - investments in lifting plants;

2 - investments in fan installations;

3 - investments in compressor plants;

4 - investments in drainage facilities;

5 - investments in transport facilities;

6 - investments in degassing;

7 - investments in thermal power plants;

8 - investments in the technical complex of the surface of the mine;

9 - investments in electrical installations;

10 - investments in other capital investments;

11 - investments in the portfolio of securities;

12 - intangible investments.

Consequently, the level of investment obtained as a result of the simulation almost coincides with the actual data, taking into account a slight deviation (Table 3.5).

Graphically, the result of testing the neural network is shown in Fig. 3.10, which shows the coincidence of the line of real and predicted data.

Thus, we can conclude that a trained neural network "Determining the volume of investment" can show the high accuracy of finding the investment in mines in Ukraine with a minimum error.

To test the Neural Network "Determine the Profit of Mine on Investments", developed in section 3.1.3. were prepared inputs of the network among which the value of investments by type (material, financial, intangible), technical factors and geological characteristics of coal by Pavlogradugol OJSC for 2009. With the help of the NeuroExcel add-on based on the already trained neural network, the source data was simulated by the network, namely the level of profit, which amounted to 52106.4 thousand UAH. The actual profit received by Pavlogradugol OJSC was UAH 52089.00 ths. Thus, the deviation of the real indicator from the simulated was 17.4 thousand UAH. or 0,00028%.

Thus, based on the results of the study of the modeling properties of the model, we can conclude that the trained neural network "Determination of the profit of the mine from the investment" can show the high accuracy of the determination of investment in mines in Ukraine with a minimum error.

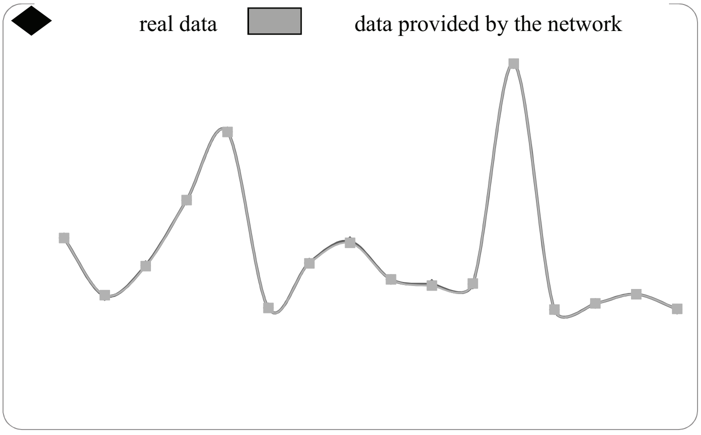

Fig. 3.4. **Results of research of modeling properties of neural determination of investment volumes**

3.2. Scientific and methodological principles of optimization of investment volumes at the coal mining enterprise

Solving any optimization tasks is related to the definition of constraints and the target function. The general formulation of the optimization problem for each particular enterprise has its own distinctive features. This is due to the fact that mines are in different economic conditions, and therefore have different economic needs and ways of their solution. Most of the mines do not receive private investment. Unfortunately, state funds do not arrive in time and in full. Therefore, before the coal mining enterprise becomes a matter of competent disposal of its own profits and the part that it allocates to investing. The author's solution to the optimization problem is aimed at optimizing the management of investment activities of coal mining enterprises at their own expense.

The optimization task includes three components:

- target function F,
- restriction g,
- boundary conditions.

Among the main goals of optimization at coal mining enterprises it is possible to allocate the following:

- increase of volumes of coal production;
- increase in profits of the coal mining enterprise;
- increase of production capacity.

As a criterion for optimization, we will choose the profit of the coal mining enterprise. Such a choice is justified by the fact that most of the mines in Ukraine operate at a loss, so a useful effect from the implementation of an investment project can be considered the calculated cash flow received during the project implementation.

With regard to the limitations that are used in constructing the optimization problem at a coal mining enterprise, the following can be distinguished:

- restrictions related to the total amount of investment. It is important that they be larger than zero and not exceed the amount that a coal mining company can allocate to investing, but this is a question of the company's own funds;

- restrictions related to the need to purchase equipment for the mine.

The mine of Ukraine, by its majority, is in such a condition that the issue of its restoration is acutely at almost every coal mining enterprise, and the amount for which it is necessary to purchase this equipment is often exceeds the amount that can be allocated by the mine. Therefore, as a constraint, it is necessary to establish reasonable priorities for the purchase of equipment.

- restrictions related to the technical characteristics of coal;

- restrictions related to geological factors.

On the basis of graphical and mathematical analysis, the connection between the technical characteristics of coal and the volume of investments has been established. Therefore, the technical characteristics of the product produced by the mine are the necessary parameters in solving the optimization problem.

For the formulation and solution of an optimization task, the purpose of which is to maximize profits of a coal mining enterprise, the econometric and mathematical models already built in subsections 3.1.2 and 3.1.3 have been based on the application of neural network technology:

- a model for determining the amount of investment in a coal mining enterprise;

- the economic-mathematical model for determining the profit of a mine from investments.

Thus, the optimization problem is a synthesis of the development of the above-mentioned models in order to maximize profits.

In the set task of optimization it is chosen:

1) unknown $x_1 - x_{12}$ – standardized by (3.3) the value of investment in:

- lifting installations;

- investments in fan installations;

- investments in compressor plants;

- investments in drainage facilities;

- investments in transport facilities;
- investments in degassing;
- investments in thermal power plants;
- investments in the technical complex of the surface of the mine;
- investments in electrical installations;
- investments in other capital investments;
- investments in the portfolio of securities;
- intangible investments.

The average indicators of coal technical characteristics and geological factors are constant values according to a separately investigated coal-mining enterprise, that is standardized for (3.3)

X_{13} , X_{14} , X_{15} , X_{16} , X_{17} , X_{18} , X_{19} , X_{20} , X_{21} are constants

where:

X_{13} – average ash content of coal,%;

X_{14} – average humidity of coal,%;

X_{15} – average sulfur content of coal,%;

X_{16} – residual industrial reserves, million tons;

X_{17} – average geological capacity of layers, m;

X_{18} – maximum development depth, m;

X_{19} – length of mining works, km;

X_{20} – angle of fall of layers, hailstones;

X_{21} – capacity (project), million tons per year.

the optimality criterion, which maximizes the profit of the coal mining enterprise.

The direct and feedback of the impact of investment on company profits is analyzed in sections 3.1 and 3.2. with the application of neural network technology. Investment volumes are given in 12 types of investments. The target function will look like (3.7):

$$OUT \rightarrow max.$$

2) Limitations on:

a) the total amount of investments should not exceed the amount that a coal-mining enterprise has allocated for the development of each type of investment. So:

$$(x_i - \frac{1}{2})8\sigma x + m_x \leq (OUT - \frac{1}{2})8\sigma y + my,$$

i=1..12;

b) investment volumes by types of investments must be inalienable:

$$(x_i - \frac{1}{2})8\sigma x + m_x \geq 0,$$

i=1..12;

c) upon request of the enterprise, additional restrictions on types of investment are established, if necessary, purchase of equipment, etc.:

$$(x_i - \frac{1}{2})8\sigma x + m_x \leq Z_i,$$

i=1..12,

where Z_i – the amount of investment that an enterprise needs to invest in a particular type of investment;

The optimization problem has found the amount of investment investment for each type of investment, which increases the profit of the considered enterprise. Thus, the solution of the optimization problem makes it possible to make an investment plan for a specific coal mining enterprise, taking into account the peculiarities of its work and experience of other mines in Ukraine. An analysis of the investment plan found by type of investment for a specific coal mining enterprise was performed in subsection 3.3.

The calculation is made using Excel spreadsheets by Newton method [143].

3.3. Estimation of economic efficiency of the investigated scientific-methodical approach of investment optimization on the example of OJSC "Pavlogradugol"

In connection with the transition of the coal industry to market relations, the ratio to the calculation of the definition of the efficiency of the planned investments in capital construction should change radically. Calculations of the economic efficiency of investments should not only protect the investor from bankruptcy, but also provide him with profits in size, the corresponding volume of investment and the duration of their development, even before the introduction of fixed assets, production capacities and the sale of products received by them. From the formally-mandatory annex to the construction projects of enterprises (or concepts of the development of the industry as a whole for the coming years or for a fairly long term), these calculations should become the main criterion for assessing the economic feasibility and actual directing of funds for the construction or reconstruction (technical re-equipment) of other business irrespective of the source of its financing.

On the basis of conducted researches in the framework of this work in the field of management of investment activity at coal mining enterprises, a method for determining the effectiveness of investment investments, based on the technology of neural networks, has been formed.

The calculation of economic efficiency of the implemented methodology is carried out according to the following method:

1. On the basis of the economic-mathematical model "Determination of investment volumes" on the basis of neural networks, the determination of the amount of investment that the coal-mining enterprise is able to allocate for investing is performed.

2. The distribution of investment resources by type of investment is accomplished by solving an optimization problem, the criterion of which is the maximization of profits of a coal mining enterprise - "Determination of optimal investment volumes" with the establishment of necessary constraints (by the amount

of investment, including types of investment, on the values of technical characteristics of coal and geological factors) Obtain the results of the distribution of investment resources by type and value of profit.

3. Determine the effectiveness of the investment project proposed by the management of the coal mining enterprise, obtaining the value of the profit of the coal mining enterprise using the model of the neural network - "Determining the profit of mines from investments."

4. In order to determine the most effective investment project, a comparison of financial results of the enterprise in the past year with the financial indicators of the enterprise for the next year, with the establishment of absolute growth rates:

- financial indicators for the past year,
- expected financial indicators,
- indicators, received as a result of realization of the investment project of the enterprise,
- indicators obtained as a result of the implementation of an investment project on the basis of solving the problem of optimal allocation of investment resources.

5. Considering that the main part of the project is investment in fixed assets, for the determination of the intensity of the use of fixed assets of the enterprise, the calculation of the coefficient of return on assets according to the formula [144] is carried out:

$$Фо = Q/Фср,$$

where $Фо$ – return on capital; Q – volume of finished products; $Фср$ – the average annual cost of the main productive assets of the enterprise.

1. Comparison of the received coefficient of return on capital ratio with the coefficient for the previous year.

2. Based on the results of comparing financial indicators with the definition of absolute growth rates, it is concluded that it is expedient to use a particular investment project as a project that has the greatest impact on improving the main financial performance of the enterprise compared to last year.

The investment project of the coal mining enterprise Pavlogradugol OJSC for 2007 has been analyzed. Planned investment volumes for 2007, presented in Table. 3.6, for the total amount of 565.9 thousand UAH.

The expected financial performance of the enterprise from the implementation of the investment project in 2007 is as follows:

- the volume of extraction - 10234,03 thousand tons;
- profit - 2370,00 thousand UAH;

The distribution of investment resources based on the model of the neural network is executed, with the purpose of determining the amount of investment, which amounted to 656.9 thousand UAH.

The results of solving the optimization problem of optimal investment distribution by type are given in Table. 3.6. The following restrictions were imposed by type of investment at the request of the management of the coal-mining enterprise (ths UAH):

- Lifting equipment - 58,4;
- Fan installations - 46,7;
- Compressor units - 35.1;
- Drainage installations - 31,2;
- Transport facilities - 50,6;
- Thermal power plants - 39,0.

In tabl. 3.6 submitted volumes of investment volumes for Pavlogradugol OJSC in 2007, proposed by the management of the coal mining enterprise in accordance with the results of work in 2006, and the investment volumes obtained as a result of the optimization task.

Based on the results of the allocation of investment resources identified in solving the optimization problem, the total amount of investments for 2007 amounted to 656.9 thousand UAH, which makes up 66.9 thousand UAH. more than suggested by the company's management. Moreover, the model proposed to increase the investment of money in research and development, training of personnel, portfolio of securities. According to the main types of equipment, the model provides the same amount of investment as in the investment project of Pavlogradugol OJSC. Reduction of investment investments by the model is proposed in this direction of other capital investments and for certain types of equipment.

Table 3.6

Volumes of investments (ths. UAH) for Pavlogradugol OJSC in 2006-2007

Investments by type	2006	2007 plan	2007 model
1	2	3	4
Lifting plants	79,6	58,4	58,4
Fan Installations	77	46,7	46,7
Compressor installation	676	35,1	35,1
Drainage facilities	42,4	34,15	31,2
Transport facilities	69	50,6	50,6
Degasification of the installation	3	16,42	31,2
Thermal power plants	53	39	39
Technical complex of the surface of the mine	69	12,36	50,6
Electrical installation	63,6	25,75	46,7
Other capital investments	198,9	240,44	146,1
Portfolio of securities	397,8	24,29	92,1
Нематеріальні інвестиції	39,8	6,79	29,2
Total:	1769,1	590	656,9

Source: Reporting data for Pavlogradugol OJSC

The financial indicators proposed by the neural network and obtained as a result of the investment project of the company with the definition of absolute growth, are given in Table. 3.7.

Table 3.7

Dynamics of the main financial indicators as a result of the investment project implementation, UAH ths.

AF	AF for 2006	PFP for 2007	FP1A 2007,	AF2	APP	APM
Profit	2210,00	2275,00	2270,00	2523,00	65,00	313,00

Applied to the table. 3.7. designations are decoded as:

AF - financial indicators;

PFP - planned financial indicators;

FP1 - financial indicators received by the neural network as a result of the implementation of the investment project proposed by the enterprise;

AF2 - financial indicators for 2007, obtained as a result of the investment project implementation in solving the optimization problem;

APP - absolute increase from the realized investment project, planned by the enterprise;

APM is an absolute growth from the investment project implementation based on optimization of investment distribution.

Results of calculating the coefficient of return on assets:

- in 2006 the volume of extraction amounted to 10432,7 thousand tons, the average value of fixed assets - 313190 thousand UAH, F = 0,03;

- in 2007 the volume of extraction as a result of the investment project implementation, according to the optimization task, amounted to 11172.4 thousand tons, the average cost of fixed assets was UAH 236789 thousand, F = 0,05.

Thus, we have an increase in the return on capital ratio in 2007 compared to 2006, which indicates a more intensive use of fixed assets of the enterprise.

Increase in fixed assets can be said about the possibility of the decision of the mine of the following tasks:

- construction of a new mine; extended playback of the operating company;

- increase of its capacity, which is carried out by reconstruction or modernization;

- maintenance of the power of the operating company, which is carried out by reconstruction or modernization of individual elements of the enterprise, but without increasing the capacity of the mine [4].

Perform a comparison. As can be seen from Table. 3.7, both investment projects - the optimization investment project and the plan of management of the coal mining enterprise - proved to be effective and have a positive impact on the increase of the main financial indicators compared to the previous ones in 2006. But the project received as a result of solving the optimization problem more intensively affects the increase of the main financial indicators of the coal mining enterprise. The profit, received as a result of the investment project of the enterprise, amounted to 2270,00 thousand UAH, and the resulting optimization distribution of investment resources - 2523,00 thousand UAH, thus, the amount of the economic effect amounted to 253,00 thousand UAH.

The investment project of Pavlogradugol OJSC for 2007, analyzed as a result of solving the optimization problem using the model for determining the optimal investment volumes, was analyzed. This project is designed for one year at an amount of UAH 656.9 ths .:

Investments by type	**Thousands of hryvnias**
- Lifting installations	58,4
- Fan installations	46,7
- Compressor installation	35,1
- Drainage installations	31,2
- Transport facilities	50,6
- Decontamination of the installation	31,2
- Thermal power plants	39
- The technical complex of the surface of the mine	50,6
- Electrotechnical installations	46,7
- Other capital investments	146,1
- Portfolio of securities	92,1
- Intangible investments	29,2
Total:	656.9

In order to test the methodology for determining effective investment volumes, a classical methodology for evaluating the effectiveness of investment projects has been used. Input values of financial indicators for Pavlogradugol OJSC for 2007:

cash receipts for 2007 - 6897,0;

balance profit - 2833.0;

net profit - 2523.0.

The following selection of metrics was applied [36,37,38]:

1. The adjusted profit (*PV*) is calculated for the constant rate of discount by the formula:

$$PV = \sum_t \frac{P_t}{(1+r)^t},$$

where P_t – cash receipts for the period r – discount rate.

$$PV = 6897{,}0/(1+0{,}2) = 5747{,}5 \text{ thousand UAH}$$

2. Net Return on Profit (NPV) is defined as the sum of flow effects (i.e., exceeding results over costs) for the entire estimated project lifetime, reduced to the initial period:

$$NPV = \sum_t \frac{P_t}{(1+r)^t} - IC\ ,$$

where *IC* – investment (expenses) for the project.

If *NPV* is positive at a given discount rate (*NPV*> 0), then the project can be considered effective and consider the issue of its adoption or further analysis. The higher the *NPV* value, the more efficient the project. If *NPV* <0, then the project is considered ineffective.

$$NPV = 6897/(1+0{,}2) - 656{,}9 = 5090{,}6\,.$$

3. The index of return on investment (RI) is the ratio of the sum of these effects to the amount of investment, that is:

$$PI = \sum_t \frac{P_t}{(1+r)^t} / IC.$$

The return on investment index (profitability) is closely related to the *NPV*: if

NPV is positive, then $PI > 1$, and vice versa. So, if $PI > 1$, then the project is considered effective, and if $PI < 1$ - ineffective.

$$PI = (6897/(1+0{,}2))/656{,}9 = 8{,}7 .$$

4. The internal rate of return *(IRR)* is the rate of discount r when $NPV = 0$ (that is, the size of the consolidated effects is equal to the consolidated investment), which is determined by the equation:

$$\sum_t \frac{P_t}{(1+IRR)^t} = IC .$$

If the NPV of the investment project answers the question of its efficiency at a given predetermined rate of discount r, then the IRR is determined by the method of successive approximations and compared with the ineligible investor the rate of return on invested capital. If the IRR is at least equal to the required return on equity, the investment is justified. Otherwise, the project is rejected.

With the IRR indicator, you can determine the maximum relative cost level permissible for the analyzed project. For example, if the project is fully financed by a commercial bank loan, then the IRR value represents the upper limit of the assumed level of the bank interest rate, the excess of which makes the project unprofitable.

$$IRR = 6897/656{,}9 - 1 = 9{,}5 \text{ тис. грн.}$$

5. The coefficient of investment efficiency (ARR) is the ratio of the year's net profit of the P_{cp} project (balance profit minus deductions to the budget) to the average annual volume of investment of ICs (without residual or liquidation value):

$$ARR = \frac{P_{cp}}{IC_{cp}}.$$

The *ARR* indicator is determined without discounting costs and benefits, so it does not allow for the difference between projects with similar annual average earnings, but those that vary in time.

$$ARR = (2833/656{,}9) = 431\%.$$

6. Payback period *PP* is the minimum time interval (from the beginning of the project), beyond which the integral income from the project becomes positive and remains the same. In other words, this is the period from which initial investments and other costs associated with the project are covered by the results of its implementation. The sequence of calculating the payback period depends on the equivalence of the distribution of projected return on investment. If the profit is distributed over the years evenly, then it is proposed to use the formula:

$$PP = \sum_t \frac{IC_t}{P_t^{'}},$$

where $P_t^{'}$ – annual return on capital.

$$PP = 656{,}9 / 6897{,}0 = 0{,}09.$$

Thus, based on the calculation of the efficiency of the investment project, based on the classical methodology for evaluating the efficiency of investments, we can conclude that, in accordance with all of the above indicators, the project proved to be effective and could be implemented at the Pavlohradvugil OJSC coal-mining enterprise.

Conclusions

In the monograph the new solution and theoretical generalization of the scientific problem, which consists in the development of scientific and methodological principles, conceptual approaches and tools of analysis, mathematical modeling and management of investment activity at a coal mining enterprise, was made.

1. Over the period of 2003-2009, 50% of domestic mines reduced coal production due to critical wear and tear of fixed assets, considerable complexity and increased accident rate for mining operations. The fall in profits from coal mining enterprises is due to the timely and incomplete calculations of consumers for coal, the inconsistency of prices for coal products with the costs of its production, the lagging coal industry from the general pace of reforming property relations in the state, credit indebtedness of mines and the lack of funds for the modernization of production.

2. In the context of the global financial crisis, the own funds of coal mines are the main source of ensuring their investment activity. It has been established that for the coal mining industry there are 12 types of material, financial and intangible investments in: lifting plants, ventilating plants, compressor plants, water supply plants, transport facilities, degassing plants, thermal power plants, technical complex of mine surface, electrical installations, other capital investment, portfolio of securities, scientific and technical research and training of personnel.

3. The most important factors influencing the investment processes of a coal-mining enterprise should be considered a group of geological factors and technical characteristics of coal, including the residual industrial reserves of the mine, the average geological capacity of the beds, the maximum depth of development, the length of the mining, the angle of the fall of the beds, the production capacity of the project mines, average ash content, humidity and sulfur content of coal.

4. The main criteria for the efficiency of the investment activity of a coal mine should include growth in profits and production volumes. Based on the analysis of existing methods of management of investment processes, it is proved that they do not take into account the specifics of the activity of the enterprise to which they are

applied. Coal Mine is a complex production-economic system, which operates in conditions of uncertainty and exposed to a large number of factors. Therefore, in order to predict the results of investment activity of coal-mining enterprises with the highest adequacy and accuracy it is expedient to use a modern mathematical device of neural networks.

5. In order to substantiate the investment plans of the coal mining enterprise in terms of the distribution of limited cash between material, financial and intangible investments an economic and mathematical model is created in the form of a neural network whose inputs are financial and economic indicators, geological factors and technical characteristics of coal.

6. In order to determine the impact of the size of investments on the profit of a coal-mining enterprise, it is recommended to apply the proposed economic-mathematical model in the form of a neural network, which takes into account inputs of investments made in 12 of its types, geological factors and technical characteristics of coal in the mine under consideration.

7. Integrated use of developed economic and mathematical models within the framework of a single concept of increasing the efficiency of investment activity of coal-mining enterprises provides an opportunity to optimize the allocation of funds allocated for material, financial and intangible investments, with the aim of maximizing the profit of a coal mine.

8. Based on the practical application of the results obtained in the field of optimization of investment allocation at the mine, taking into account the selected factors that have a significant impact on the investment activity of the coal-mining enterprise, the rationale of managerial decisions and the efficiency of the choice of investment projects increases, which, for example, OJSC Pavlo GraduGill ", can provide more than 11% of additional annual profit.

The mechanism of management of investment activity of enterprises on the example of enterprises of the coal industry can be used in their practical management activity, because it allows:

- To increase the degree of validity of decisions taken in the implementation of investment projects, taking into account economic efficiency;
- to find out the influence of economic, geological factors and technical characteristics of coal on the volumes of investment, which determine the deviation of the actual indicators of the efficiency of investment projects being implemented, from their design values.

The developed scientific approach to calculating investment volumes, in order to maximize the profit of coal mines, can be applied to the creation of similar methods of investment process management for quarries, concentrating factories, metallurgical and machine-building enterprises.

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