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The scientific monograph presents the theoretical and practical aspects of the development of modern scientific research. General questions of economics and enterprise management, regional economics, marketing, technical sciences, technology of food and light industry, and so on are considered. The publication is intended for scientists, educators, graduate and undergraduate students, as well as a general audience.

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PLANNING AND FORECASTING OF FINANCIAL ACTIVITIES IN OSCHADBANK

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Abstract. *The purpose* is to scientifically substantiate theoretical and methodological provisions on planning and forecasting the financial results of the bank, objectifying the practical application of the concept of strategic plan development, justification of the effectiveness of the implemented method of machine learning in planning and forecasting. The financial and economic crises of recent years have been the result of serious shortcomings in the system, structure and functioning of most credit institutions. In the process of creating and operating a new credit system and intensifying interbank competition, banks will face acute problems such as choosing the strategic direction of the bank's development, planning and development, as well as identifying specific measures to study and develop the banking market. *Methodology*. The paper also uses such general scientific research methods as analysis and synthesis, deduction and induction, methods of prognostic, logical-analytical modeling, mathematical statistics. This paper uses the results of research and practical activities of the author, data on social and economic development of Ukraine, commercial banks, the main theoretical principles and conclusions of modern economics, as well as official materials of statistical bodies. *Results*. In order to improve the quality

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of the financial planning and forecasting system, the use of machine learning in the process of planning and forecasting the bank's financial results and expanding the range of macroeconomic indicators was proposed. Also, some provisions and conclusions of the study are practically implemented in the activities of Oschadbank in developing a system of planning and forecasting financial results. *Value/originality*. The scientific novelty of the work is that the proposed methodological and theoretical developments in the formation of planning and forecasting system brought to the stage that allows them to be used in the preparation of planning and calculation justification of efficiency and development of commercial banks of various profiles.The obtained scientific results are also of practical importance, characterizing the economic, financial, social efficiency and effectiveness of the system of planning and forecasting of the strategy of activity and development of the bank formed in the work.

1. Introduction

Formation and development of a market economy directly depends not only on the formation and effective functioning of the financial market, but also on the need to ensure the organization and regularity of current functioning and long-term, strategic development of one of the main links banking system -credit organizations. In this case, the effective functioning of the credit institution can be ensured by a system of planning and forecasting indicators of its activities and development. Part of such a system is not only current, medium and long-term plans of the bank, but also strategic planning, development of strategic direction of the bank, which is directly related to the planning of banking marketing.

The financial and economic crises of recent years have been the result of serious shortcomings in the system, structure and functioning of most credit institutions. In the process of creating and operating a new credit system and intensifying interbank competition, banks will face acute problems such as choosing the strategic direction of the bank's development, planning and development, as well as identifying specific measures to study and develop the banking market. This is due to the fact that the main reason for the most common gaps in the activities of banks is the low quality of strategic management, as well as the lack of an effective planning system as a basic management function.

The urgency of solving these problems and problems is especially growing in economic crises, as the presence of effectively functioning commercial banks – one of the conditions for successful development of the financial market. In turn, the effective functioning of commercial banks as participants in the financial market, its dominant sectors – money market, securities market, loan capital market, directly depends on the rationale for current, long-term medium – and long-term planning and development strategy. Expanding the range of banking operations, blurring the line between traditional banking and quasi-banking operations, completing the extensive development of the banking system and competition for cheap resources leads to the need to plan and regulate relations related to the formation and use of monetary resources. Therefore, the formation of theoretical, conceptual and methodological provisions of the mechanism for planning and forecasting the activities of a commercial bank, the development of its development strategy is becoming increasingly important. Currently, the theoretical and methodological foundations of systematic planning and forecasting of activities and development of a commercial bank, including strategic planning, development of long-term, medium-term and current plans and marketing planning to achieve strategic goals in agreeing on resources, intermediate stages and ultimate goals are clearly insufficiently developed. There is a need to form such methodological, methodological and practical provisions of system planning and forecasting of socio-economic development of a commercial bank, which could form the basis of this system.

Objectification and substantiation of the importance of system analysis and methodological decisions for the long-term development of the banking services market in the presence of such areas as planning product and pricing strategies, planning delivery systems and incentives are also waiting for a solution.

The urgency of the topic lies in the need to solve such important economic and social problems as the creation of a scientifically sound system of planning and forecasting the effectiveness of a commercial bank as a full participant in the financial market.

The main purpose is to scientifically substantiate theoretical and methodological provisions on planning and forecasting the financial results of the bank, objectifying the practical application of the concept of strategic

plan development, justification of the effectiveness of the implemented method of machine learning in planning and forecasting.

Theoretical and methodological basis of the work were educational works in the field of management, regulation, planning and forecasting of socio-economic systems of commercial organizations, banking management, machine learning, analytical reviews of banking portals, statistics. In the course of the research the legislative and normative acts of Ukraine, NBU resolutions, Presidential Decrees were studied.

The paper also uses such general scientific research methods as analysis and synthesis, deduction and induction, methods of prognostic, logical-analytical modeling, mathematical statistics. This paper uses the results of research and practical activities of the authors, data on social and economic development of Ukraine, commercial banks, the main theoretical principles and conclusions of modern economics, as well as official materials of statistical bodies.

The scientific novelty of the work is that its proposed methodological and theoretical developments in the formation of planning and forecasting system brought to the stage that allows them to be used in the preparation of planning and calculation justification of efficiency and development of commercial banks of various profiles.

2. Economic crisis effects on consumer behavior

In a constantly changing financial market environment, the most responsible part of banking management is planning, in the process of which banking policy is developed, from the emergence of the basic idea and its implementation in the plans of specific measures and quantitative (digital) indicators.

Planning of the bank is a management process associated with the study of financial and economic results of its operation, identifying factors, trends and proportions of economic processes, sound areas of development of the bank.

However, the plan cannot be firm. This is due to the fact that the external among banks is dynamic, flexible, as it develops according to market laws.

The results of the activity cannot be successful if the bank strictly adheres only to the implementation of the plan without taking into account the requirements of the external environment (needs and demands of customers, actions of competitors, various public organizations, press behavior, etc.).

The plan cannot be given exceptional importance. It should be promptly changed in accordance with the situation in the financial market. In the process of carrying out planned tasks, it may change depending on the market situation.

Planning allows to determine the prospects of the bank's development, ie to predict its future, use all resources more rationally, avoid possible risks as a result of active and passive operations, timely introduce new services, improve the quality of services according to market conditions, ensure profitability and consistent capital growth.

Planning should apply to all objects of management, areas of activity of the credit institution and the ongoing processes or existing relationships. At the same time, the bank's management constantly has to solve a number of complex tasks, including: prioritization and selection of financial market sectors that allow the bank to make optimal use of its human and customer potential, as well as a portfolio of banking products; setting interest rates that provide a sufficient margin; allocation of free resources taking into account the specifics of liabilities, their value, urgency, which would allow to comply with certain liquidity requirements, risk limits; determining tactics of behavior in the markets, the use of free resources for transactions with securities, currency values; risk management, hedging; personnel and branch management, setting limits on their operations.

The practice of development and decision-making in each credit institution has its own characteristics, which are determined by the nature and specifics of its activities, organizational structure, the current system of communications. However, there are common features of the activity planning process. These are the only principles that shape the technology of developing and adopting a plan used by any commercial bank.

1. Formation of strategic thinking in senior managers, ensuring that each leader understands the need to implement planning.

2. Creating optimal conditions and evaluation system for the implementation of strategic goals and objectives. Such conditions include the introduction of management of individual units as independent business / units whose activities are regulated and evaluated on market principles; introduction of financial management, which allows to adequately calculate the potential profitability and evaluate various aspects of their activities. At this stage, it is important to implement a system of

evaluation of the bank's performance in terms of compliance with external and internal objectives as part of financial and management accounting, which will be the basis for monitoring the progress and evaluation of planning results.

3. Creating a strategic planning infrastructure, which means ensuring control and evaluation of planning results by senior management; creating a system of responsibility of employees and managers of various departments, stimulating the achievement of goals; allocation of a special unit, provides strategic planning.

4. Formation of a detailed strategic plan based on the assessment of the possible impact of the external environment, as well as on the assessment of the strengths and weaknesses of the bank, its capabilities and risks.

5. Implementation of the system mutually support the goals of the bank, departments and the employee. Personal goals of employees, being realized, should lead to achievement of the purposes of division, set of the reached purposes should provide performance of the corresponding strategic purpose of bank and strategy as a whole. One of the most common approaches to implementing this principle is the implementation and maintenance of a corporate culture.

6. Implementation of a system for monitoring and forecasting the behavior of the external environment and adjusting strategies. At this stage, it is necessary to create conditions under which not only the relevant unit, but also the organization as a whole would be involved in monitoring the environment.

Strategic plans should be adjusted accordingly based on the information received.

7. Development of strategy and tactics of behavior in the current environment. The implementation of the described principles allows the credit institution to create an effectively functioning planning system. Its most significant characteristics are:

a) flexibility and indicativeness, ie the ability to quickly adjust the plan in the event of unexpected changes in the market situation;

b) a carefully thought-out and organized process of monitoring the implementation of targets, which aims not only to register the actual deviation from the plan, but also to determine the real reasons for non-compliance and untapped potential;

c) alternative planning – drawing up a multivariate plan for rapid response to changing market conditions;

d) integration of the planning system into the organizational structure of the bank, which involves participation in the preparation of the plan and control of its implementation by managers of all levels of government;

e) orientation of development strategy and individual plans to maximize financial results,

The bank should create a single information base for situational analysis conducted during strategic planning, business / planning, current planning and planning of bank operations.

It is created and implemented in the practice of the bank due to a certain management technology that provides the creation of a data warehouse (DATA WARE NOUSING). In a mode close to real time, it receives information about the bank's operations and external characteristics of financial markets, and the formats of descriptions of operations and market indicators should be unified. This will create standard procedures for their processing and obtain comparable reports on the dynamics of external and internal processes and indicators used for situational analysis in resource planning and current management.

The effectiveness of the planning function in a commercial bank is determined primarily by the regularity and level of organization of this process. The need for continuity and consistency of principles and methods of preliminary analysis, planning and control leads to a high degree of formalization of this procedure, which is expressed in the minimum requirements for technology to determine future indicators and information used, which include the following.

1. The bank must have a special unit, based on strategic analysis, prepares draft documents that reflect the concept, goals and plans for the development of the bank, and keeping them up to date (adequate to changing conditions). Such a unit must act in accordance with the provisions of a special package of internal regulations, the core of which are the methods used by the information support service to collect, process, analyze and submit information. It should be borne in mind that the problem of quickly obtaining reliable and high-quality management information can be solved only comprehensively. This requires, on the one hand, to have the appropriate methodological support, clear to every head of the bank, on the other – to optimize the structure of the bank and its document flow.

2. A developed system of internal banking planning should ensure the development and approval (documentation) of:

a) the concept (mission) of the bank, designed for the period, realistically predictable;

b) systems of qualitative and most important quantitative goals of the bank's activities or intentions ("goal tree" of the bank) for a specific planning period;

c) the system of policy directions of the bank in relation to all significant objects of banking management, ie the system of objectives of the bank, received a refined qualitative and quantitative expression (for the same or less period);

d) lists of practical measures (organizational, legal, analytical, financial / economic, technical and technological, personnel) indicating the specific deadlines, volumes, performers to be taken to implement each of the approved policies of the bank and the bank budget.

We should keep in mind the most common mistakes in the interpretation of banking planning: limiting planning tasks only to making plans or identifying ways to achieve the intended goals (ie excluding tasks related to the formulation of concepts, priorities, goals and policies). bank); restricting the planning of the bank's activities only by planning its finances; full or partial focus of planning results exclusively on senior management.

The result of the development of a system of policy directions of the bank and practical measures for their implementation are financially sound plans for the development of the bank, which should: be a coherent, consistent set of plans, characterized by different planning periods, different levels of detail of work that apply to the development of the bank as a whole and (or) its individual units, the implementation of individual decisions; be in a state of constant development (regularly reviewed and, if necessary, updated according to fixed rules).

3. The bank must have at its disposal a special service and integrated information support technology (justification) of all management decisions made in it, for which this service must: to promote the strategic analysis carried out by a special planning unit; timely (in a mode close to the real time mode) to provide processed in a certain way current information and data on the results of its operational analysis, the process of making management of the bank and its departments of management decisions

of an operational nature. Such information and the conclusions made on its basis should characterize, first of all, the current state of all assets and liabilities of the bank, their consistency, urgency, associated risks.

4. In the process of planning and operational management, the heads of the bank and its main divisions must have at their disposal documented and regularly updated according to certain rules substantiated information: about the characteristics of the bank itself, including a description of its weaknesses and strengths, a list of external opportunities that can provide the bank with comparative advantages, a list of obstacles to the bank's activities; determining its specialization for the current and future periods; description of the qualities that distinguish the bank from competitors, as well as key corporate values recognized by all employees of the bank; determination of the principles and limits of the bank's flexible response to certain possible changes in the conditions of its activities; comparison of actual results with planned ones; on the markets and industries covered by the bank's interests; about the clientele (as detailed information as possible).

This means that in fact planning should be based not on analysis in general, but on strategic analysis (analysis of deep factors), while regulation (operational management) should be based on the requirements of approved plans (programs) of bank development, but taking into account operational results current, daily) analysis.

The planning process includes the preparation of long-term forecast plans. The purpose of these documents is to provide the bank's staff with an understanding of the general objectives, strategies and tactics of their implementation, as well as what resources the bank has at its disposal.

In other words, planning provides an understanding of the goal, the invariance of ways to achieve it depending on certain parameters that determine the external environment. planning allows you to interconnect all aspects of the bank's activities with the help of consolidated indicators, to link the results with the interests of the team through a system of material and other incentives. Each credit organization's practice of development and decision-making has its own characteristics, determined by the nature and specifics of its activities, organizational structure, the existing communication system. However, as already mentioned, there are common features for the planning process, wherever it takes place. This is the only

core on which the technology of development and adoption of the plan, which is used by any credit institution.

Currently, several strategies are known that allow not only to exist but also to develop even in times of crisis.

The first is to find, identify and target small growing market segments within the stagnant sector.

The most difficult thing in this approach is to correctly identify and predict their development.

Another approach is to diversify through continuous work to improve the quality of existing and introduce new banking information technologies. This approach is promising because successful innovation or significantly higher quality can contribute to the growth of the customer base, as well as the benefits of this kind allow you to win in non-price competition and earn high profitability of new services.

The third approach is to focus on a sharp reduction in costs in order to achieve higher profitability at competitive prices for services. First of all, it is the rejection of unprofitable business units and structural units, reducing operating and operating costs by optimizing internal technological processes. Naturally, there are many strategies of the bank, but these approaches can be used in different modifications depending on the state of the environment and the availability of resources for their implementation.

Planning the activities of credit institutions requires consideration of specific conditions associated with their place in the system of market relations.

First, the movement of financial capital prevails in the process of providing banking services. Accordingly, special attention is paid to the planning of financial indicators and characteristics of cash flows. Based on the specifics of the banking institution, the main emphasis should be on planning own funds, operations to raise and place funds. Planning of fixed assets, the cost of inventories is relatively less important.

Second, regulating the activities of credit institutions by establishing mandatory economic standards makes it necessary to plan these standards, which allows you to decide whether or not to carry out operations and helps to avoid violating the limits of standards. planning the timing of banking operations allows them to be completed before the reporting date.

Third, the bank is a settlement center and an intermediary in the financial operations of other economic agents. This leads to his active participation in many other organizations of various industries and forms of ownership. Thus, the dependence of banks on the customer base is very high, so it is important to plan and forecast the activities of counterparties and customers of the bank in the part that is directly related to it: lending, raising funds, etc.

Extreme instability of the external environment should also be taken into account. Theoretically, we can identify four blocks of change that can affect the credit institution: political, economic, technological, social.

Recently, the rate of change in the external environment has increased significantly, which has increased risk and uncertainty. To overcome the risk, a flexible planning structure is needed, based on various proposals related to the development of environmental conditions.

Now the concept of strategic planning of banking is of undoubted interest, as this form of planning is effective with a high level of instability, which is determined in terms of three characteristics: the degree of familiarity of events, the pace of change and predictability of the future. Factors influencing the value of these characteristics are quite diverse, which gives hope for positive results of strategic planning in modern conditions.

As a rule, the bank's strategic plan reflects: 1) the initial conditions and assessment of the environment in which the bank should operate; 2) market priorities, depending on which the distribution of funds; 3) assessment of the strengths and weaknesses of the bank, opportunities and dangers; 4) adjustments to the strategy in order to realize market opportunities; 5) the choice of time for strategic action; 6) expected results.

Starting with setting long-term goals and determining investment priorities, the bank develops an action strategy, in the inseparable unity of which is the amount of funds needed for its implementation. In the development of the strategy are formed current plans aimed at making strategic changes, the need for which is dictated by constant changes in market conditions. The implementation of these changes determines the range of tasks of managers. this is the fundamental difference between the dogmatically accepted planning of our country and the strategic planning practiced in many Western banks.

It is thanks to the current situation that you can adjust the chosen strategy, which is an integral condition for achieving the desired strategic goals in any type of banking.

In addition to strategic planning, the theory of banking management mentions other, diverse types of planning: marketing, current, tactical, operational, financial, personnel planning, etc. The following types of planning can be distinguished according to the scope and level of detail of the defined tasks and targets: planning of the bank's strategy, which involves determining the bank's mission, its goals and objectives, priorities for future development; marketing planning aimed at developing banking products that are in demand in the market; business planning, designed to identify specific ways to address strategic objectives and the implementation of promising banking services and structural constraints on the bank's operations, which will allow it to achieve optimal financial results while limiting the overall level of risk of the bank; operational planning, which determines the list and timing of specific projects that ensure the implementation of the business plan, as well as the amount and structure of resources required for this and the payback period; financial planning, the purpose of which is to assess the financial results expected in the implementation of a particular version of the business plan or current plan, and the construction of the bank's forecast balance sheet; drawing up cost estimates and using the bank's profits, touches on the issue of determining the amount of overhead costs of the bank and the necessary capital costs for new programs or projects; budget planning, which determines the main directions and planned financial performance of individual structural units of the bank (so-called business units); current activity planning, the task of which is to prepare and coordinate current decisions on specific operations of the bank in order to maintain its current liquidity and solvency and ensure compliance with the bank's limits; structuring the organization and planning of personnel, which are designed to determine the system of powers and responsibilities for the implementation of targets, to ensure operational interaction of the bank in the implementation of the plan and select staff with the necessary qualifications to solve long-term and current problems.

All types of planning are closely interconnected, most of them are both separate stages of the process of developing the bank's strategy, and elements of the current management of the credit institution. To avoid contradictions that arise in management decisions due to the inconsistency of individual planning and analytical procedures, it is necessary to develop a technology of current, long-term and strategic planning, which would determine the

general standards of these processes. The solution of this problem involves the creation of: a single information repository of the bank, containing all external and internal information necessary for planning and management decisions, a single methodology for analysis and planning of the bank, ensuring comparability of all planning and analytical indicators used in credit management; unified regulations for planning the activities of the credit institution, which defines the responsibilities of management and structural units of the bank at different stages of the planning process, deadlines, regularity and responsibility for the implementation of planning procedures.

In turn, forecasting is one of the main components of the management process. Without forecasting, without an idea of the expected course of events, it is impossible to make an effective management decision. Anticipation of possible consequences when making any decision is a necessary condition for an effective management system. Management theorist and practitioner Henri Fayol defined the term "Management" as follows: "To manage – means to anticipate, organize, dispose of, coordinate and control; anticipate – take into account the future and develop a program of action.

The generalized concept of "prediction" combines many different ways to obtain information about the future. predictions in the most general form can be divided into scientific and non-scientific. Scientific prediction is based on knowledge of the laws of nature and society. Unscientific prediction – on the foreboding, human intuition.

The basis of such foresight may be life experience or belief in supernatural forces that determine the future.

The study of the concept of "prediction" allows you to specify its content more fully. In the scientific literature you can find various forms of concretization of this concept. The generalization of these studies, which have not lost their relevance today, is the concept of the famous scientist, sociologist IV Bestuzheva-Lada, who identifies the following sets of forms of concretization of prediction: predictive (belongs to the category of "prediction"); attributive.

Foresight in this context implies a description of possible or desired prospects, states, solutions to problems of the future and includes such specific forms as premonitions, predictions and predictions.

In turn, the prescription is related to solving problems, choosing from a variety of alternatives, using information about the future for purposeful activities, including the construction of the future. The prescription, in contrast to the prediction, in some way affects the future. Here we can identify the following specific forms: planning, goal setting, programming, design. Due to the fact that at the moment nothing is known for sure about the future, all forms of prediction have features of uncertainty. Moreover, its various forms are characterized by varying degrees of uncertainty. As the procedure for predicting the future becomes more complicated and the associated level of validity of these developments increases, the degree of uncertainty of judgments about the future inherent in each of the forms of prediction gradually decreases.

Indeed, if foreboding is a simple form of prediction inherent in any living organism, and contains information about the future at the level of intuition, and prediction is defined as a type of intellectual activity based on personal experience, then goal setting is associated with conscious human activity. as a way of integrating its actions into a system and characterizes the prediction in thinking of the result of activities, and design – is a set of measures that involves the implementation of a set of actions that ensure the achievement of certain goals. Unlike specific forms of anticipation that may exist on their own, goal-setting, planning, programming, and design are interrelated characteristics of the decision-making process on which any management system is based.

Attempts to predict the future can not ignore the constant changes in the world, nature and society, including projected objects and conditions of their existence. But it is impossible to predict everything. However, the forecast, as well as knowledge, can be constantly changing and thus be quite accurate. In scientific research, foresight is so important that it is no exaggeration to say that science is first and foremost a scientific foresight. The largest of them have always been a kind of turning point in cognition, indicating the direction of movement.

Planning the bank's activities – a complex analytical process, requires extensive experience and knowledge from the economist to take into account all possible factors affecting the activities of this credit institution.

The need to accurately determine the future socio-economic and demographic situation in the region, as well as the dynamics of the bank's

performance determines the widespread use of different methods of planning and forecasting depending on the economic nature of the object of study. The main difference between the forecast and the plan is that the indicators are projected, which the bank can not fully manage: the amount of customer funds, risks and actions of competitors; what is completely in the sphere of influence, such as costs, can be planned.

However, the specifics of banking is such that not only external but also many internal factors of credit institution development do not depend on it: the monetary policy of the central bank, its performance of supervisory functions, public confidence in the banking system, currency regulation and other factors that lead to the widespread use of forecasting methods.

There is no universal method of forecasting due to the variety of simulated situations; economists use more than 100 forecasting methods. One of their options for classification, based on inductive and deductive approaches, assumes that the whole set of forecasting methods is represented by two groups depending on the degree of their homogeneity: simple and complex. A group of simple methods combines homogeneous in content and tools forecasting methods. Complex methods – a set of methods implemented by special prognostic systems.

In addition, all forecasting methods are divided into three classes: factual, expert (intuitive) and combined. Their selection is based on the nature of the information on the basis of which the forecast is made:

1) factual methods are based on factual information material about the past and present of the development of the forecasting object. They are most often used in search forecasting for evolutionary processes;

2) expert (intuitive) methods based on the use of knowledge of specialists / experts about the object of forecasting and generalization of their views on the development of the object. These methods are more in line with the normative forecasting of abrupt processes, but due to the low accuracy of such forecasts and their high dependence on the experience of a particular employee or group of employees, they are not widely used in banking. They are mostly used either in small credit institutions or during the current planning of secondary indicators;

3) combined methods include methods with a mixed information basis, in which as primary information along with expert and factual is used.

The most common in banking are the following forecasting methods.

I. Statistical methods

1. Extrapolation on the moving average. Used for short-term forecasting purposes (up to one year). The need for this method arises when the available data of the time series do not allow to detect any trend (trend) of a process due to random and periodic fluctuations of the original data.

This method is to replace the actual levels of the time series with calculated ones, which have much smaller fluctuations than the original data. The average is calculated for data groups for a certain time interval, and each subsequent group is formed with a shift of one period.

The moving average method assumes that when calculating the average seems to slip from one period to another; with each new step the average is updated due to new information about the actual process.

Thus, the forecast is based on the assumption that the next time in its size will be equal to the average calculated for the last time interval.

The advantage of this method is the ease of use, the disadvantage is the low probability of realization of the planned indicator (and for economic processes, this probability should be equal to 95%).

2. Exponential average. When calculating the forecast using the moving average, the earlier the observation time, the less it affects the value of the moving average, ie the effect of past values should fade as you move away from the moment for which the average is determined. One of the methods of smoothing the time series with regard to "aging" is the calculation of exponential averages, which are widely used in short-term forecasting and are based on the use as a forecast of a linear combination of past and current observations.

This method has the advantages of the moving average method and allows to achieve greater accuracy of the forecast through the use of a correction factor, but the linearity of the exponential mean function allows it to be applied to phenomena for which functional dependence is expressed by a more complex model.

3. Autoregressive dependence. This method is based on the premise that economic processes have certain specifics: they are interdependent and inertial. The latter means that the value of almost any economic indicator at time t depends in some way on the state of this indicator in previous periods: the value of the projected indicator in previous periods should be considered as a factor.

4. Multifactor regression analysis. This method is used to build a forecast of any indicator, taking into account the existing relationships between it and other indicators. First, as a result of qualitative analysis, k factors (X1, X2, ..., Xk) are identified, which, according to the analyst, affect the change in the predicted Y, and build a regression dependence of any type: linear, parabolic, hyperbolic, exponential, logarithmic, power, and others.

The use of this method gives good results with a high degree of accuracy, but there are difficulties in selecting the most significant factors influencing the modeled process: in addition to close connection with the resultant factor, they should not be multicolleniary . In addition, the problem is the choice of dependence, because in banking, linear relationships are rare, which complicates the process of selecting the regression equation.

II. Mathematical method of forecasting. It is necessary in order to formalize (ie write in terms of a mathematical model) the task of optimal management and forecasting. With high accuracy of the planned indicators, this method is not common due to the complexity of the selection of indicators for the vectors of the resulting, status and controlled variables, environmental characteristics so that they are interrelated and comparable. In addition, not all banking processes can be described by mathematical formulas, and at certain periods of time or at certain values of variables do not lose the economic meaning of the phenomenon.

III. Plan-forecast based on the model of economic dynamics of the bank. The model is based on the theory and methods of automatic regulation and takes into account the impact of the main aggregate economic indicators of the bank, as well as tax payments and depreciation of fixed assets on the growth trajectory of the bank's capital. In modeling, a basic assumption is made about the continuity of financial flows of revenues and payments, which is justified in the case of choosing a fairly long period of averaging, for example, a month.

The dynamic model is used for forecast and planned calculations of aggregate performance indicators of the credit institution. Based on it, spreadsheets are developed, "matrix plans" for calculating monthly indicators for the medium-term planning period – from three to 12 months. The calculation method is built as follows: part of the indicators is set as the initial parameters of the model, and the other part of the indicators is calculated using the equations of the model.

For example, you can thus predict the monthly capitalized income and the amount of equity, using as a source of borrowed resources, set on the basis of the method of extrapolation or other methods. This set of initial and calculated indicators will answer the question of what will happen to capital in this dynamics of resources involved.

If, on the contrary, initially set the amount of capitalization of profits, and the estimated value of the amount of resources involved, the planning model will answer the question of what resources must be owned to ensure the desired capital growth in the planning period. This opposition of calculation models is conditional, as it is advisable to use a larger set of initial parameters when planning and forecasting to increase the accuracy of forecasting and planning in accordance with the bank's strategy.

Developed electronic "plan-matrices" allow you to quickly lose different situations of the future. They can serve as a working tool for both analysts and managers at any level.

Technological forecasting is divided into research and regulatory. The basis of exploratory forecasting is the focus on the opportunities presented, the establishment of trends in situations on the basis of information available in the development of the forecast.

Exploratory forecasting corresponds to the movement in the space of technology from lower-level technology to higher-level technology. In other words, from means and opportunities to needs and goals.

The basis of regulatory forecasting is the focus on the mission of the credit institution, the needs and goals to which it seeks to achieve. Normative forecasting corresponds to the movement in the space of technologies from higher-level technologies to lower-level technologies.

Within the framework of technological forecasting, such tasks as the development of forecasts in the field of economic and commercial activity, social and political activities are solved. One of the central problems in forecasting is an effective combination of survey and normative forecasting methods.

Exploratory forecasting is characterized by the use of such methods as extrapolation, modeling, the method of historical analogy, scriptwriting, etc., which are based on the analysis of accurate empirical data.

When using exploratory forecasting methods, quantitative information is preferred, although the use of non-quantitative information in exploratory forecasting is also possible.

An example of this is the use of intuitive methods, the method of scenarios or the method of expert curves, which allow to identify emerging trends, based not only on empirical data, but also on the experience of highly qualified experts.

Among the main methods used in normative forecasting are the methods of Patern, Delphi, forecast graph Glushkov, Pospelov, etc.

Among other types of forecasting are sometimes predictions using feedback, intuitive methods, "workarounds", etc. but the main ideas used in the development of forecasts are quite fully represented in the survey and regulatory forecasting.

In the conditions of general globalization, informatization and constantly changing economic stop in the country the main task of the management becomes forecasting of future indicators, optimization and increase of efficiency of activity. Most of the processes that take place in business are in continuous interdependence. analysis of these relationships helps to reveal the essence of the processes and try to predict future phenomena and indicators. forecasting is necessary in all areas of management and at all levels of activity.

Recent advances in both analytical and computational methods have greatly simplified empirical studies of nonlinear models and led to the emergence of numerous analytical approaches in this area, significantly increasing the number of forecasting methods. Artificial intelligence technologies are completely new in this field. Artificial intelligence (AI) is a branch of computer science that studies the possibility of providing intelligent reasoning and action with the help of computer systems and other artificial devices. In most cases, the algorithm for solving the problem is unknown in advance.

The idea of creating an artificial human resemblance to solve complex problems and model the human mind has existed since ancient times. However, the ancestor of artificial intelligence (II) is the medieval Spanish philosopher, mathematician and poet Raymond Raymond, who in the XIII century. tried to create a mechanical machine for solving various problems on the basis of the general classification of concepts developed by him. However, only invented by Charles Babbage in 1833, a mechanical calculator can be considered the direct ancestor of the intelligent computer.

The final birth of artificial intelligence as a scientific field occurred only after the creation of computers in the 40's of XX century. At the same time, Norbert Wiener created his main works on a new science – cybernetics .

The term "artificial intelligence – II" was proposed in 1956 as part of an annual project of the same name at Dartsmouth College (USA). After the recognition of artificial intelligence as a separate branch of science, it was divided into two areas: neurocybernetics and cybernetics of the "black box". these parts. The basic idea of neurocybernetics is that the only object capable of thinking is the human brain, so any "Thinking" device must somehow reproduce the structure. Thus, neurocybernetics focuses on software and hardware modeling of structures similar to the structure of the brain. The efforts of neurocybernetics have focused on creating elements similar to neurons and combining them into functioning systems. these systems are called neural networks, or neural networks. Actively developing field of artificial intelligence – machine learning (Machine Learning) – includes models, methods and algorithms focused on automatic accumulation and formation of knowledge based on data analysis and generalization. Machine Learning is the systematic learning of algorithms and systems, as a result of which their knowledge or quality of work increases as experience is gained.

To build such algorithms and systems used mathematical statistics, numerical methods, optimization methods, probability theory, graph theory, various techniques for working with data in digital form.

In recent years, this area is closely related to the rapidly evolving systems of data mining – data analysis and knowledge discovery – the search for patterns.

There are two types of learning: inductive learning, or learning by precedent, based on the identification of empirical patterns in the data; deductive learning involves the formalization of knowledge of experts and their transfer to the computer in the form of a knowledge base.

Deductive learning belongs to the field of computer systems that can partially replace a specialist in solving a problem situation. Therefore, the terms machine learning and inductive learning can be considered synonymous. Most precedent teaching methods have been developed as an alternative to classical statistical approaches.

There are many objects (situations) and many possible answers (reviews, reactions). There is some relationship between answers and

objects, but it is unknown. We know only the final set of precedents-pairs "object, answer", called the training sample. On the basis of these data it is necessary to restore the implicit dependence, ie to build an algorithm capable of issuing a fairly accurate classifying answer for any possible input object. This dependence is not necessarily expressed analytically, and here neural networks implement the principle of empirically formed solution. An important feature is the ability of the trained system to generalize, ie to adequately respond to data beyond the existing training sample. To measure the accuracy of the answers, an evaluative quality functional is introduced.

This formulation is a generalization of the classical problems of approximation of functions. In classical approximation problems, objects are real numbers or vectors. In real applied problems, the input data on objects can be incomplete, inaccurate, non-numerical, heterogeneous. These features lead to a great variety of machine learning methods.

3. Differences in consumer spending behaviour among age groups

Oschadbank is a universal bank serving the retail sector, SMEs and corporate clients in all market segments. It is state-owned. As of January 1, 2020, the bank's assets amounted to UAH 233 billion. Oschadbank's national banking network includes about 2,200 branches, almost 3,000 ATMs and 2,800 payment terminals. More than 35,000 commercial POS-terminals are connected to the bank's processing. Sberbank issued more than 10 million payment cards. The bank owns Internet banking and the Oschad 24/7 payment system.

In 2015–2016, Oschadbank rebranded and changed its financial strategy. According to the Report on financial results in 2020, the bank received a profit of 2776371 thousand UAH, which is 2615165 thousand UAH. above the level of 2018. This indicates the effectiveness not only of rebranding and marketing strategy, but also the management of financial results in the financial management of the bank.

The main purpose of managing the financial results of PJSC "Oschadbank" is to maximize net profit as the main source of growth of the bank's value and well-being of all participants in market, corporate, commercial and social relations.

In February 2018, the Government of Ukraine approved the Principles of Strategic Reform of the State Banking Sector of Ukraine. According

to these principles, the main goal of the reform of public sector banks (PrivatBank, Oschadbank, Ukreximbank and Ukrgasbank) was to create and maintain a reliable and competitive banking system, much of which was to become private. medium-term horizon.

The state remains committed to building a reliable and competitive banking system, which in the medium term is largely focused on private property, and the main priorities identified in the strategic principles of 2018, namely:

1. Implementation of strategies for individual banks, in order to ensure their functioning as stable, profitable institutions operating on a commercial basis.

2. Sustainable model of leadership and management of public sector banks: protection and support of corporate governance reform together with supervisory boards with a majority of independent members, accountability and strategy implementation, while avoiding political interference in the management and operations of banks.

3. Decrease in the share of non-performing assets in the balance sheets of public sector banks.

4. Reduction of exposure of the state and state enterprises in public sector banks.

During the revision of the Principles in 2018, the position of the leading universal bank of Ukraine was chosen as a key area for Oschadbank. Sberbank's strategy focused on several key components: remaining a leading player in corporate banking, increasing its presence in the micro, small and medium business segment, strengthening its position in retail lending and commission products, optimizing its branch network, and ensuring IT development in terms of digital. distribution and security of the system, optimize the operating model and improve the risk management system and non-performing loans.

In general, the financial results of Sberbank during 2018–2020 were within the approved strategy, which provided for a non-market ROE for this period. The bank reached a profit of 2.7 billion UAH. in 2020. The bank's ROE was below 2% in 2018–2020.

In addition to the general financial indicators, the review of the key components of the bank's strategy shows that the bank has made achievements in achieving some of the goals set by the strategy. The position

in retail lending and commission products showed a moderate strengthening by increasing the share of the retail lending market by 1.1 percentage points. and commission income growth of 56%.

Maintaining a leading position in the segment of corporate business and SMEs: achievements have been insignificant. In general, the market share of corporate clients and SMEs decreased by 1.4 percentage points. in 2019 compared to 2017. Optimization of the branch network: the bank is implementing the initiative at a sufficient level, reducing the number of branches by 27% to ~ 2400 branches in 2019. The Bank plans to continue this trend and reach the target size of its branch network in 1800-2000 branches in 2020.

The operating model has undergone major changes as the bank has centralized its back office and IT functions. Such centralization is also necessary for other divisions of the bank. At the same time, the bank's cost-effectiveness ratio (CIR) ranged from 78% in 2017, rising to 147% in 2018 and recovering to 98% in 2019. Improving the IT system: some progress has been made, in particular the bank has introduced a single IT platform in all regions, which allows you to consolidate customer data into one centralized system, and introduced new systems to protect against cyber fraud. Risk and non-performing assets management has been strengthened. The Bank reduced the share of non-performing assets by 6 percentage points. from 2017 to 2019 and reduced the cost of risk (CoR) for the entire loan and investment portfolio to almost 0%. The state expects Oschadbank to become a full member of the Individual Deposit Guarantee Fund in 2020.

Based on the previously chosen direction and strengths of the bank, as well as key assumptions about the business model of the bank and the macroeconomic situation, Oschadbank should review its strategy for further development.

Table 1

Expected performance indicators in 2024

	Oschadbank	Privatbank	Ukrgasbank	Ukreximbank	Total
Net profit, UAH billion	3-3,7	15,8-19,3	1,6-2,0	1,8-2,2	22,2-27,2
ROE, %	14-18	31-37	16-19	13-16	22-28

In 2018, Oschadbank adopted the principles of development of the banking sector until 2024. Sberbank considers further improvement of customer experience and technological leadership to be its strategic priorities. According to the report, Oschadbank JSC increased the share of lending to individuals and legal entities in 2020 compared to 2018, the annual increase was 0.4%.

One of the important components of assessing the bank's performance is to assess the growth rate of key indicators, which is carried out in order to determine in which direction the bank is developing – decline or growth, to identify the level of banking development in the future.

Table 2

Growth rates of key indicators of Oschadbank

Name of article	2018	2019	2020	Absolute deviation of 2018 from 2020, +; -
Annual growth rates of assets, %	34,05	13,85	-6,6	-40,65
Annual growth rates of liabilities, %	4,01	12,00	-8,47	-12,48
Annual growth rates of equity, %	22,08	5,1	10,8	-11,28

The share of Oschadbank in the Ukrainian banking market in terms of assets increased from UAH 2,146,353,373 thousand. up to 233599897 thousand UAH or 8%. This figure decreased by 6% compared to 2019. According to the results of 2020, the growth rates of liabilities decreased by 12.48% and equity by 11.28% compared to 2018.

Table 3

Financial results of Oschadbank

Indexes	2018	2019	2020	Absolute deviation of 2018 from 2020, thousand UAH
Interest income	19351416	15442611	15099630	-4251786
Interest expenses	(13896078)	(13576217)	(10476135)	-3419943
Net interest income	5455338	5498549	7990807	+2535469
Commission income	5236356	6438707	8043794	+2807438
Commission expenses	1771336	2235702	3080856	+1309520
Net profit (loss)	161206	255074	2776371	+2615165
CIR, %	98	97	80	-18

From the analysis we see that Oschadbank in 2020 increased interest income by 4251786 thousand UAH, while reducing interest expenses by 3419943 thousand UAH. this provided an opportunity to increase the bank's net profit by 2615165 thousand UAH. The stable dynamics of growth of Sberbank's commission income, namely an increase of 1.5 times compared to 2018, ensured that Sberbank maintained its leading position in the market on this indicator. Oschadbank increased the amount of net profit by UAH 2,615,165 thousand. in 2020 compared to 2018 The positive dynamics of the growth rate of net profit is explained by the increase in the dynamics of net interest income by 2635469 thousand UAH. for the study period. Interest expenses in 2020 decreased by 3419943 thousand UAH and amounted to 10476135 thousand UAH. Commission expenses tended to increase by 42% during the study period. Following the results of 2020 there is a decrease in such an indicator as CIR. CIR – Cost Income Ratio – is the ratio of operating expenses to operating income. CIR is actively used around the world to assess the effectiveness of the bank by investors, shareholders, rating agencies, etc . Calculation of Cost / Income means the presence in the numerator of operating costs, which traditionally include labor costs, administrative costs, depreciation. The denominator contains the bank's net operating income: income in the form of interest and commissions on banking operations, income from securities transactions and other income. Thus, the CIR determines how many hryvnias must be spent to generate one hryvnia of income. The negative dynamics of this indicator in recent years indicates that the bank needs to spend less money every year to receive one hryvnia income. Over the last year, the cost of such costs has decreased by 17%.

Understand the causes and factors of changes in the main financial results of the bank need a more detailed analysis of balance sheet indicators, income and expenses in terms of components, macroeconomic trends.

According to the figure, it is obvious that the reason for the increase in interest income was an increase in the share of interest on investments. This type of income increased by UAH 2,500,635 thousand, the share of which increased from 10% to 22%. At the same time, it should be noted that the share of interest on loans to customers is gradually decreasing. Thus, the amount of interest received on loans amounted to 9625781 thousand UAH in 2018 and gradually decreased to 8704190 thousand UAH in 2020. In 2020. almost no interest was received on funds in banks, other

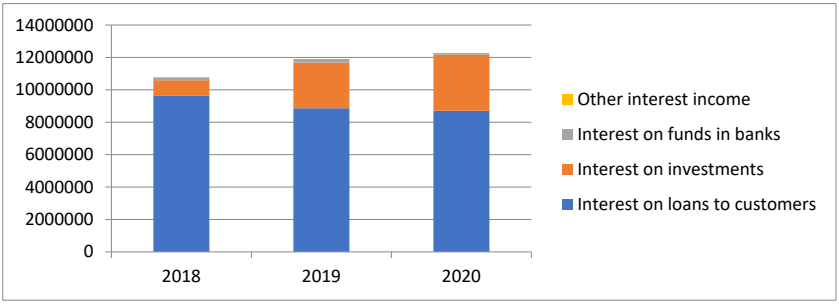

Figure 1. Interest income on financial assets measured at amortized cost of Oschadbank

interest income. When planning interest income, banks expertly determine the indicators for achieving the target level of interest income. Some indicators are planned based on the dynamics of previous years. The main macroeconomic indicators and trends of their development (household income, inflation, industrial production index, GDP, etc.) are also taken into account. Thus, the planning of bank interest income is a complex process that affects many factors, including those that go beyond the activities of the bank itself. Interest expenses are planned in similar ways. In particular, to forecast the interest costs of attracting customer funds, the main drivers are: the amount of borrowed funds in terms of private and corporate customers, current accounts, banking products, currency; interest rates, etc. Among the macroeconomic indicators in the calculation of planned interest costs are the following indicators: household income, average interest rates of commercial banks, retail trade, etc.

Interest expenses of Oschadbank during 2018–2020 decreased due to a decrease in the amount of interest on customer accounts and interest on issued Eurobonds. Interest expenses on customer accounts for this period decreased by 1477380 thousand UAH and in 2020 amounted to 8840648 thousand UAH this type of expense has the largest share among other types of interest expenses. Interest on issued Eurobonds, the share of which decreases annually, also has a large impact on the amount of interest expenses. Thus, the amount of interest on Eurobonds issued decreased from UAH 2,879,165 thousand to UAH 1,210,767 thousand, or 2.3 times. The sum of other interest expenses has insignificant shares.

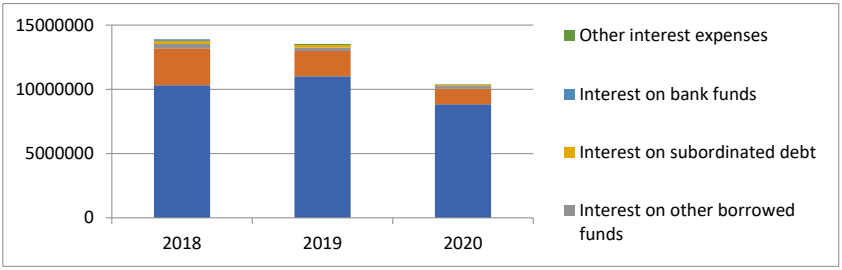

Figure 2. Interest expenses on financial liabilities valued at amortized cost of Oschadbank

In 2018–2020 the amount of interest income decreased by 884474 thousand UAH, and the amount of interest expenses by 3419943 thousand UAH. This provided an opportunity to receive in 2020 net interest income in the amount of UAH 7,990,807 thousand.

Figure 4 presents some of the main indicators of Oschadbank's activity for 2018–2020, including the bank's assets and loans to customers.

The figure shows that throughout the analyzed period, the bank's assets show an uneven increase in the total amount. Thus, compared to 2018, assets in 2019 increased by 14%, compared to 2019 by 7% in 2020. There is also a decrease in the bank's loan portfolio. In 2020, compared to 2018, there is a decrease in the amount of "Loans to customers" by 4317099 thousand UAH or 6.4%. Among the reasons for the decrease in assets should be noted: fluctuations in the national currency, a decrease in corporate loans and the revaluation of government securities in accordance with international financial reporting standards (Ruda, 2021).

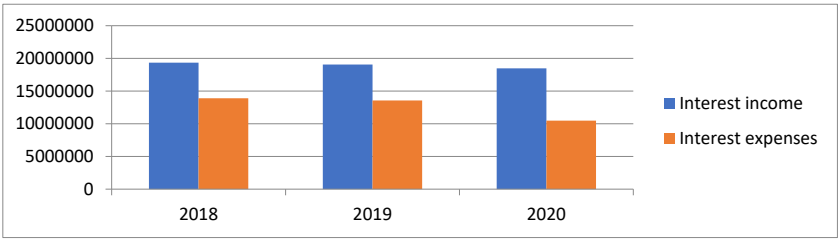

Figure 3. Dynamics of the ratio of income and expenses of net interest income of Oschadbank

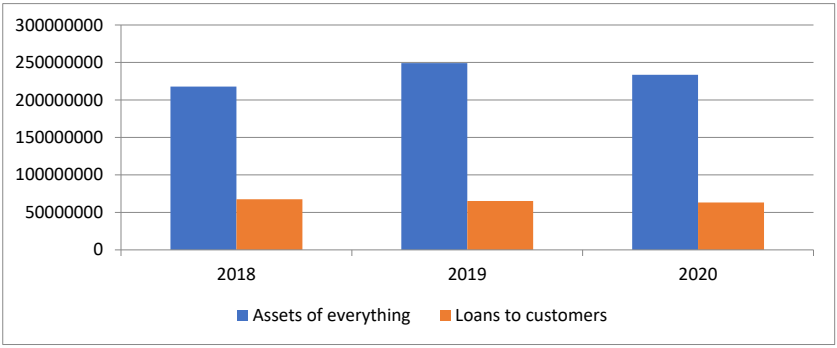

Figure 4. Dynamics of assets and loan portfolio of Oschadbank for 2018–2020

Thus, Oschadbank JSC is one of the largest state-owned banks in Ukraine, which demonstrates the positive dynamics of capital growth. In order to effectively manage the bank, find ways to minimize costs and maximize profits, it is necessary to explore the methods of planning and forecasting that the bank uses in its activities.

The bank's equity is the most important indicator that can be considered separately from others; allows you to see the reliability of the bank, efficiency and prospects. Share capital is the main component of equity, its share of less than 100% demonstrates the efficiency of the bank, because the components of equity are also reserve and other funds, retained earnings.

The bank's equity is the main means of ensuring the stable operation of the bank and the implementation of financial planning. Consider the dynamics of the bank's equity. The equity of Oschadbank JSC increased by 18% during the study period.

In the structure of equity, the largest share during the analyzed period is occupied by share capital, the amount of which is constant. Retained earnings, which have fallen by 8.7% in recent years, also account for a significant negative share. The equity of the studied bank in 2020 increased by 18.27% compared to 2018.

Retained earnings are an extremely important source of equity formation and indicate the bank's own development potential. Analyzing retained earnings as a source of equity, it should be noted that JSC "Oschadbank" has

Table 4

Dynamics of equity of Oschadbank for 2018–2020, thousand UAH

Liabilities articles	2018	2019	2020	Growth rate (decline) 2018 from 2020,%
Equity	49724980	49724980	49724980	-
Reserve for overvalued buildings	1821887	1817194	1572968	86,3
Reserve for revalued investments	215554	1018205	976060	at 4,5 times
Cumulative amount of exchange differences	1513	1061	1583	-
Uncovered damage	(33215794)	(33004661)	(30334988)	91,3
Uncontrolled share of participation	13529	13493	13524	-
Total equity	18561669	19570272	21954127	118,27

an uncovered loss on 01.01.2020 – 30334988 thousand UAH, the amount of which has decreased in recent years. But in general, the amount of the bank's equity is positive, which indicates the required level of efficiency and quality management of the bank.

The Bank performs capital management in order to ensure the continuation of the bank's activities, maximizing shareholder profits by optimizing the ratio of borrowed funds and equity. The Management Board of Oschadbank systematically reviews the capital structure. The course

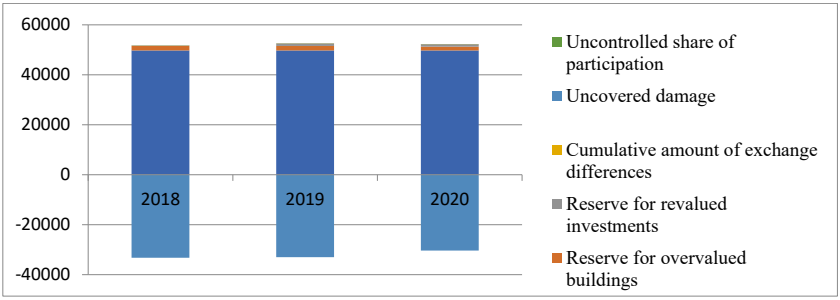

Figure 5. Dynamics and structure of Oschadbank's own capital, UAH mln

examines the cost of capital and the risks associated with each class of capital. Based on the recommendations of the bank's board, it introduces adjustments to the capital structure by issuing additional shares, attracting additional credit funds or repaying existing loans. Thus, equity acts as self-insurance, providing a buffer against insolvency, and if it is positive, it reduces the degree of risk of the activity, which allows for effective planning of future activities.

Let's define the absolute autonomy of Oschadbank, which is determined by the ratio of equity (net assets) to the total value of assets, which is characterized as part of the property formed at the expense of equity.

Table 5

Dynamics of assets and equity of Oschadbank

Name of article	2018	2019	2020	Absolute deviation of 2018 from 2020, +; -
Assets, thousand UAH	217786209	249144745	233599897	+15813688
Equity, thousand UAH	18561669	19570272	21954127	+3392458
Ratio between equity and assets, %	8,5	7,6	9,3	+0,8

Oschadbank's asset fund, formed at the expense of equity, is growing annually, and in general has increased by 0.8% during this period.

The dynamics of net profit of Oschadbank JSC shown on the chart showed that in 2020 the profit amounted to 2776371 thousand UAH. As you can see from the chart, there is a rapid increase in net income. Compared to the two previous analyzed years, we can see a significant improvement in the financial situation, because in 2018–2019. the bank received small amounts of net profit. The income received by the bank in 2020 was due to the following components: net interest income and commission income, as well as a significant reduction in the cost of deductions to the provision for impairment of loans and advances in other banks.

The most commonly used method of analyzing the efficiency of the bank is the DuPont model. This method examines the relationship between profitability and risk of the bank and reveals the impact of individual factors on the results of its activities. The calculation of indicators is carried out according to the financial statements.

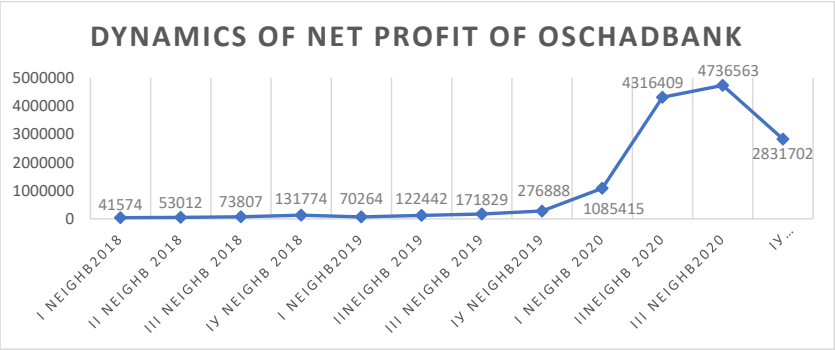

Figure 6. Dynamics of net profit

In Dupont's model, the bank's risk indicator is the capital multiplier (MC) – the ratio of average assets to the bank's equity. The greater the expression of the capital multiplier, the greater the risk. Or the higher the profit, the riskier the structure of the bank balance sheet will be, other things being equal.

$$ROE = ROA*МК,$$

$$ROE = ЧП/А *А/К$$

The ROE indicator is the ratio of the bank's net profit to the average amount of the bank's equity over the period and characterizes the efficiency of own funds (generated by share and additional capital, as well as reserve fund and retained earnings) invested in the bank's business. The value of the ROE indicator is to determine the level of return (in the form of net profit) from the shareholders' funds invested in the bank, as well as retained earnings directed by the bank to business development.

ROA is the ratio of net income to the average for the period of the bank's assets and allows assess the effectiveness of active operations of the bank: how many hryvnias of net profit the bank earns for each hryvnia invested in its assets as financial (loans to individuals and legal entities, interbank loans, securities) and non-financial (fixed assets and intangible assets). Its use makes it possible to assess the effectiveness of the bank's investments in the base for the formation of profits of its assets. Both of the above indicators are related to the consideration of the bank as a whole as a business entity. This approach is manifested both in the calculation of the numerator of

indicators (net profit – the final financial result of the bank after accounting for interest and non-interest expenses, write-offs and revaluation of assets and tax payments) and in the calculation of the denominator (bank assets – its investment in various financial market instruments, as well as fixed assets and intangible assets).

Table 6

Decomposition analysis of equity of Oschadbank

Name of article	2018	2019	2020	Relative deviation of 2018 from 2020,%
Net profit, thousand UAH	161206	255074	2776371	1722,25
Assets, thousand UAH	217786209	249144745	233599897	107,26
Equity, thousand UAH	18561669	19570272	21954127	118,27
ROE	0,86	1,30	12,64	1469,76
ROA	0,07	0,10	1,18	1685,71
MK	11,73	12,73	10,6	90,36

Indicators of the efficiency of the use of financial resources during 2018–2020 were positive, which is explained by the profitability of Oschadbank for this period. The change in ROE and ROA in 2020 was due to changes in net income – by UAH 2,615,165 thousand, which led to significant increases in these indicators. At the same time, the capital multiplier decreased by 10%.

ROE is an indicator of stability. The analysis of this indicator makes it possible to predict how stable the bank's profitability level is. Analyzing this indicator, it is necessary to compare the growth rate of net profit and equity. This indicator characterizes the bank's ability to manage all its funds. The optimal value of this indicator is at least 15%. Oschadbank demonstrates a steady increase in this indicator during the study period, which is close to the recommended one.

ROA characterizes the return on assets. In practice, it is considered that if the level of return on assets exceeds 1%, the bank operates profitably. Although Oschadbank JSC received a net profit during 2018–2020, the recommended value of the indicator the bank received only in 2020, which amounted to 1.18%.

The equity multiplier shows how many hryvnias of assets each hryvnia of equity should provide and, accordingly, what share of bank resources can be formed in the form of debt obligations. The MC (capital multiplier) ratio of Oschadbank JSC decreased from 11.73 in 2018 to 10.6 in 2020, which indicates a decrease in the degree of risk of the banking institution.

In general, the DuPont model provides an assessment of the state of the bank in the market, the formation of financial benchmarks in the planning and forecasting of bank finances.

Summing up the analysis of all the above indicators, the financial condition of Oschadbank can be described as quite stable, despite the uncertainty and instability of the financial market and the pandemic of coronavirus infection, which has a negative impact on economic activity. In the reporting period, the bank continued to serve primarily the population, which provided it with a leading position in the retail banking market. During this period, new economically sound approaches in tariff policy were developed to maintain the leading positions in servicing settlement and cash operations of corporate clients, which allowed to increase the mobility of price management for products and services of corporate business.

To improve the performance of Oschadbank, it is necessary to develop a policy on the formation, distribution, use of its financial results for various banking operations, various activities, etc. It is also necessary to develop and implement measures and justification of management decisions to maximize profits. In accordance with the developed measures to make current and operational plans of income and expenses, with the main attention to plans for the formation of interest income.

Having analyzed the financial indicators of the Bank, we can characterize the financial condition of Oschadbank as good, as evidenced by the gradual increase in indicators such as bank capital, increase in loan portfolio.

Thus, the main direction in the bank's management system is financial management, which involves planning, regulating and controlling the bank's operations and their income and expenses, ensuring the stability of financial results and improving the economic efficiency of the bank.

Thus, planning is an integral function of bank management, carries out the formation of a comprehensive financial and economic policy of the bank, which allows you to maximize the bank's share in the market, gain leadership and is a multifaceted, multifaceted management process.

4. Findings

Based on the above disadvantages of the system of financial planning and forecasting, it is proposed to consider the introduction of such technological innovations as machine learning and artificial intelligence.

Let's start by studying aspects of these technologies. At present, machine learning and artificial intelligence are some of the most advanced modern technologies. Machine Learning is a unit of artificial intelligence that uses algorithms that can learn on their own, ie they do not need to be specially programmed for a specific task. The technology is used for face recognition, music, machine translation, medical diagnostics, fraud detection, prediction of stock price dynamics and so on.

Currently, bank vaults are literally inflated by a huge amount of customer data (questionnaires, transaction and communication histories) and inside information – in general, from all the data that arise as a result of all the activities of the bank. Artificial intelligence in conjunction with Machine Learning makes it possible to study the behavior and needs of customers, and based on them to make decisions autonomously, which would take an ordinary person more than one hour, and maybe a day. For example, JPMorgan Chase has developed a Machine Learning algorithm called Contract Intelligence (COiN), which is used to analyze documents and aggregate important data from them.

This tool allowed the bank to process 12,000 loan agreements in a few seconds, which usually took 360,000 man-hours. Artificial Intelligence and Machine Learning have been used for many years, but it is Big Data that allows them to reach their peak – it is a set of approaches, tools and methods of processing structured and unstructured data of huge volumes so that a person can their further effective application. accordingly, the greater the amount of information received, the more and more accurate the result can be obtained, for example, about the needs and behavior of customers. In this regard, it is critical for the banking industry to rely on and collect a large amount of information about each customer. An example of the collection of such information can be ATM transactions, mobile banking, which the client performs on a daily basis. In this case, the bank's goal will be to achieve a quick normal transaction for the client with one button, without unnecessary search and input of information based on information about all transactions performed by the client.

The main areas of banking where machine learning methods are currently actively used are: search, segmentation and customer retention; scoring and underwriting; fight against fraud; search and retention of employees; investment management; collection management; collection activities; customer support.

Some examples of cases of application of machine learning methods in Ukrainian banks: the work of Ukrsibbank contact center operators has been accelerated twice; 24% more efficient than live operators was the robot collector in PJSC Oschadbank; the maximum time required to make a decision on a loan in Alfabank Bank has been reduced by 3 times; the index of detection of suspicious transactions in VTB Bank was increased to 95%; 1.5 times reduced collection costs in Ukrgasbank.

Ukreximbank actively uses machine learning to increase sales.

Models of propensity to consume product help Bank to divide customers into groups in terms of probable response to the product offer, the method of classification – to divide customers into certain classes. In addition, the bank monitors the customer's transaction activity. For example, when you reduce the number of purchases on debit or credit cards, the customer falls into a class with a high probability of outflow. For initially undefined classes, the clustering method allows you to divide objects into clusters. It consists in allocating client segments with a unique combination of characteristics on a set of product parameters.

To improve the quality of models, Ukeximbank uses several methods of machine learning – neural networks, random forest, gradient boosting. These methods have already improved the propensity to purchase consumer credit and credit cards by 10 to 12% compared to the classical logistic regression.

In Ukrsibank, the decision to implement models based on machine learning methods was made in February 2018. Already the first results of the pilot project showed a significant increase in the quality of models compared to traditionally used in practice models based on logistic regression. Ukrsibbank actively uses machine learning in collection activities.

The best results are shown by Ukrsibbank – ensembles from the models constructed by a method of gradient boosting with optimization of hyperparameters. The constructed models show good quality and stability, and the organization of ensembles allows to create combinations

of noncorrelated predictors, for example, points from various vendors. In addition, the use of Machine Learning methods allows you to most effectively use the data of the bank and to refuse sampling. An important advantage is the self-learning models, ie the ability to rebuild with new data.

Scoring system has become very widespread on the basis of machine learning technology – not only the system, but also the method of credit risk assessment, as well as risk management based on the forecast of the probability of default by a particular borrower on the loan. In this case, machine learning has automated the process of issuing loans, which now also takes little time to process loan applications, both for individuals and legal entities. Previously, the last time of consideration could take more than a week, which slowed down the activities of companies applying for this service. Currently, the scoring model is used by Oschadbank, Bank Kyiv, and VTB Bank.

But not only in Ukraine there is success in the use of participatory methods, but also abroad. For example, back in February 2017, Wells Fargo invested in the creation of a chat bot with Artificial Intelligence for the company's Facebook messenger. this virtual assistant is used to reset the password and provide account information without having to fill out multiple pages of forms. Now this is a simple dialogue that can take a few minutes.

Citibank, for example, has invested in FeedzAI, a company that focuses on using data science to detect and stop fraudulent transactions in a variety of financial activities, including online banking and mobile banking. FeedzAI uses machine learning algorithms to analyze huge amounts of Big Data data in real time and immediately notifies financial institutions of suspected fraud.

The symbiosis of "big data" and machine learning offers a fundamentally new approach to the problems of customer segmentation, lending and forecasting, as well as solving a wide range of analytical problems.

Thus, current experience in the use of machine learning methods shows positive results of the bank, in particular, improving processes, saving resources and increasing the efficiency of the bank. However, it is necessary to compare modern machine learning methods in planning and forecasting .

5. Conclusions

The main results of the work are: acquaintance of the authors with modern scientific literature on planning and forecasting in banking institutions; research of modern and advanced methods of machine learning, directions and spheres of their use in credit organizations; basic methods of planning and forecasting, stages of business planning, analysis of key performance indicators, development strategies, values, core values and goals of Oschadbank; study of methods of planning and forecasting of financial results used in Oschadbank; analysis and evaluation of planning and forecasting methods used in the bank; identification of the main shortcomings of the existing planning and forecasting system; comparison of applied forecasting methods in Oschadbank and modern forecasting methods using machine learning; identifying ways to improve the shortcomings found in the planning and forecasting system of Oschadbank.

The goal set by the authors, which is to develop and scientifically substantiate theoretical and methodological provisions on planning and forecasting the financial results of the bank, objectifying their practical application of the concept of strategic plan development, substantiation of the effectiveness of the implemented planning and forecasting system, was achieved. The authors proposed a specific model for forecasting commission income from the trading acquiring market using modern Machine Learning methods. The effectiveness of the implemented forecasting system has been proven: the model has higher forecasting accuracy, requires less human and time resources. In turn, the high accuracy of the forecast of the bank's operating indicators allows: to see the future picture of developments until the end of the year; to carry out competent coordination of the organization of employees; to adjust the planned values, which are set before the beginning of the year, when critical data is detected; improve or change the strategy for achieving the targets of each territorial bank; assess the future profitability of the bank; evaluate the work done and reward the bank's employees.

The set tasks were achieved in the work. Theoretical and methodological provisions of the features characterizing the directions of planning and forecasting of financial results of activity of commercial banks in the market of banking services are formulated. The main functions of planning and forecasting, their importance in the management of a commercial bank

are revealed in the work. The author has developed a rational system of planning and forecasting the activities and development of a commercial bank and methodologically based on the example of Oschadbank. In addition, the paper analyzes, compares and evaluates the planning and forecasting system operating in the bank, and modern, promising methods of forecasting planning.

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TOURISM INSURANCE MANAGEMENT

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Abstract. *The purpose* of the tourism insurance management is the tourism industry has always had a definite danger to life as tourists themselves and its employees. Natural disasters, unfortunate cases, miscalculations in production and economic activities and other unforeseen events may disrupt the balanced activities of tourism complex. At the same time with the development of science technological progress of natural and industrial economic cataclysms are not reduced. For ensuring stable tourist activities enterprises and guaranteeing quality to tourists, in particular in areas of increased risk, there are various management tools risk, one of which is insurance. Fear- as a component of the security system in tourism industry contributes to the stabilization of activities tourist enterprises and tour operators companies, as well as the safety of tourist travel both in Ukraine and abroad. Tourist travel carries a lot surprises. A tourist can become a victim disaster or robbery, sudden due to changes in weather and other circumstances may not live up to his expectations quiet rest. In these and many others In some cases, there will be a need to provide burn yourself from their harmful effects or minimize them. Therefore, the issue of insurance services management in tourism is important. Effective implementation of insurance products in the field of tourists through various distribution channels These intermediaries are an important area of marketing. *Results*. Tting strategy of insurance companies of Ukraine, therefore, generalization is necessary for its development domestic and foreign experience, scientific ensuring the formation and functioning sales systems of this type. That is,

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for the plant- building a strong position in the insurance market tourists for the insurer it is important to have message to offer more diversified service package. Ukrainian insurers are actions to rethink global trends to improve the business climate tourism. *Value*/*originalit*. Ukraine lags far behind in implementing measures to support the tourism sector, which poses a serious threat to the competitiveness of the industry in the global market during the projected recovery in 2021. The world still faces serious challenges, from the indefinite duration of the pandemic to restrictions on movement, all in the context of the global economic recession. Countries around the world are implementing a wide range of measures to minimize the effects of the COVID-19 pandemic and encourage the recovery of the tourism sector. The prospects for the tourism economy remain extremely uncertain, and confidence in business and travel has been hit hard. Clear communication, well-developed information policies and clear epidemiological criteria will be particularly important where there is a need to change travel restrictions and containment measures in response to virus outbreaks and changes in the health situation. The crisis is a once-in-a-lifetime opportunity that encourages us to move towards fairer, more sustainable and sustainable (socio-environmental-economic) models of tourism development. The pandemic again revealed structural weaknesses in the tourism system and vulnerability to external shocks. There is an urgent need to diversify and strengthen the resilience of the tourism economy, better prepare for future shocks, address long-standing structural weaknesses and encourage the digital, low-carbon transformations needed to move to stronger, fairer and more sustainable tourism models.

1. Introduction

The relevance of the research topic is determined by the fact that the transition of Ukraine to market rails dramatically washed away the previously existing way of doing business. In this perspective, the organization of insurance is becoming one of the significant factors influencing all sectors of the economy, including tourism. In modern conditions, insurance is an important and necessary tool that ensures overall economic and social stability and security, business development, effective protection against numerous risks, the implementation of state social policy in the field of tourism. In the context of Ukraine's accession to the European Union,

the problems of functioning and legal regulation of the tourism insurance industry are of great importance along with the solution of socio-economic, organizational and other problems, because they are not only national but also international.

Insurance is a way of compensating for losses incurred by an individual or legal entity by distributing them among many persons (insurance group). Compensation for losses is made from the funds of the insurance fund managed by the insurance organization (insurer). The objective need for insurance is due to the fact that losses sometimes occur as a result of destructive factors that are not under human control, such as natural disasters. In such a situation, it is impossible to recover damages from anyone and a pre-established insurance fund can be a source of compensation. Nowadays, tourism is an industry that is not only developing rapidly, but also affects the level of development of related industries, one of which is hiding. Insurance is the most important element of economic wearables and an effective way to recoup costs. Insurance and tourism belong to the sphere of services and have what is the impact on the economic development of almost every developed country they. According to the United Nations World Tourism Organization (UNWTO), international tourism accounts for 29% of global exports of services. In 2018, tourists spent a total of 1.7 trillion US dollars. The growing dynamics of tourist flows requires increased requirements to the quality of tourist services and the development of the insurance market in this area. The tourism industry operates at risk. Protection of the interests of tourists can be provided by instruments, among which insurance has a special place. Insurance is a way to reduce the risks that arise in the field tourism, in particular for its subjects – tourism organizations and tourists. Along with the fact that there are common risks inherent in the majority economic entities, in the field of tourism there are specific risks, thorns for this type of activity. In addition, during the interaction of a large number of independent one from one of the business partners (foreign tour operators, consular services, hotel administrations, catering establishments, transport companies etc.) the probability of insured events increases. The study of this problem is also important from the standpoint of tourism ethics. In our country, the most developed outbound tourism, and therefore, under time of tourist operations, the interests of more than one are affected states.

One of the important trends in the world economy at the beginning of the XXI century is its socialization, which concerns both the practice of economic activity and the methodology of economic science. In the development of tourism, socialization is manifested primarily through the growing role of social factors, as well as through the transformation of tourism into an important part of the lifestyle of a growing proportion of the population in many countries.

2. Economic crisis effects on consumer behavior

A large number of scientific publications by both domestic and foreign authors are devoted to determining the peculiarities of the development of insurance market management and insurance in tourism. The works of such authors as: Aleskerova Y.V., Bodnya A.V., Ivanchenko M.A., Ponomareva O.B., Grabchuk O.M., Zaitseva V.M. and other.

At the same time, tourism as an object of study of economics has been affected very socially. First of all, we are talking about the work of domestic scientists economists. In particular, L. Nemets, S. Tsohla and others consider social factors as part of the general analysis of factors in the development of the tourism industry in their works. Other studies of social aspects of tourism development are confined mainly to the socio-psychological direction. At the same time, the theoretical and methodological basis for the study of various aspects of social security of tourism is being actively formed in foreign science. In particular, the works of G. Bon, K. Zimani and I. Kovari, G. Mikhalko, S. Michurin and others are devoted to this direction. At the same time, a clear definition of the essence of social security of tourism and justification of approaches to assessing its condition, in particular, at the regional level has not yet been proposed.

At the same time, a number of publications on various aspects of the legal regulation of insurance in the tourism business have been hotly debated recently, while little research has been done so far. As a result, the development of theory and methods to analyze the features of the tourism insurance system in modern conditions is an important area of modern science.

Going on a tourist trip, a tourist may encounter with a number of problems that can have negative consequences for his life, health and property. He may be the victim of a catastrophe or robbery, suddenly fall ill

due to weather changes and others circumstances. In these and many other cases, there will be a need to to protect themselves from adverse effects or to reduce them to a minimum mum, which is made possible by the legal institution of insurance. Insurance is the main form of guaranteeing consumers of tourism security services in the country (place) of temporary stay. In order to protect the rights and interests of tourists, the legislator has identified system of regulatory guarantees of tourist insurance.

Thus, the provisions of Art. 9 of the Law of Ukraine "On the procedure for leaving Ukraine and entering to Ukraine of citizens of Ukraine "regulated that in order to create conditions that guarantee reimbursement of expenses to a citizen of Ukraine, related to extraordinary circumstances during his stay abroad, he must be insured. Detailing this legislative provision, the Law of Ukraine "On tourism "provides for compulsory insurance of tourists (medical and accident), which is provided by the subjects of tourism based on agreements with insurers. It is worth noting that tourists are subject to insurance regardless of whether they travel in Ukraine or abroad. At the same time in the Law of Ukraine "On Insurance" personal insurance tourists (medical and accident) are not included in the list compulsory insurance. Instead of Art. 7 of the specified normative act provides for such a type of compulsory insurance as insurance liability of tourism entities for damage, caused to the life or health of the tourist or his property. The activity on the insurance market is determined by the Law of Ukraine "On insurance", which regulates relations in the field of insurance and aimed at creating a market for insurance services, strengthening insurance protection of property interests of enterprises, institutions, organizations organizations and individuals4. However, this Law defines only general principles the implementation of insurance, and therefore can not take into account all the specifics travel insurance. Contrary to the requirements of Art. 7 of the Law of Ukraine the Cabinet of Ministers of Ukraine has not identified a separate "On Insurance" procedure for compulsory insurance in the field of tourism. Licensing conditions for tour operator activities are also not address issues of insurance protection of tourists and entities tourism activities.

Object of research – management of insurance in tourism.

The subject of research – the system of economic interests and relations of policyholders, insurers and society in the face of insurance regulators in the field of tourism insurance in Ukraine.

The study used information that reflects the state of foreign and domestic insurance systems, the content of laws and regulations governing insurance activities in Ukraine, regulations, official statistics, documents and works of domestic and foreign economists. General scientific and special research methods were used in the work. The methodological basis of the study to identify effective mechanisms for financial support of tourism are general scientific methods. The article uses the methods of abstract-logical method, namely: analysis and synthesis, induction and deduction. Statistical methods and tabular presentation of information were used to estimate gross income. Based on the structural algorithm, a strategy for overcoming the global crisis in the tourism industry based on SWOT-analysis has been developed.

The purpose of the study is to develop measures to manage insurance in tourism.

3. Results

Officially, there is no such thing as "travel insurance" in Ukrainian law. According to Article 16 of the Law of Ukraine "On Tourism" is mandatory insurance for tourists is medical and accident insurance. In the reports of insurance companies, this type of insurance is defined as "health insurance". For the vast majority of insurance companies, this type of insurance is not a priority. According to statistics on the functioning of the insurance market in Ukraine, the share of medical expenses insurance in 2019 amounted to 3.56% or UAH 1885 million in gross insurance premiums, 2.45% or 349.9% in gross insurance costs. UAH million.

With the spread of the COVID-19 pandemic, the tourism industry has faced a crisis that could be the worst in history. In recent years, the tourism industry has been one of the fastest growing industries, sometimes faster than the world economy as a whole. 2019 brought unprecedented changes in the world order, affecting all sectors of the economy and all social contacts. The global pandemic, the first in a new era of interconnectedness, has threatened 100 million jobs, most of them in micro, small and medium-sized enterprises, which employ a high proportion of women, accounting for 54 percent of tourism, according to the World Tourism Organization. UN (UNWTO).

Tourism-dependent countries are likely to experience the negative effects of the crisis much longer than other economies. The pandemic is

disproportionately affecting contact services, which are key to the tourism and travel sectors, and they will continue to fight until people feel safe for mass travel.

From the white sand beaches of the Caribbean, Seychelles, Mauritius and the Pacific to the deaf streets of Bangkok to the vast national parks of Africa, countries are struggling to lure visitors, avoiding new outbreaks. Solutions range from attracting the rich, who can guarantee quarantine on their yachts, to inviting people to stay for up to a year and work practically while enjoying the tropical view.

Revenues from tourism worldwide are not expected to return to 2019 by 2023. In fact, 43% of respondents to a UNWTO survey [2] point to 2023, while 41% expect a return to 2019 only in 2024 or later. Extended UNWTO scenarios for 2021–2024 indicate that it may take two and a half to four years for international tourism to return to 2019.

In the first half of 2020, the number of tourists worldwide fell by more than 65 percent, almost stopping since April – compared with 8 percent during the global financial crisis and 17 percent against the SARS epidemic of 2003, according to current IMF research on post-pandemic tourism. world [3].

According to the United Nations World Tourism Organization (UNWTO), as of December 2020, the decline in the number of tourists in the world as a percentage of the previous year was 85%, in December 2020 compared to December 2019, the decline is 74%. Figure 2 shows the changes in the number of tourists in the world and by region in the months of 2020 to the level of the previous year [4]. As we can see, during 2020, the largest decline occurred worldwide in April and May. In most regions, a slight increase in the number of tourists began in the summer. The most affected regions, to which tourists have not yet returned, are North Africa, Central and South America, Asia and the Pacific, and the Middle East.

The norms of the Ukrainian legislation on compulsory health insurance and accident insurance do not provide full protection of domestic tourists from all risks when buying tourist services and traveling. Certain steps have already been taken to increase the insurance coverage of tourists. Thus, in the draft law № 4162 On Amendments to the Law of Ukraine "On Tourism" registered in the Verkhovna Rada, insurance of return of Ukrainian tourists to Ukraine in case of detention abroad is added to the list of obligatory types of tourist insurance.

However, the problem of insuring the risks of delay or cancellation of the trip remains relevant. Today, this type of insurance is not mandatory, but it is especially important. For example, a trip to Egypt, which is the most popular destination for organized tourism, requires a PCR test for the absence of coronavirus disease with a certificate when entering the country of rest. However, testing should be done no more than 72 hours before arrival in Egypt. If you receive a positive test, the tourist will not be able to travel, but compensation is possible only if you have travel insurance. Some tour operators automatically include it in the travel product, and some offer tourists to buy such an insurance policy in addition. Moreover, the conditions of compensation for this type of insurance are also not always acceptable for tourists: deductible may be 10-20% of the tour price, the amount of compensation may be limited to certain amounts, which when buying expensive tours does not correspond to the money spent by tourists; may not apply to all tourists from one reservation, but only to those tourists from the reservation who are not able to travel directly for objective reasons.

With the introduction of the rule on compulsory travel insurance, insurance companies could optimize their services within such a package, reducing their cost due to the massive demand for such a service. But travel insurance can also be considered in another aspect. The risk of bankruptcy of tour operators, especially in a pandemic, has increased significantly, but effective protection of tourists in the event of bankruptcy of tour operators is not provided. Article 15 of the Law of Ukraine "On Tourism" regulates the need for financial support for tour operators. However, the amount of 20,000 euros for international tourism is purely symbolic, as the annual sales of major tour operators can be measured in tens or hundreds of millions of euros. At the moment, there are proposals to increase the financial support of tour operators and bring it to 5-10% of the annual volume. Naturally, such proposals will not find support from tour operators, but during the global crisis caused by the coronavirus pandemic, the withdrawal of even a small percentage of funds from the turnover of tour operators may lead to the suspension of their activities or even bankruptcy.

It is in this situation that travel insurance is of additional importance, as it can provide compensation for cancellation of the trip not only for the usual list of reasons, such as illness of the tourist, his death or loved one, natural disasters, lawsuits, etc., but also in case of impossibility making

a tourist trip through the fault of the tour operator, including in case of bankruptcy.

According to the UN World Tourism Organization, the contribution of tourism to world GDP, taking into account the indirect effect is 10 percent. As of 01.01.21 in the rating of the IC in the field of tourism insurance, the Ministry of Finance identifies the following insurers:

Table 1

Rating of the IC in the field of tourism insurance Ministry of Finance

Name SC	Rating	Tourist insurance			In general, for all types of insurance	
		Awards	Payments	Level of payments, %	Awards	Level of payments, %
VUSO	1	175142	42427	24,24	1162350	37
PZU	2	140524	40060	28,51	1485570	48
European travel insurance	3	121027	57929	47,86	182440	53
TAS	4	84125	20415	34,27	2026920	43
Guardian	5	74549	9076	12,17	371320	21
Knyazha	6	71454	7681	10,75	823700	37
USI	7	62299	9785	15,71	457700	77
Povidna	8	34853	3533	10,14	841120	52
ARX	9	28889	15633	51,11	2680020	42
Persha	10	26916	6561	24,38	451600	38

The largest share in tourism insurance in the insurance premium of the UK has European travel insurance (66%); VUSO Insurance Company (15%), Guardian (20%), USI (13.61%) have a small share; all other insurance companies have a small share of tourism insurance premiums: ROM (9.4%). TAS (4%); Knyazha (8.6%), Leading (4.14%); ARX (1.07%), First (5.95).

We will group insurance companies according to the ratings of the Ministry of Finance for 2018-2020. on tourism insurance.

In 2018–2020, the amount of insurance premiums increased only in two rhinestone companies (VUSO and TAS), while the amount of insurance premiums also increased. The dynamics of these indicators is unstable.

Table 2

Grouping of insurance companies according to the ratings of the Ministry of Finance for 2018–2020 on tourism insurance

Name SC	Indicator	2018	2019	2020	Relative deviation of 2020 from 2018, %
VUSO	Awards Payments	116601 23777	156702 40839	175042 42427	150,12 178,43
PZU	Awards Payments	157821 46603	267640 64744	140524 40060	89,67 85,96
European travel insurance	Awards Payments	147712 66178	205824 75128	121027 57929	81,93 87,53
TAS	Awards Payments	78953 17374	81568 18670	84125 20415	106,55 117,50
Knyazha	Awards Payments	156720 9306	172196 1360	71454 7681	45,49 82,53

The amounts of insurance premiums and insurance payments of the ROM Insurance Company, European Strategic Insurance, and Kniazha decreased during the period under study. But despite this trend, they are still making increasing payments.

The value of gross insurance payments is growing, so for the period from 2018 to 2010 there was an increase of 15%, while during this period the amount of gross insurance premiums decreases, which means that there

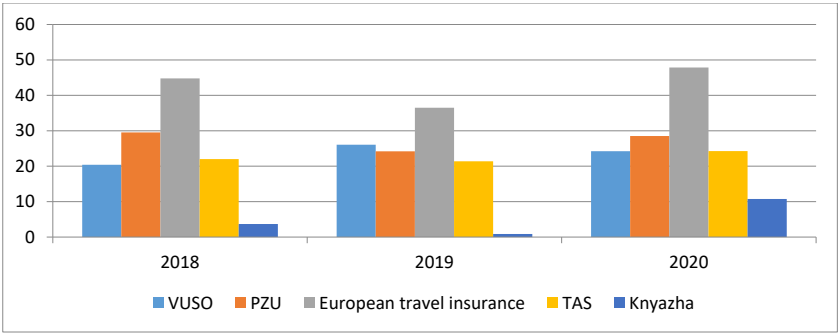

Figure 1. Dynamics of the level of payments of the leading insurance companies of Ukraine for tourism insurance, %

Table 3

Dynamics of payments and premiums of insurance companies of Ukraine

Indicator	2018	2019	2020	The relative deviation of 2020 from 2018, %
The relative deviation of 2020 from 2018, %	49367,5	53001,2	45184,9	91,52
Gross insurance payments, million UAH	12863,4	14338,3	14852,7	115,46

is an increase in gross payments (from 26.1 in 2019 to 32.9% in 2020). Such changes indicate, on the one hand, a slight increase in financial risks of insurance companies, and on the other – the development of positive trends in the national insurance market. But if we compare the level of payments in Ukraine and the world, the values of this indicator are very low, in European countries it is 70%.

The growth of insurance activity was one of the factors in the growth of insurance reserves and assets.

Table 3

Dynamics of assets and insurance reserves of the Insurance Company of Ukraine

Indicator	2018	2019	2020	The relative deviation of 2018 from 2020, %
Assets, million UAH	63493,3	63866,8	64925,2	102,25
Insurance reserves, million UAH	26759,6	29558,8	34192,1	127,7

The volume of formed reserves as of 01.01.21 amounted to UAH 34192.1 million (increase by UAH 7,432.5 million compared to 2020), which affected the expansion of financial opportunities of insurers to invest funds, increase in assets.

SWOT-analysis of factors influencing the prospects for recovery and development of the tourism industry in the world after the pandemic is presented in Figure 3, where the relevant factors are divided by impact

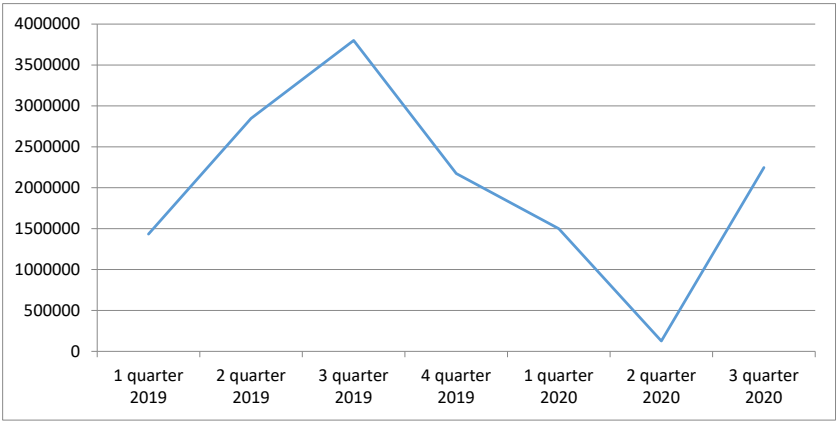

Figure 2. Volume of realized services of travel agencies and tour operators of Ukraine, thousand UAH

on industry development (positive or negative) and the nature of factors (internal or external).

The proposed SWOT-analysis of the factors influencing the prospects for the recovery and development of the tourism industry allows us to assess the strengths and weaknesses of the strategy to overcome the tourism crisis, take into account its opportunities and threats.

The COVID-19 crisis has come as a huge shock to the tourism economy, with a major impact on people's livelihoods, industries, regions and businesses. As the pandemic continues to develop, all its consequences still cannot be calculated and taken into account. However, a return to "ordinary business" is unlikely. Politicians will need to learn from the crisis to build a stronger, more resilient tourism economy for the future. Although it is too early to say for sure, there are a number of lessons to be learned: The crisis was a call for action by governments at all levels to respond in a coordinated manner, and the importance of integrated tourism policy approaches to support recovery.

Taking into account all four components of the SWOT-analysis in the complex will allow to determine the main strategic directions of tourism development, to formulate goals and specific tasks. In addition, the SWOT-analysis will allow to outline a plan for strategic development of the tourism

industry in the future, to anticipate the necessary actions and tools, to take into account new opportunities.

In the context of European integration processes in tourism, the use of SWOT-analysis should be combined with other management tools that improve the quality of tourism products to international standards, attract more consumers of tourism services, which, according to researchers, are dissatisfied with cost-quality. On tourism products of domestic enterprises. Therefore, in the conditions of transformational changes of the national economy it is necessary to pay special attention to the development of management tools in tourism.

Government at all levels and the private sector need to be better prepared and able to respond and adapt quickly. This requires a more reliable assessment of risks and crisis response mechanisms, as well as closer coordination at the local, national and international levels.

Providing targeted and affordable support as quickly and efficiently as possible for vulnerable tourism businesses, workers and tourists is and remains extremely important. Tourism generates foreign exchange, supports jobs and businesses, stimulates regional development and supports local communities. Prior to the pandemic, the tourism sector was directly contributed by 4.4% of GDP, 6.9% of employment and 21.5% of exports of services in OECD countries on average (and 6.5% of world exports according to the World Trade Organization [7]). However, these shares are much higher in several OECD countries, where tourism is the main driver of economic activity, such as France (7.4% of GDP), Greece (6.8%), Iceland (8.6%), Mexico (8.7 %), Portugal (8.0%) and Spain (11.8%). The indirect impact of tourism is also significant, exacerbating the shock to the national and local economies. Ensuring policy clarity and taking measures to reduce uncertainty (as far as possible) will be crucial to support the resumption of tourism. The prospects for the tourism economy remain extremely uncertain, and confidence in business and travel has been hit hard. Clear communication, well-developed information policies and clear epidemiological criteria will be particularly important where there is a need to change travel restrictions and containment measures in response to virus outbreaks and changes in the health situation.

A crisis is a once-in-a-lifetime opportunity that encourages us to move towards fairer, more sustainable and sustainable (socio-ecological-

Positive	Negative
Strengths • Proven sustainability of tourism in past crises • Domestic tourism can be a buffer • Power of adaptation: safety and hygiene protocols, travel closer to home, value for money, responsible consumer behavior • State support of the sector	**Weaknesses** • Segments that can potentially be affected are also high costs: international, long-term, business travel and events • Major disruptions in air transport with airline failures and concentration • Lack of references in previous declines • Perception of travel as a risk • Low level of demand when restarting tourism due to social distance
Opportunities • Rethink the business model • Innovation and digitalization • Sustainability and sustainable development segments (rural, nature, health, eco-tourism) • De-escalation phases initiated by several countries to the "new norm" • Progress in adaptation plans in areas and companies	**Threats** • Economic environment: global downturn, rising unemployment and job threat, business closures, mainly of SMEs, disposable income, uncertainty that burdens consumer and business confidence • Indefinite duration of the pandemic (including rebirth) and vaccine unavailability • Degree of blocking and restriction of travel • Unknown form of "new rule"

Figure 3. SWOT-analysis of factors influencing the prospects for recovery and development of the tourism industry

economic) models of tourism development. The pandemic has again revealed structural weaknesses in the tourism system and vulnerability to external shocks. There is an urgent need to diversify and strengthen the resilience of the tourism economy, better prepare for future shocks, address long-standing structural weaknesses and encourage the digital, low-carbon transformations needed to move to stronger, fairer and more sustainable tourism models.

4. Personal insurance in the tourism business

Personal insurance is one of the branches of insurance. It associated with a special area of the reproduction process – namely – with reproduction of labor and due to the risk nature activities of people with an increased degree of risk associated with deteriorating environment, increasing the proportion of older people in the total population, etc. Personal insurance is provided for the purpose of organization insurance protection of individual citizens and members of their families in case the occurrence of various events that affect life, health and working capacity of these citizens. Personal insurance in tourism is a system of relations between insurance company and tourist to protect his life and health in the event of insured events. The organization of tourist activities is associated with many risks, so there is a need for insurance.

Harmful factors (risk factors) in tourism are possible classify as follows:

– risk of injury (movement of mechanisms and objects, bodies, complex terrain, movement of rocks, unfavorable ergonomic characteristics of camping equipment and inventory, dangerous atmospheric and other natural phenomena);

– environmental impact (increase or decrease in temperature, humidity and movement of air masses, precipitation in the tourist service area, sharp changes in atmospheric pressure);

– fire danger (compliance with regulatory requirements fire safety documents);

– biological factors (pathogenic microorganisms and their products life, poisonous plants, reptiles, insects and existing animals carriers of infectious diseases, burns, allergies and other toxic reactions;

– psychophysiological loads (physical and neuropsychological overload).

– danger of radiation (advanced level ultraviolet and radiological radiation);

– chemical exposure (chemical factors: toxic, irritating, sensitizing);

– stage of transportation (type of vehicles);

– increased dust and gassiness;

– other factors.

According to the Law of Ukraine “On Tourism” and for the purpose ensuring the safety of tourists and tourism entities are obliged to carry out:

– preparation of safe conditions for tourists, arrangement of routes of campaigns, walks, excursions, places of carrying out competitions;

– training of tourists in the means of prevention and protection against injuries and accidents, briefing on the provision of the first medical assistance, as well as information on sources of danger that may be determined by the nature of the route and the behavior of the tourists themselves;

– control over the preparation of tourists for travel, hiking, competitions, other tourist events;

– providing emergency assistance to tourists in distress, transportation of victims. Types of personal insurance in the tourism business:

– insurance against accidents;

– Medical Insurance.

Article 17 of the Law of Ukraine "On Tourism" provides that tourist insurance (medical and accident) is obligatory and is carried out by subjects of tourist activity on based on agreements with insurance companies. An insurer can only be an insurance company that has appropriate license. Insurers of personal insurance tourists can perform both individuals and legal entities (tourists and tourist firm), and insured – only tourists. When insuring tourists, insurance events include: short-term, unexpected, unintentional accidents, disease (poisoning, injury, etc.), death (death), but only in places provided by the tourist voucher. Insurance events in the personal insurance of tourists can not be considered chronic, infectious and recurrent diseases (cardiac vascular, oncological, tuberculous, dental and other).

Personal insurance in the travel business includes such an important sub-branch of insurance as accident insurance cases. Accident insurance in the tourism business – it is a risk insurance that involves the payment of the sum insured only in the event of an insured event (in full or in full its part, depending on the damage caused to the victim). On expiration of contracts of risky types of insurance no neither payments of insurance sums, nor return of the received are provided insurer of insurance premiums. Accident insurance in the tourism business can be both individual and collective. Insurance is considered individual if insurance payments are paid natural (insured) persons; in the case of collective insurance payments are made by organizations with which the insured persons are employed or other (provided by law) relations. Object of insurance protection in case of accident insurance cases in the tourism business are the property interests of the insured persons associated with temporary or permanent decline in income or additional costs due to disability, as well as death of the insured as a result of an accident.

Varieties of accident insurance tourism business e:

– Compulsory personal accident insurance air transport passengers;

– Compulsory personal accident insurance railway passengers.

– Compulsory personal insurance of air passengers transport (tourists, tourists) is carried out by concluding agreements between carriers and insurance companies that have a license to conduct this type of compulsory insurance.

The carrier is obliged to draw up a report on each accident, which happened on the transport with the insured passenger (tourist). Object of obligatory personal insurance against accidents cases of rail passengers have property interests insured related to their life and health. Performance of the contract the insurance covers the entire trip. Insurance cases are recognized injuries or death (death) of the passenger the result of an accident on the railway.

The insurance premium is calculated on the basis of the sum insured and tariff rates set by insurers by agreement with the Ministry of Railways and approved by the body insurance supervision. Under the contract of compulsory insurance passengers rail transport are considered insured from the moment announcement of boarding the passenger train and until leaving station or destination station, but not more than one hour after his arrival. Transit passengers are considered insured on the territory of the station (station) for the entire period of waiting or landing in train.

The carrier is the insured under the contract. For receiving an insurance payment to the injured insured (injuries), must submit to the insurer the following documents:

– application;

– a report drawn up by the carrier on the accident that occurred with a tourist by rail;

– certificate of medical institution;

– travel document and identity document. In case of death (death) of the insured heirs submit to the insurance company: application; compiled by the carrier accident report; death certificate of the insured; a document certifying the entry into the rights of inheritance (will); identity document.

Claims for payment of the sum insured may be made to the insurer within 3 years from the date when the insurer had to make an insurance payment. The size of the insurance rate is set by insurers for in coordination with the Ministry

of Transport and approved by the body supervision of insurance activities. The amount of the insurance premium is included in the fare document and is charged to the tourist when selling a travel document. The sum insured is set at 120 minimum wages. Passenger in case of injury as a result of an accident the part of the sum insured corresponding to its level is paid severity. In case of death of the insured person the heirs receive the sum insured in full (100%). At onset: disability group III – 50% of the sum insured; disability of the II group – 75% of the sum insured; disability group I – 100% of the sum insured.

Voluntary health insurance is a sub-sector of personal health insurance in the tourism business. Voluntary medical form insurance allows tourists to conclude insurance contracts (assistance) in case of sudden illness, bodily injury as a result of an accident, as well as death while in prison border. The main purpose of "assistance" – immediate response to emergencies circumstances, providing the client with moral, medical, and technical assistance. The insurance contract may provide for liability the insurer in need of medical transportation of the patient to the nearest or specialized hospital; transportation to the country accommodation with medical support; repatriation of the body the insured; early return; emergency dental help; legal aid, etc. However, the LCA policy does not cover citizens who go abroad provides for reimbursement of the cost of medical services from targeted treatment abroad, for the treatment of diseases that were known to the insured (insured) at the time of conclusion insurance contract, medical care or treatment, which is not urgent. The health insurance policy provides an opportunity to cover the following risks:

– emergency inpatient care;
– emergency outpatient care;
– payment for medicines purchased with a doctor's prescription;
– necessary, prescribed by a doctor to replace glasses;
– necessary dental care;
– emergency maternity care;
– evacuation / repatriation;
– visit of a third party or arrival of one of the close relatives;
– early return;
– transportation of the child (children) of the insured person;
– transmission of urgent messages. To date, there are two forms of insurance tourist service;
– compensatory.

Provides payment by the traveler of all medical expenses and reimbursement only after return on homeland service (assistance). Provides a list of services provided at the right time in kind or in kind cash through technical, medical and financial assistance. Varieties of personal insurance in the tourism business are insurance of foreign nationals who are temporarily on territory of Ukraine, travel insurance, cost insurance tourists when canceling a tourist trip. The object of such insurance is property interests related to health and ability to work of the insured person, as well as the occurrence of costs for medical and other types provided to the insured services in connection with the occurrence of sudden, unforeseen events during stay of the insured person on the territory of Ukraine. Insurance risk is a sudden, unforeseen, independent from the will of the insured person the event that actually happened to him under time of his stay in Ukraine, namely: sudden illness, death as a result of a sudden illness, accident (injuries, death as a result of an accident), accident or breakdown of vehicles, theft of luggage, tickets, documents.

Non-travel insurance is the payment of the sum insured tourist in case of his inability to go on a trip due to refusal issuing him a visa or any other force majeure. In case of non-departure of the tourist the full cost will be refunded tourist trips less the consular fee for a visa.

Insurance of expenses of tourists at cancellation of tourist the trip is realized on the basis of the insurance agreed in the contract the amount (insurance indemnity) that is paid in full or in part, if the impossibility of the trip came from the following reasons:

– sudden illness or death of the tourist or his members family or close relatives;

– damage to tourist property as a result of exposure the environment or the actions of third parties;

– the participation of the tourist in the trial at the time of the alleged travel;

– receiving a call for military service;

– failure to obtain an entry visa if all requirements are met paperwork;

– other reasons specified in the contract. Specific types of tourist insurance are: in case untimely departure; in case of bad weather in the place of temporary stay; from not leaving; from not obtaining a visa; for cases non-fishing during fishing, non-shooting animals during hunting, etc.

Specific rules (conditions) of tourist insurance for each type of insurance is developed by each insurer independently within the framework of current legislation and regulations Of Ukraine on insurance supervision.

5. Risks of the tourist enterprise

The tourism business, like any kind of business, contains there are a huge number of obvious and hidden threats, equally dangerous both for tourists and for companies in the field of travel services – travel agencies, hotels, restaurants, casinos, airlines and other enterprises of the tourism industry. A scientifically sound classification of risks is the determination of the place and functions of each specific risk in their overall system the possibility of effective use of methods and techniques in risk management. Particular attention is paid to the study of such risk properties as generality, systematicity, dynamic probability. The generality of risks has the form of an abstract and concrete possibility. Abstract risks are risks that can be realized, but for this there is no set of necessary and sufficient conditions. They are distinguished by the following signs: the reasons that give rise to them; degree of maturity; time of onset. Examples are the risks of bankruptcy from declining demand, due to the possibility of the national economy entering a phase of crisis. However, this feature requires a set of system changes that are not required will take place. Thus, technical progress leads to the formation of a new one technological basis of the economy, the demise of old industries, but this process may not be accompanied by the bankruptcy of certain enterprises that make up the basis of these industries.

Specific risks are risks that are quantified losses over time, to minimize which entities operate as necessary managerial and material resources. Complicating the system of public relations, growth of total production tiveness, the creation of a system of mass consumption leads to the fact that the number of individuals who are removed from the production process and become passive consumers. Under these conditions, the risks associated with that increase resources aimed at education, vocational training of large groups of people, will never pay off. The risks that exist in the field of tourism can be divided into two categories. In the first case, the risk is a tourist who enjoys travel services. During the trip, tourists are exposed to danger from different reasons: unfamiliar location, ignorance of a foreign language, various kinds surprises and cataclysms (loss of luggage, medical

illness, robbery, unforeseen events during excursions, etc.). In the second case, the risk is the tourism company itself, which is also is obliged to provide food, accommodation and leisure services related with financial losses due to risky circumstances. Entrepreneurial structures are always faced with risk solving both current and long-term tasks. There are certain types of risks that affect everyone without exception, business organizations, but along with the general ones are specific types of risk inherent only in certain activities: for example, tourism risks differ from risks in the provision of hotel services, and the latter, in turn, differ from the risks in manufacturing. Net risks mean the possibility of getting negative and zero results. These risks include natural, environmental, political, transport and part of commercial risks – property, production, trade (depending on causes).

Natural hazards include risks associated with natural disasters forces of nature: fire, hurricane, earthquake and others. Natural and climatic risks significantly affect tourism activities, as the possibility of implementation tourist travel directly depends on natural and climatic conditions in the countries of the world. Tsunamis in Thailand and Indonesia, floods in Western Europe, forests fires in Montenegro have kept tourists from traveling to these countries. Environmental risks are risks associated with environmental pollution. For example, tropical coastal areas are geographically more exposed natural disasters due to climate and location, and more vulnerable than elsewhere due to the natural purity of the marine environment and coastal ecology. High the concentration of tourist attractions is typical for all tropical regions of the world. In these areas, the tourism industry is environmentally dependent, ie tourism is based largely on pristine ecology. Political risks are risks associated with the political situation in a country and the activities of the state. Political risks include:

– inefficiency of state support for domestic tourism enterprises;

– imperfection of the legislation regulating activity in the field of tourism;

– strictness of requirements for registration of entry documents of foreign tourists;

– weak harmonization of current legislation with the law other countries in the field of tourism;

– international conflicts;

– prohibition or restriction of conversion of national currency into payment currency.

Thus, the unstable political situation, terrorism, war, revolution, introduction visa regime negatively affects the tourist flow. In particular, as a result revolution in Tunisia in the first half of 2011, the tourism industry lost almost half a billion dollars, and the number of foreign tourists in the country decreased by 40%. Unearned profits in the tourism industry in Egypt as a result of the revolution February-April 2011 amounted to more than two billion dollars, and in March the country visited by 60% fewer vacationers than the same month last year. The authoritative publication Forbes annually publishes a list of the most undesirable and dangerous for tourists countries. As of January 2016, the list topped the list the following countries: Somalia, Afghanistan, Iraq, the Democratic Republic of the Congo, Sudan, Pakistan and Yemen. Transport risks are risks associated with transportation. Trade risks are risks associated with losses due to delay payments, refusal of payments for the period of the contract, etc. Therefore, the production risk arises in the process of providing services and is associated with the inability of the firm to perform its obligations under the contract or agreement with the customer. Sources of production risk are:

– incorrectly chosen strategy of the firm;
– imbalance in the distribution of internal resources of the firm;
– increase in production costs;
– reduction of production volumes;
– ill-conceived innovations, new technologies;
– uncoordinated actions of individual divisions of the firm;
– reducing the level of competitiveness of the firm;
– dissatisfaction of the company's employees and the risk of strikes;
– disclosure of trade secrets;
– making the wrong decision by managers;
– loss of property.

The following production risks can be identified in tourism:

– the risk of complete cessation of activities in a certain direction due to inability of tourists to travel due to force majeure (military actions, natural disasters, epidemics, etc.);

– risk of non-receipt or late receipt of funds for sold tourist products and services;

– the risk of the client's refusal of a tourist trip;

– risk of refusal of concluded agreements on granting loans, investments or loans;

– price risk associated with determining the price of tourist products and services. It is primarily growing in the face of rapid inflation;

– the risk of bankruptcy of both business partners and the tourist enterprises.

Social risks in tourism are related to the following:

– rising poverty, falling living standards;

– changing consumer preferences in the tourism market;

– falling solvency of population demand;

– stratification of society;

– reducing the cost of recreation and tourism.

Speculative risks include the possibility of obtaining as negative, and positive results.

Commercial risks arise during the implementation of tourist services on market in case of unreliability of partners and is caused by the following factors:

– lack of own link in the market;

– incorrect use of information;

– reduction of sales of services;

– lack or incorrect organization of marketing research;

– erroneous pricing;

– loss of consumers of services;

– unsatisfactory fulfillment of the terms of the contract by the counterparty;

– imbalance of supply and demand in the market.

The risks of choosing and reliability of a partner are very significant in the tourism industry, because during the creation and implementation of a tourist trip tour operator cooperates with many partners (carriers, insurance companies, travel agencies, hotels, etc.). Failure or improper performance counterparty of its obligations leads to negative feedback from tourists about the work of a tour operator as a travel organizer. The risk of inflation is associated with the depreciation of tourism assets firms. Currency risks reflect the threat of currency costs associated with by changing the exchange rate of one foreign currency against another, in particular the national one currency, in the implementation of foreign economic, credit and other

currency operations. For tourism businesses, this risk is always significant. Liquidity risk is the risk associated with the possibility of losses over time sale of securities or other goods by changing the assessment of their quality and consumer value. Financial risk is the probability of incurring losses relevant operations in the financial and credit and exchange spheres, implementation securities transactions. Financial risks include credit risk, interest rate (interest rate) risk, currency risk, risk of financial loss benefits. Financial risks are possible due to the loss of financial resources (cash) and the probability that the firm will fail to meet its obligations for investors. They can occur due to:

– deterioration of the financial condition of the firm;
– passivity of equity;
– reduction of profits;
– the occurrence of unforeseen costs;
– possible withdrawal of part of the money by the business partner from the authorized capital of the company;
– non-payment for the delivered goods;
– lack of demand for manufactured products;
– changes in exchange rates;
– increase in interest rates on the loan;
– insufficiency of own working capital;
– non-receipt of investments from commercial banks, investment companies.

Investment risks are related to the specifics of business investment firm funds in various projects and are determined by:

– unreasonable investment;
– depreciation of the investment and financial portfolio;
– the disappearance of sources of funding for the implementation of a particular project;
– failure of the chosen method of financing;
– increasing the previous cost of the project;
– reduction of the share price on the stock exchange;
– the probability of losses due to the company's compliance with stock exchanges agreements;
– forced increase of the previously planned amount of dividends on the company's shares;

– investing a large amount of money in one project.

Investment risks are divided into:

– the risk of lost financial gain is determined by the probability of financial damage that may result from failure to take certain action or termination of the tourist enterprise;

– risks of reduced profitability may arise in the event of a reduction in size interest and dividends on investments, investments and interest-bearing loans rates paid on borrowed loans.

The risks of lower profitability include credit and interest rate risks. Credit risk is the threat that a borrower will default on its principal debt and creditor interest. Credit risk is the risk of a situation in which the issuer the issuer of the securities will be unable to pay the principal amount of the debt. Interest rate risk is the threat of costs by commercial banks, credit institutions, investment funds due to the fact that due to the increase interest rates paid by them on borrowed funds, they begin exceed rates on loans.

Risks of direct losses are divided into:

– exchange risks are the threat of losses from exchange transactions;

– selective risks are risks of incorrect choice of variety capital investment;

The risk of bankruptcy is a threat due to a false variety capital investment, total loss of the entrepreneur's equity and his inability to settle commitments.

There are other types of risks, among which are the risks associated with criminogenic market regulation; risk of forgery of financial documentation etc.

Another classification of risks is also of practical interest:

– the risk to be accepted or the risk that is part of the structure business;

– risk that can be afforded;

– risk that cannot be afforded;

– a risk that can never be tolerated at all.

It should be noted that the new tourism projects have three types of risks:

– risk associated with technical innovations;

– risk associated with economic or organizational parties production;

– risk determined by the "youth" of the enterprise.

All of the above types of risks affect performance firms, so they need to be considered, evaluated and reduced to real limits.

6. Liability insurance in the tourism business

Liability insurance is an independent branch insurance. The object of liability insurance is liability of the insured under the law or by virtue of the contract before third parties for causing harm to them, health, life or property). The purpose of liability insurance is insurance protection economic interests of policyholders capable of causing harm third parties. Liability insurance combines features like property insurance, if the damage is caused to property, and personal insurance, if the damage is caused to health, life citizens. In terms of economic content, liability insurance plays a role dual role: on the one hand – protects the property interests of himself the insured, and on the other hand – the victim (third party) on case of insolvency of the person who caused the damage. Basically insurance relations in liability insurance imposed norms of domestic and international law, which are enshrined in the Laws Of Ukraine and resolutions of the Verkhovna Rada of Ukraine, international conventions and agreements.

The Civil Code of Ukraine provides liability of the person who caused damage to life, health and property third party. The subject of liability insurance is:

– risks of personal insurance (life, health, working capacity) – those related to the possibility of harm;

– risks of property insurance (destruction, shortages, damage).

Specific features of liability insurance include:

– the subjects of insurance relations are three parties: the insurer, the insured, the third party – the insured, who will to pay insurance indemnity – not predetermined;

– provides compensation to third parties and at the same time acts as a protection of property interests of the self the insured;

– the sum insured is set as a limit (limit) liability of the insured, which may arise in the event of infliction damage insurer, for the entire term of the insurance contract or for one insured event, and for the obligatory form – established by the Cabinet of Ministers of Ukraine.

Insurers enter into insurance contracts administrative, civil and material liability Administrative liability is one of the forms of legal responsibilities of citizens and officials for their implementation administrative offense. Liability is the responsibility of the employee to reimburse the losses caused by him to his company clearly Types of liability Civil Law Material Insurance

participants responsibility Insurance company Insurer Third parties Contract insurance Fears reimbursement Possibility damage Administrative 78 illegal actions in accordance with the procedure established by labor legislation. Civil (civil) liability as one of the types legal liability of business entities is established by the rules of civil and commercial law legal consequences for non-performance or improper performance by a person obligations under the law related to the violation subjective rights of another person. Liability insurance is classified as:

– by form of implementation: voluntary and mandatory;

– by types of insured entity: legal entities and individuals persons;

– by object of insurance: debt insurance (credit insurance, deposits) and insurance in case compensation for damage (professional liability insurance doctors, lawyers).

Owners' liability insurance vehicles – one of the most common and popular types of liability insurance worldwide. It provides payment to the victim of monetary compensation in the amount of which would be collected from the owner of the civilian vehicle a claim in favor of a third party for damage to life and health, and also for damage or loss of property belonging to her, which arose due to an accident or other traffic accident (accident) with the fault of the insured. The object of this type of insurance is civil liability owners of vehicles that they carry before the law as owners of a source of increased danger to others, ie third parties persons. In Ukraine, this type of insurance is mandatory under The Law "On Insurance" and the Regulations "On the procedure and conditions compulsory civil liability insurance owners of vehicles", approved by the resolution Of the Cabinet of Ministers of Ukraine of September 28, 1996 No. 1175. In In June 2004, the Verkhovna Rada of Ukraine adopted the relevant one the law, which comes into force on January 1, 2005. The essence of compulsory liability insurance vehicle owners is to protect property interests persons injured in traffic accidents that occurred with the fault of the insured Subjects of compulsory civil insurance responsibilities of vehicle owners are:

– Insurers – owners of vehicles, which in accordance with the Regulations is considered a legal or natural person who operates a vehicle owned by her, full economic management, operational management or on on other grounds;

– insurers – legal entities that have received the appropriate a license to conduct this type of insurance.

According to Art. 13 Law of Ukraine "On Insurance" insurers who are allowed engage in liability insurance of transport owners funds for damage caused to third parties, under the conditions provided by international agreements of Ukraine in this regard type of insurance, form the Motor (transport) insurance bureau Of Ukraine (M (T) SBU), which is a legal entity and is held by account of insurers – third parties (victims) – legal entities and individuals damage to the vehicle as a result of road traffic accident. According to the law, the insured event is considered a traffic accident caused by the insured and as a result of which comes his civil liability for the inflicted his vehicle harms the property, life and health of third parties persons. In international insurance activities insurance liability of vehicle owners is known under called "Green Card". "Green card" for tourists. If a person travels on own car, then when crossing the border of the participating country in the Green Card agreement (there are only 45 of them), a policy will be required from him motor third party liability insurance funds for damage caused to third parties. This policy is so is called – "Green Card" and is analogous to "Civilians", only international level. The policy is valid in all countries – parties to the agreement exempts from the need for additional civil insurance responsibilities when moving from one country to another. To specific types of liability insurance travel business include professional insurance responsibility. This type of insurance in many countries around the world is mandatory. Insurance in Ukraine professional responsibility with the adoption of a new version of the Law Ukraine's "On Insurance" is provided for in the mandatory form, but only on the list of professions identified by the Cabinet Ministers of Ukraine. For other professions, such insurance can also be conducted on a voluntary basis. Feature of professional liability insurance in travel business is that the insurer is committed according to the insurance contract to pay to the insured compensation at the suit of a third party for damage caused to it the insured due to negligence or error in his performance their professional responsibilities. The basis for lawsuits is negligence, related errors with the performance of professional activities that lead to financial loss or deterioration of the health of customers or third parties. The liability of the insurer arises in the event of fault the insured is proven.

There are 2 groups of risks in this insurance, in case which is the insurance of certain types of professional activities:

– risks associated with harm to life and health, ie the possibility of inflicting bodily harm;

– risks associated with material damage.

The object of insurance is liability for material costs incurred by a third party as a result of inadvertently incurred the insured of the actual direct material damage during provision of services. Insurers can be legal entities and individuals who have a qualification certificate and a license to carry out activities for the provision of professional services.

Liability arising from the following reasons is excluded: through discredit and slander, through dishonesty, fraud, criminal actions of the insured, lawsuits that fall under the influence of others insurance contracts. The result of the rapid development of industry, complications technological processes was an increase in the number of unfortunates cases and occupational diseases among workers. Employer liability insurance has become a form of protection life and health of the employee.

The employer is responsible before employees in the case of:

– personal negligence of the employer (if the employer is an individual);

– if the employer could not provide delivery appropriate and safe equipment, equip safe working place and organization of work, as well as select qualified, competent employees;

– Violations of legislation that may lead to employer's responsibilities;

– negligence of one of the employees, which led to injuries to another employee.

Employees are persons who work for hire or study, train at the employer's company. Every the employee must exercise reasonable caution during work health and safety, and health and safety other persons who may suffer from his wrongdoing. Under the employer's liability insurance contract insurers reimburse the insured in case bringing him to justice for the damage he had caused life and health of the employee, and this happened during the term of the contract insurance, when the employee worked for the insured, performing official duties. In addition, insurers will pay the costs of the insured incurred by him with the consent of the insurance company and related to investigations, medical and technical reports on circumstances of the accident, as well as with protection in court.

Liability insurance in the tourism business it is the insurance company's obligation to settle and pay the court civil lawsuits against the insured,

which inadvertently caused damage to the property of third parties, their health or even the health of animals that they belong. Insurance companies provide liability insurance subject of economic activity – hotel and tourist complex for damage caused to third parties temporarily residing in hotels (consumers of hotel and tourism services), associated with possession, use or disposal of property the insured. Injuries of any origin are insured (chemical, mechanical, thermal, etc.), obtained as a result of:

– fire, explosion;
– falling on a slippery floor due to poor lighting, cluttering of passages, etc.;
– electric shock;
– inflicting bodily harm on another person (including premeditated murder);
– accidents, destruction of houses, buildings and structures;
– natural disasters, emergencies;
– others that are not included in the list of cases that caused themselves temporary or permanent damage to health (disability) or death consumer of hotel and tourist services or harmed him personal property.

7. Conclusions

Tourism is one of the sectors of the world economy that has suffered the most due to restrictions on movement, and the aviation situation is particularly difficult.

As of April 20, 2020, due to a pandemic, 100% of all international destinations have imposed entry restrictions. Governments have responded immediately to the need to minimize the economic impact of the COVID-19 pandemic, based on two general approaches: the first is to provide affordable credit lines for business and the second is to delay debt and tax arrears.

Today in Ukraine there is a significant lag in the pace of implementation of measures to support the tourism sector, which poses a serious threat to the competitiveness of the industry in the global market during the projected recovery period in 2021. Key industry players, including international hotel chains, are introducing a number of external and internal measures to minimize the effects of the COVID-19 pandemic, including market guarantees (postponement or reimbursement of booked rooms, optimized loyalty programs, community support), health and safety measures and internal reorganization (reductions, unpaid leave, reductions / waivers of capital investments). As for the consequences of the COVID-19 pandemic

in the field of tourism, Ukraine is in a relatively better situation than most countries, as the share of domestic and outbound tourism far exceeds the inflow. The current temporary positive trends are not able to fully compensate for losses from "idle" business. Adaptive quarantine has not become a panacea for tourism – often in the regions simply do not comply with any quarantine restrictions, so hotels are becoming centers for the spread of coronavirus. The expected economic recession in Ukraine, the decline in the welfare of the population, which will result in the inability to spend money on recreation, will have an even more destructive effect on the industry.

Thus, as of today, Ukraine lags far behind in implementing measures to support the tourism sector, which poses a serious threat to the competitiveness of the industry in the global market during the projected recovery in 2021. The world still faces serious challenges, from the indefinite duration of the pandemic to restrictions on movement, all in the context of the global economic recession. Countries around the world are implementing a wide range of measures to minimize the effects of the COVID-19 pandemic and encourage the recovery of the tourism sector.

Thus, although the COVID-19 pandemic in early 2020 had a great impact on the state and further development of the tourism industry, any crisis leads not only to negative consequences, but also to the emergence of new opportunities and prospects for the tourism market. Among these opportunities are the acceleration of the processes of digitalization of tourist services, more active introduction of modern technologies, the use of ideas of the economy of impressions, the actualization of individual approach to the client, expanding the geography of tourist routes and others. In addition, the importance of travel safety (including the sanitary and epidemiological situation of the place of residence) is expected to increase. Tourists will prefer individual tours or tours in small groups at inland resorts. After the pandemic, a new stage of competition in tourism will begin, which will lead to a completely new distribution of resources in this market.

Thus, we can conclude that at the moment there are many problems in the insurance of tour operators. However, certain changes in the tourism market will undoubtedly take place. The way out of this situation could probably be the development of any combined banking and insurance products. For example, the bank provides a guarantee in case of intentional dishonesty of the travel agency. But it will be quite expensive, because from the point

of view of the bank, it is a guarantee of payment for intentional fraud by fraudulent travel agencies. Or the bank will agree to give guarantees only to known to him, proven, large travel agencies. But in any case, it should be understood that the purpose of all these guarantees – not so much to simplify the payment scheme, as to reassure tourists leaving through the normal, fulfill their obligations travel agencies. Maybe it would be good to make everyone aware of this situation as soon as possible, and those tour operators and travel agents who are unknown to anyone do not have the money to buy normal financial security, which did not fool people and quickly left the market. The COVID-19 pandemic has caused a huge crisis for the tourism industry, with a major impact on people's livelihoods, industries, regions and businesses. The most affected regions, to which tourists have not yet returned, are North Africa, Central and South America, Asia and the Pacific, and the Middle East. Government at all levels and the private sector need to be better prepared and able to respond and adapt quickly. This requires a more reliable assessment of risks and crisis response mechanisms, as well as closer coordination at the local, national and international levels. Politicians will need to learn from the crisis to build a stronger, more resilient tourism economy for the future. Although it is too early to say with any certainty what the final consequences will be, a number of initial lessons have already been set out. Ensuring clarity of policy and taking measures to reduce uncertainty (as far as possible) will be crucial to support the resumption of tourism. The prospects for the tourism economy remain extremely uncertain, and confidence in business and travel has been hit hard. Clear communication, well-developed information policies and clear epidemiological criteria will be particularly important where there is a need to change travel restrictions and containment measures in response to virus outbreaks and changes in the health situation. The crisis is a once-in-a-lifetime opportunity that encourages us to move towards fairer, more sustainable and sustainable (socio-environmental-economic) models of tourism development. The pandemic again revealed structural weaknesses in the tourism system and vulnerability to external shocks. There is an urgent need to diversify and strengthen the resilience of the tourism economy, better prepare for future shocks, address long-standing structural weaknesses and encourage the digital, low-carbon transformations needed to move to stronger, fairer and more sustainable tourism models.

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METHODS OF BANKRUPTCY PREDICTION AT THE ENTERPRISES UNDER CONDITIONS OF QUARANTINE RESTRICTIONS DUE TO THE COVID-19 PANDEMIC

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Abstract. The problem of bankruptcy prevention is growing in importance under conditions of the decline of economic growth and quarantine restrictions caused by the COVID-19 pandemic, which has significantly affected the domestic economy. In the second reading, the Ukrainian Parliament adopted amendments to the Code of Ukraine on the Bankruptcy Procedure, which banned moratorium on bankruptcy initiation by the creditors. Thus, there was approved "Draft Law on Amendments to Certain Legislative Acts to Regulate Certain Issues of Bankruptcy Procedures for the Period of Implementation of the Measures Aimed at Preventing the Emergence and Spread of the COVID-19 Pandemic" No 4220. This moratorium was introduced in the framework of measures for business support due to the COVID-19 pandemic. Quarantine restrictions caused by the COVID-19 pandemic have affected many businesses throughout the world. First of all, this is due to strict quarantine measures imposed by the governments of many countries: closure of shopping and entertainment centers, a ban on all public events, restrictions on the movement both within the country and when crossing its borders, reduction of production (due to the establishment of limits for the simultaneous stay of workers in one room), etc. Quarantine has ruined consumer sentiment and almost halted several industries including retail, hotel and restaurant business, air travel. The amount of budget revenues has decreased. As a result of quarantine, Ukrainian companies have frozen investments and production chains, and some of them are on the verge of bankruptcy. The main economic sign of bankruptcy is reduced to a single point. It is inability of the enterprise to meet the requirements of creditors. However, in order

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to avoid numerous bankruptcies on insignificant debts, the minimum amount of debt is determined, at which a bankruptcy case can be initiated. Macroeconomic efficiency of the institution of bankruptcy directly depends on the systemic nature of the relevant fragment of the national legislation, availability of the detailed representative economic statistics and the level of conceptual development of effective anti-crisis regulation. At the level of microeconomics, bankruptcy means not just stopping the local production process, i.e. the loss of a sustainable source of permanent income and social security. And at the level of macroeconomics there is the opposite situation; bankruptcy means rehabilitation of production from inefficient forms of its organization and inefficient management, overcoming cyclical recession and modernization of the technological base of production. A modern approach to the study of bankruptcy is associated with the definition of objective economic signs of corporate bankruptcy and specific signs of financial insolvency of the enterprise, assessment of the effectiveness of basic legal procedures for bankruptcy (supervision, external management, bankruptcy proceedings, and amicable settlement). Financial preconditions for insolvency and bankruptcy of the enterprise are analyzed in accordance with Methodical recommendations on detection of signs of insolvency of the enterprise and signs of concealment of bankruptcy, fictitious bankruptcy or bringing to bankruptcy; Methodology of in-depth analysis of the financial and economic condition of insolvent enterprises and organizations. Financial statements are the sources of information for analysis and detection of signs of bankruptcy. To predict the risk of bankruptcy, it is necessary to be guided by regulatory sources, data of accounting, statistical, operational accounting and reporting. Necessary information can also be obtained from documentary inspections, audits, orders, directives, economic and legal materials (contracts). To study the results of financial and economic activities of the object of study there can be used accounting data, which contains extensive analytical information. According to primary documents, it is possible to establish the causes of overspending, payment of fines, perpetrators, determine the legality and appropriateness of business transactions.

The main sign of bankruptcy is inability of the company to comply with creditors' claims within three months from the date of payment. After this period, creditors have the right to apply to the arbitral tribunal to declare

the debtor company a bankrupt. Bankruptcy is the result of interaction of internal and external factors. Due to the limitations of the COVID-19 pandemic, 1/3 of the business destruction is associated with internal factors and 2/3 with external factors. Bankruptcy characterizes realization of catastrophic risks of the enterprise in the course of its financial activity, as a result of which it is unable to meet the requirements set by creditors and meet obligations to the budget.

Among a wide range of methods used to determine the characteristics of various phenomena and processes, to identify the features of development, to study the dynamics of changes at the enterprises under conditions of the threat and development of crisis, there can be distinguished the main ones: expert (expert assessments); research and statistical; analytical; method of analogues. The whole set of methods for assessing the state of the enterprise is based on three main approaches, which include: the use of a system of indicators and informal indicators (criteria and features); setting the maximum number of indicators in different areas of the enterprise; creation of a separate system of integrated indicators. In the practice of analysis and assessment of the enterprise state the most common approach is the one that involves the use of a system of indicators and informal indicators. Integrated factor models developed using multidimensional multiplicative analysis are often used to assess the probability of bankruptcy and the level of creditworthiness of the enterprise. Bankruptcy forecasting methods based on the use of financial ratios are as follows: Two- and five-factor models for estimating the probability of bankruptcy based on Altman's "Z-score"; Model of Roman Lis, W. Beaver; Method of rating assessment of financial condition (rating number); R – bankruptcy risk prediction; Taffler's prediction model; Fulmer's model; Springgate model; Generalized model developed on the basis of discriminant function; PAS-ratio. Integrated factor models of E. Altman, Lis, Taffler, Tishau and others are often used to assess the probability of bankruptcy and the level of creditworthiness of the enterprise (Table 1), developed using multidimensional multiplicative analysis.

1. Introduction

The problem of bankruptcy prevention is growing in importance under conditions of the decline of economic growth and quarantine restrictions caused by the COVID-19 pandemic, which has significantly affected the

domestic economy. It should also be considered that since 1991 the existing financial and economic ties of enterprises that were operating at that time have been destroyed, new ones have not been formed yet, while the state's leadership has been minimal. Financial crises of 2007–2010 and 2014–2018, reduction of the activities of enterprises due to the pandemic beginning from 2020 provoked the transition of domestic businesses to the raw material model of economic development, which in turn led to an increase in the export component in commodity markets, and affected the economic downturn. However, economic policy, which provides compensation for the decline in market activity due to the growth of raw materials in the structure of the economy when creating regulatory state institutions, currently does not meet the requirements of the economic system. In this regard, new vectors have emerged as state priorities, including scientific and technological development, innovation and modernization of enterprises, accordance to which new mechanisms and tools are used to regulate economic relations, state support is provided to enterprises.

Recently, a new approach to the formation of economic policy has become a priority one, and the need to establish new institutions and build economic relations on a fundamentally new basis has been recognized. The Draft "Sustainable Development Strategy of Ukraine 2030" No 9015/2018, the Decree of the President of Ukraine "On the Goals of Ukraine's Sustainable Development 2030" No722/2019, regional development strategies by 2027 have been adopted.

In addition, in the second reading, the Ukrainian Parliament adopted amendments to the Code of Ukraine on the Bankruptcy Procedure, which banned moratorium on bankruptcy initiation by the creditors. Thus, there was approved "Draft Law on Amendments to Certain Legislative Acts to Regulate Certain Issues of Bankruptcy Procedures for the Period of Implementation of the Measures Aimed at Preventing the Emergence and Spread of the COVID-19 Pandemic" No 4220. This moratorium was introduced in the framework of measures for business support due to the COVID-19 pandemic.

According to the innovations in the current legislation:

– creditors' meetings can be held by videoconference;

– creditors' meetings can be conducted through surveys.

Immunity has been determined for the arbitral trustee concerning disciplinary liability for the failure to preform actions, if their performance is

prevented by the quarantine requirements. This is possible if the arbitration trustees has notified the creditors of the committee or "creditors' committee, in particular those whose claims are secured by the debtor's property.

It is expected that the court at the request of the creditors' committee, creditor, arbitration trustee or on its own initiative may extend the terms while:

– holding a preliminary court hearing in the case of bankruptcy (insolvency);

– applying for invalidation of transactions committed by the debtor, moratorium on satisfaction of creditors' claims within the bankruptcy proceedings (insolvency);

– announcing the first, repeated or second repeated auction;

– implementing the plan of rehabilitation or restructuring of debtor's debts, procedures for disposition of property, liquidation, restructuring and repayment of debtor's debts.

Amendments exclude the provisions according to which:

– it is not allowed to open bankruptcy proceedings against debtors – legal entities at the request of creditors on the claims against the debtor, which arose since March 12, 2020;

– a one-month period for filing an application for bankruptcy with the debtor's manager due to the spread of the COVID-19 pandemic or measures to control the spread of this disease is extended;

– the creditors' committee and the secured creditor (in respect of the property that is the subject of security) have the right to decide whether to suspend the auctions for the sale of the debtor's property.

However, the norm will remain in force, which ensures the following points:

– the accrual of interest on the debtor's obligations to creditors, which are restructured by the plan of reorganization or restructuring of the debtor's debts, is stopped;

– penalties for non-fulfillment of such obligations by the debtor are not accrued;

– overdue obligations provided in the plan of rehabilitation or restructuring of the debtor's debts are subject to installments for the period of execution of the plan of rehabilitation or restructuring of the debtor's debts.

However, the measures applied today in the framework of the economic development program, especially in the field of mechanisms on

the enterprise bankruptcy prevention, are aimed at solving certain local problems and are not effective enough, and the position of enterprises is not significantly improved.

Quarantine restrictions caused by the COVID-19 pandemic have affected many businesses throughout the world. First of all, this is due to strict quarantine measures imposed by the governments of many countries: closure of shopping and entertainment centers, a ban on all public events, restrictions on the movement both within the country and when crossing its borders, reduction of production (due to the establishment of limits for the simultaneous stay of workers in one room), etc. Some companies have orgnized distance work, while others are forced to start vacation for their employees. At the same time, there are cases of abuse and violation by some employers of the terms of the employment contract, which require employees to write applications for dismissal on their own volition or to take vocation at their own expense. All this has a negative impact on the welfare of the population, their financial situation and in the near future will reduce their demand for a number of goods and services.

2. Bankruptcy in modern economic conditions

Quarantine has ruined consumer sentiment and almost halted several industries including retail, hotel and restaurant business, air travel. The amount of budget revenues has decreased. As a result of quarantine, Ukrainian companies have frozen investments and production chains, and some of them are on the verge of bankruptcy. Bankruptcy characterizes realization of catastrophic risks of the enterprise in the course of its financial activity, as a result of which it is unable to meet the requirements set by creditors and meet obligations to the budget.

Bankruptcy (i.e. financial failure) is the documented inability of an enterprise to pay its liabilities and finance its current activities due to the lack of funds. This state of the enterprise indicates deterioration of all indicators that determine financial stability.

The main economic sign of bankruptcy is reduced to a single point. It is inability of the enterprise to meet the requirements of creditors. However, in order to avoid numerous bankruptcies on insignificant debts, the minimum amount of debt is determined, at which a bankruptcy case can be initiated.

According to domestic economists [1, p. 232; 2, p. 220; 3, p. 208; 4; 5, p. 246–250], solvency of the enterprise depends on the relationship of the following factors:

– the needs of buyers to regularly buy and fully pay for goods and services;

– the quality of the legal regime of the business environment;

– level and volatility of prices for goods and services;

– consistency and rationality of financial policy measures;

– the amount of tax deductions;

– completeness and timeliness of fulfillment of obligations by budgetary institutions.

Macroeconomic crises that have a cross-sectoral system-wide nature and cover macroeconomics in general should be distinguished from a single act of bankruptcy. There can be revealed the following dependence: local bankruptcy is not the cause of macroeconomic crisis, while macroeconomic crisis is always the cause of a series of local bankruptcies. That is why, when analyzing the pace of development of the national macroeconomy, it is necessary to highlight the amount of debt caused by bankruptcy.

External (macroeconomic) causes that can provoke the emergence and spread of bankruptcy are such objective processes as recession in the economy as a whole (or in this industry), reduction in sales, which is a key condition for optimizing the ratio between aggregate demand and aggregate supply), as well as difficulties with the mass repayment of previously issued loans. In the institution of bankruptcy there is a contradiction between its macroeconomic nature and microeconomic effect.

Macroeconomic efficiency of the institution of bankruptcy directly depends on the systemic nature of the relevant fragment of the national legislation, availability of the detailed representative economic statistics and the level of conceptual development of effective anti-crisis regulation. Operation of special state control bodies that prevent corruption and shady activities, fictitious and counterfeit transactions, i.e. those types of illegal business that act as independent factors of real bankruptcy are of special importance.

At the level of microeconomics, bankruptcy means not just stopping the local production process, i.e. the loss of a sustainable source of permanent income and social security. And at the level of macroeconomics there is

the opposite situation; bankruptcy means rehabilitation of production from inefficient forms of its organization and inefficient management, overcoming cyclical recession and modernization of the technological base of production. In other words, in the macroeconomic aspect, bankruptcy is an opportunity to transform a particular enterprise.

Nowadays, there can be stated a change in the ratio of importance of macroeconomic (global) and microeconomic (local) factors of bankruptcy. While macroeconomic factors (inflation, intra-industry crisis, production recession, extensive methods) were dominating during the industrial era, during the post-industrial era the determining causes of bankruptcy were quarantine restrictions associated with the COVID-19 pandemic, as well as inefficiency of the enterprise management.

Thus, bankruptcy is becoming a special tool of progressive dynamics of the management system in this chain of social production. For the theoretical characteristics of bankruptcy from the point of view of the economy, economic analysis of the process of providing credit resources, taking into account the growth of financial assets of the enterprise is of special importance. In this regard, the development and introduction of credit risk models based on long-term representative dynamics of accounting data of the leading industrial enterprises and market prices for the relevant products is of priority significance.

The effect of the study of bankruptcy patterns is achieved by shifting to credit risk models based on forecasting the share price of enterprises, as well as financial models. When analyzing the bankruptcy process, considerable attention is paid to testing and use of credit risk models, default ratings.

In conditions of the world production globalization, credit risk, which forces to change portfolio approaches to credit assessments and adjust the planned short-term profit taking into account financial risks and irrational distribution of the enterprise capital, is getting the status of a key factor in economic dynamics. Precautionary analysis aimed to prevent bankruptcy involves the creation of a generalized model of crisis management based on the fixation of the hallmarks of “crisis” management from the usual administrative management of the day-to-day operation of the corporation. An important macroeconomic indicator of the success of anti-bankruptcy policy is the ratio between primary and repeated bankruptcy. In this regard, it is necessary to overcome the independence of the growth of management

income of the bankrupt enterprise from the economic condition of the whole corporation. This is facilitated in particular by the transformation of the bankrupt corporation into the status of "debtor in possession", which allows the corporation's management to maintain control over business, but with sanctions. This is especially important at the stage of the domestic economy development.

In the long-term prospect, the risk of new shocks in the financial sector of the credit market is associated not so much with high-tech corporations, but with corporations representing the traditional economy (often the so-called resource economy). For "resource" corporations working in the consumer sector, which are usually in a difficult financial position due to stable final demand and low interest rates, it is especially difficult to prevent pre-bankruptcy situations when the prices changes.

Financial insolvency of enterprises is a theoretically and practically relevant issue of economic research for many economists. The studies, which allow to build an economic model of the bankruptcy situation, are aimed at developing a common methodology for predicting corporate bankruptcies, and thus prevent and reduce the total number of bankruptcies. A modern approach to the study of bankruptcy is associated with the definition of objective economic signs of corporate bankruptcy and specific signs of financial insolvency of the enterprise, assessment of the effectiveness of basic legal procedures for bankruptcy (supervision, external management, bankruptcy proceedings and amicable settlement). Appropriate economic analysis can form the basis for conceptual improvement of changes in the legal regulation of corporate bankruptcy including such norms as the grounds for bankruptcy, the level of professional competence of arbitral trustees, the procedure for their appointment and control over their activities, rehabilitation procedure for financial recovery of the debtor, the order of satisfaction of creditors in bankruptcy proceedings, insolvency (bankruptcy) of organizations and subjects of natural monopolies.

The scale, intensity and potential danger of corporate bankruptcy largely depends on the interaction between government and business. Obviously, coordination of public (primarily state) and private (primarily corporate) interests forms the economic basis of all conceptual programs for sustainable growth of the national economy. It can be argued that the frequency and scale of corporate bankruptcy in the national economic

system is a kind of objective indicator of the degree of mutually beneficial cooperation between government and business (large, medium, small). In fact, such mutual benefit means that the state shares and protects inevitable risks of long-term strategic investments with large corporations.

Insolvency (or, in the common language of the conceptual apparatus of economic science – "bankruptcy") is the inability of the debtor to satisfy creditors' claims. The market mechanism of transformation of a corporate debtor into a "bankrupt" and a creditor into a loss-making financial agent is the main problem when analyzing the mechanism of formation of the institutional nature of corporate bankruptcy. Since in most cases this applies to financial requirements, situations that arise as a result of long-term excess of cash costs of the enterprise over its cash income are usually considered. Therefore, at first glance, bankruptcy is a fact of unbalanced financial technology, i.e. a phenomenon that has a purely financial origin, financial nature and financial consequences.

However, a "narrow-sectoral" interpretation of bankruptcy as "financial bankruptcy" only is not correct. As fairly noted in the literature [6, p. 57–60; 7, p. 224; 8, p. 209; 9, p. 227; 10, p. 25; 11], "structural optimization of capital, aimed at financial recovery and restoring the solvency of the enterprise, is a strategy bringing its capital, individual units and property complex as a whole to such proportions that help minimize debt, increase incomes and save outgoing financial flows". The content of the problems studied by economics is generally social: in any period it involves analysis of production efficiency, conditions of full employment, minimization of transaction costs, fair differentiation of income distribution, dominated by factors of economic growth. The problem arises from the fact that the mechanism of their implementation has a spatial specificity and temporal dynamics. These specifics and dynamics form problematic nature of the national economy.

The analysis of financial preconditions of bankruptcy of the enterprise is carried out according to:

– methodical recommendations on detection of signs of insolvency of the enterprise and signs of actions with concealment of bankruptcy, fictitious bankruptcy or bringing to bankruptcy;

– methods of conducting an in-depth analysis of the financial and economic condition of insolvent enterprises and organizations.

Financial statements are the sources of information for analysis and detection of signs of bankruptcy.

To predict the risk of bankruptcy, it is necessary to be guided by regulatory sources, data of accounting, statistical, operational accounting and reporting. Necessary information can also be obtained from documentary inspections, audits, orders, directives, economic and legal materials (contracts).

First of all, it is necessary to study data of the annual report: Income statement, Statement on on the aggregate income). In addition, it is necessary to study the notes to the financial statements.

To study the results of financial and economic activities of the object of study there can be used accounting data, which contains extensive analytical information. According to primary documents, it is possible to establish the causes of overspending, payment of fines, perpetrators, determine the legality and appropriateness of business transactions.

The main sign of bankruptcy is inability of the company to comply with creditors' claims within three months from the date of payment. After this period, creditors have the right to apply to the arbitral tribunal to declare the debtor company a bankrupt.

Economic performance of any business entity is subject to fluctuations and depends on many factors. Most businesses are in the ups and downs, and some are almost bankrupts. The causes of ups and downs in the activities of enterprise are considered as the effect of a number of factors: external (the company cannot influence them or its influence may be weak) and internal (depending on the organization of the enterprise itself). It is impossible to prioritize these factors. External factors are the main ones, including the constraints caused by the COVID-19 pandemic, political, economic and financial instability, leading to business insecurity and insolvency in general.

Bankruptcy is the result of interaction of internal and external factors. Due to the limitations of the COVID-19 pandemic, 1/3 of the business destruction is associated with internal factors and 2/3 with external factors [12, p. 136; 13; 14, p. 87; 15, p. 553–558; 16, p. 65; 17, p. 244–250].

Thus, bankruptcy characterizes realization of catastrophic risks of the enterprise in the process of its financial activities, as a result of which it is inconvenient to meet the requirements set by creditors in a timely manner and fulfill obligations to the budget.

The main reasons are as follows:

1. Serious violation of financial stability of the enterprise, which impedes its normal economic activities.

2. Significant imbalance within a relatively long period of its cash flows.

3. Prolonged insolvency of the enterprise caused by low liquidity of its assets.

Features of bankruptcy can be divided into two groups:

1. The first group includes indicators that reveal possible financial difficulties and the likelihood of bankruptcy in the near future: decline in production, reduced sales, chronic losses; presence of bad debts and receivables; low values of liquidity ratios and a steady tendency to their further reduction; equity deficit; growth to the dangerous limit of the share of borrowed capital in its total amount; adverse changes in the order book; decrease in the market value of the company's shares; reduction of production capacity.

2. The second group includes indicators, negative values of which only signal the possibility of a sharp deterioration of the financial situation in the future in case of failure to take effective measures: excessive dependence of the company on a particular project, type of equipment, market; loss of key contractors or experienced employees of the management staff; forced downtime, irregular work; ineffective long-term agreements; deficit of capital investments [18, p. 86–90; 19, p. 101–103].

The reasons for the ups and downs of the company during the COVID-19 pandemic are considered as the effect of a number of factors:

– external factors: crisis of the economy, general decline in production, inflation, instability of the financial system, changing market conditions, insolvency or bankruptcy of partners, political instability of the state, imperfection of legislation in economic law and antitrust policy, tax oppression, increased international competition, the level of welfare of the population, changes in production technology, development of science and technology, etc.;

– internal factors: competence of the company's management, high production costs, unprofitable production, insufficient sales due to unsatisfactory marketing services of the enterprise, lack of working capital, low level of equipment, technology and organization of production, creation of excessive balances, unsatisfactory payment discipline, insufficiently considered credit policy of the compny, etc.

External factors are the main ones, and the main of them is political, economic and financial instability, which leads to uncertainty and insolvency in general, to the bankruptcy of business entities. The decline in profitability is caused by various reasons both internal and external.

External causes include:

1. Economic: the crisis of the economy: inflation, general decline in production, instability of the financial system, rising resource prices; change in market conditions, insolvency and bankruptcy of partners; strict fiscal policy of the state (high level of taxes).

2. Political: unstable political situation in the country; change in the foreign economic policy of the state; antitrust policy of the state; imperfection of legislation, etc.

3. Demographic: change in population number and composition; level and structure of consumption; living standards and solvency of the population.

4. Natural: COVID-19, flood; natural disaster, etc.

Internal causes include:

– low level of equipment, technology that does not contribute to the production of competitive products;

– low level of organization of production, which leads to reduced efficiency of production resources, production capacity, creation of excess balances and results in slowing down the turnover of capital, creating its deficit, forcing the company to take loans;

– the use of loans on unfavorable terms, which leads to increased financial costs, reduced profitability;

– poor clientele of the company that pays late or does not pay and leads to chain bankruptcy;

– lack of a portfolio of orders, which leads to a decrease in sales, cash flow, increase in accounts payable;

– rapid and unplanned expansion of economic activity, which leads to a deficit of working capital, as the growth of inventories and costs is faster than sales.

The main internal reasons involve, first of all, imperfect management, because of which, for example, the company might have made inefficient long-term financial investments that did not ensure the growth of its income in the expected period; the enterprise is burdened with excessive production

stocks that do not increase production and cash inflows; the company produces finished products that are not sold; maintains a disproportionate socio-cultural sphere or an excessive number of staff, etc. Such reasons in modern conditions include ineffective marketing strategy and tactics when there is a significant number of intermediaries between producers and consumers, in which the vast majority of revenue settles.

External reasons for non-fulfillment of obligations may be, in particular, situations when the market reduces the overall demand for the company's products due to the lack of demand for it, high prices, reduced solvency, the emergence of substitute goods, etc. Such situations may arise when unscrupulous consumers do not make payments for shipped products or services. In these cases, the company, having no revenue, cannot fulfill its obligations to other entities of its economic relations and activities.

There may be situations of abrupt changes in tax policy, introduction of increased customs tariffs, direct bans on exports or imports, which also leads to the inability of the company to meet its obligations [20, p. 19; 21, p. 83; 22, p. 120].

External factors can be international and national. International factors are formed under the influence of the dynamics of general economic indicators of the leading countries of the world financial system, stability of international trade, customs policy, level of international competition, movement of international capital, etc.

It is the unjustified economic policy of the government, uncontrolled inflation, total economic crisis, political instability of society, decline of business activity in the economy that most affect the performance of enterprises primarily due to imperfect legal framework. At the present stage, the development of science and technology has slowed down due the deep crisis in the investment sphere.

One of the first signs of bankruptcy is a decrease in the profitability of the enterprise (in this case, profitability is the share of profits of the enterprise after paying taxes on annual revenue).

Under relative decline in profitability of the enterprise, there are difficulties with cash and possible difficulties with payment. Although lenders receive fixed amounts specified in loan agreements, they may consider it dangerous to resume lending, even at higher interest rates, because the risk of repayment increases when the value of the company's

equity decreases. Then the company will have to pay the amount of principal, in addition to interest.

To prevent business bankruptcy, financial preconditions for insolvency and bankruptcy of the enterprise are analyzed in accordance with Methodical recommendations on detection of signs of insolvency of the enterprise and signs of concealment of bankruptcy, fictitious bankruptcy or bringing to bankruptcy; Methodology of in-depth analysis of the financial and economic condition of insolvent enterprises and organizations.

3. Bankruptcy prediction methods

Among a wide range of methods used to determine the characteristics of various phenomena and processes, to identify the features of development, to study the dynamics of changes at the enterprises under conditions of the threat and development of crisis, there can be distinguished the main ones:

– expert (expert assessments);
– research and statistical;
– analytical;
– method of analogues.

The whole set of methods for assessing the state of the enterprise is based on three main approaches, which include:

– the use of a system of indicators and informal indicators (criteria and features);

– setting the maximum number of indicators in different areas of the enterprise;

– creation of a separate system of integrated indicators.

In the practice of analysis and assessment of the enterprise state the most common approach is the one that involves the use of a system of indicators and informal indicators.

Integrated factor models developed using multidimensional multiplicative analysis are often used to assess the probability of bankruptcy and the level of creditworthiness of the enterprise.

Bankruptcy forecasting methods based on the use of financial ratios are as follows [20, p. 21; 21, p. 90; 22, p. 121; 23, p. 18–22; 24]: Two- and five-factor models for estimating the probability of bankruptcy based on Altman's "Z-score"; Model of Roman Lis, W. Beaver; Method of rating assessment of financial condition (rating number); R – bankruptcy risk prediction; Taffler's

prediction model; Fulmer's model; Springgate model; Generalized model developed on the basis of discriminant function; PAS-ratio.

Integrated factor models by E. Altman, Lis, Taffler, Tishau and others are used to assess the probability of bankruptcy and the level of creditworthiness of the enterprise (Table 1), developed using multidimensional multiplicative analysis.

Table 1

Integrated models for assessing bankruptcy probability

Model name	Field of activity	Basic formula	Components of formula	Limit value
Altman model (1968)	Trade	$Z = -0.3877 - 1.0736R_c + + 0.0579R_a$	R_c – coverage ratio R_a – ratio of autonomy	< 0
Altman model (1968)	Trade	$Z = 1.2K_1 + 1.4K_2 + + 3.3K_3 + + 0.6K_4 + + 0.999K_5$	K_1- Owned working capital / Balance sheet currency; K_2 – Retained earnings / Balance sheet currency; K_3 – Net profit / Balance sheet currency; K_4 – Market value of equity / Raised capital; K_5 – Revenue from sales / Balance sheet currency.	2.675
Alman model (1983 p.)	Trade	$Z_c = 0.717K_1 + 0.847K_2 + + 3.107K_3 + 0.42K_4 + + 0.995K_5$	All components are similar, except K4 K_4 – Balance sheet reporting of equity / raised capital;	1.23
Lis model (1972 p.)	Hotel and restaurant business	$L = 0{,}063\ X_1 + 0{,}092\ X_2 + + 0{,}057X_3 + 0{,}001\ X_4$	X_1 – working capital / amount of assets; X_2 – operating profit / amount of assets; X_3 – retained earnings / amount of assets; X_4 – equity / debt capital;	0.037

(End of Table 1)

Model name	Field of activity	Basic formula	Components of formula	Limit value
Taffler model (1997)	Air transportation	$Z=0.03\ X_1 + 0.13\ X_2 + + 0.18\ X_3 + 0.16\ X_4$	X_1 – operating profit / short-term liabilities; X_2 – current assets / amount of liabilities; X_3 – short-term liabilities / amount of assets; X_4 – revenue / amount of assets.	0.2
R-model	Wholesale and retail trade	$R = 8.38\ K_1 + 1.0K_2 + + 0.054K_3 + 0.63\ K_4$	K_1 – working capital / asset; K_2 – net profit / equity; K_3 – sales revenue / assets; K_4 – net profit / integrated costs	0.32
French-Copan and Golder model	Air transportation, trade	$Z_{cg}= 0.16X_1 – 0.22X_2 + + 0.87X_3 + 0.10X_4 \pm \pm 0.24X_5$	X_1 – (Accounts receivable + cash and cash equivalents) / Balance sheet currency; X_2 – Fixed capital / Balance sheet currency; X_3 – Financial expenses / Revenue from sales; X_4 – Staff costs / Value added; X_5 – Gross profit / Raised capital.	- 0.068

One of the simplest models for predicting of bankruptcy probability is a double-factor model for assessing bankruptcy probability. It is based on two key indicators: current liquidity and the share of borrowed funds, which depends on the bankruptcy probability.

If the result of Z is negative, bankruptcy probability is low. If Z = 0, then bankruptcy probability is 50%, and a positive value of this indicator indicates high bankruptcy probability. The greater the value of Z is, the greater bankruptcy probability is. This model can be shown as follows [20, p. 21; 21, p. 90; 22, p. 121; 23, p. 18–22; 24]:

$$Z = – 0.3877 – 1.0736\ R_c + 0.0579\ R_a, \quad (1)$$

where R_c – ratio of coverage or coverage ratio,

R_a – ratio of autonomy

To obtain a more accurate forecast, American practice recommends taking into account the level and trend of changes in profitability of products sold, as this indicator significantly affects the financial stability of the enterprise. This allows you to compare simultaneously the risk of bankruptcy Z and the level of profitability of sales. If the first indicator is within safe limits and the level of profitability is quite high, bankruptcy probability is very low.

Altman model developed in 1968 and also known as "Z-calculation" is an integrated indicator of the level of the bankruptcy threat. This method was proposed by the famous Western economist Altman. The index of creditworthiness is built using the apparatus of multiplicative discriminant analysis. It allows in the first approximation to divide economic entities into potential bankrupt and non-bankrupt.

When constructing the index, Altman surveyed 66 companies, half of which went bankrupt between 1946 and 1965, and half of them were successful, and 22 analytical ratios that could be useful for predicting bankruptcy probability. Among these indicators, he selected five most significant and built a multivariate regression equation

$$Z = 1.2\ K_1 + 1.4\ K_2 + 3.3\ K_3 + 0.6\ K_4 + 1.0\ K_5 \quad (2)$$

This is a five-factor model, where the factors are individual indicators of the financial condition of the enterprise:

K_1 – Owned working capital / Balance sheet currency;

K_2 – Reinvested (retained earnings) / Balance sheet currency;

K_3 – Net profit / Currency of the balance;

K_4 – Market value of equity / Raised capital;

K_5 – Revenue from sales / Balance sheet currency.

Value of "Z" is related to bankruptcy probability:

$Z \leq 1.8$ – very high;

$1.81 \leq Z \leq 2{,}70$ – high;

$2.71 \leq Z \leq 2{,}99$ – possible;

$Z \geq 3.0$ – very low.

According to some sources, the accuracy of bankruptcy prediction according to this model is 95%.

To assess the financial position of the enterprise, in 1972 Roman Lis suggested the following formula [20, p. 21; 21, p. 90; 22, p. 121; 23, p. 18–22; 24]:

$$L = 0.063\ X_1 + 0.092\ X_2 + 0.057\ X_3 + 0.001\ X_4 \quad (3)$$

where: X_1 – working capital / amount of assets;

X_2 – operating profit / amount of assets;

X_3 – retained earnings / amount of assets;

X_4 – equity / debt capital.

The limit value for this model is 0.037.

The method of rating assessment of the financial condition of the enterprise (rating number). R.S. Saifulin and G.G. Kadykov suggested using a rating number to quickly assess the financial condition of the company:

$$R = 2K_o + 0.1\ K_{cl} + 0.08K_i + 0.45K_m + K_r \quad (4)$$

where: K_o – ratio of provision with the owned funds;

K_{cl} – current liquidity ratio;

K_i – intensity of the turnover of advanced capital, which characterizes the volume of sales per one monetary unit of funds invested in the enterprise;

K_m – management ratio characterized by the ratio of profit from sales to the amount of sales revenue;

K_r – return on equity.

If the rating number R for the enterprise has a value that exceeds 1, the enterprise is in satisfactory condition. If this value is less than 1, it is characterized as unsatisfactory. Rating assessment of financial condition can be used to classify enterprises according to the level of risk, the relationship with them, banks, investment companies, partners. Prediction of insolvency on the basis of the rating number, however, does not allow us to assess the causes of the falling into "the zone of insolvency" by the enterprise. In addition, normative content of the ratios used for rating also does not take into account sectoral characteristics of enterprises.

R–model of bankruptcy risk prediction [20, p. 21; 21, p. 90; 22, p. 121; 23, p. 18-22; 24]. Scientists have proposed a four-factor model of bankruptcy riskprediction (R-model), which is as follows:

$$R = 8.38\ K_1 + 1.0K_2 + 0.054\ K_3 + 0.63\ K_4 \quad (5)$$

where: K_1 – working capital / asset;

K_2 – net profit / equity;

K_3 – sales revenue / assets;

K_4 – net profit / integrated costs.

The probability of bankruptcy of the enterprise in accordance with the value of the model is determined by:

Value R (Ratio of bankruptcy probability)	Bankruptcy probability
Lower than 0	Maximum (90 – 100)
0 – 0.18	High (60 – 80)
0.18 – 0.32	Medium (35 – 50)
0.32 – 0.42	Low (15 – 20)
More than 0.42	Minimal (up to 10)

The advantages of this model include the fact that the mechanism of its development and all the main stages of calculations are quite simple and can be explained in detail and justified.

In 1977, British scientist Taffler proposed a four-factor prediction model using the following approach in its development. When using computer technology in the first stage, 80 relationships are calculated according to the data of solvent companies and bankrupt companies. Then, using a statistical method known as multidimensional discriminant analysis, you can build a solvency model by determining the private ratios that best distinguish two groups of companies and their ratios. Such a selective ratio calculation is typical for determining some key dimensions of a corporation's performance, such as profitability, return on capital, financial risk, and liquidity. A typical model for the analysis of companies whose shares are listed on stock exchanges takes the following form:

$$Z = 0.3\ X_1 + 0.13\ X_2 + 0.18\ X_3 + 0.16\ X_4 \quad (6)$$

where: X_1 – operating profit / current liabilities;

X_2 – current assets / amount of liabilities;

X_3 – short-term liabilities / amount of assets;

X_4 – revenue / amount of assets.

If the value of Z-score is more than 0.3, this indicates that the company has good long-term prospects and if it is less than 0.2, bankruptcy is more than likely.

Fulmer's model [20, p. 21; 21, p. 90; 22, p. 121; 23, p. 18-22; 24]. The average size of the total assets of firms in Fulmer's sample is 455 thousand dollars. The initial version of the model included 40 ratios. The model predicts exactly 98% of cases per year before bankruptcy, in 18% of cases two years before.

General view of the model:

$$H = 5.528\ K_1 - 0.212\ K_2 + 0.073\ K_3 + 1.270\ K_4 - 0.120\ K_5 - 2.335\ K_6 + \\ + 0.575\ K_7 + 1.083\ K_8 + 0.894\ K_9 - 6.075 \quad (7)$$

where: K_1 – retained earnings of previous years / total assets;

K_2 – sales volume / total assets;

K_3 – pre-tax profit / total assets;

K_4 – cash flow / amount of liabilities;

K_5 – debt / total assets;

K_6 – liabilities / total assets;

K_7 – log (tangible assets);

K_8 – working capital / aggregate liabilities;

K_9 – profit before interest and taxes / interest paid.

According to the results of the model, you can get the following forecast:

– loss of solvency is inevitable when H is less than 0;

– when H is more than 0, the enterprise functions normally, with the subsequent gradation.

Springgate model [20, p. 21; 21, p. 90; 22, p. 121; 23, p. 18–22; 24]. This model is as follows:

$$Z = 1.03\ A + 3.07\ B + 0.33\ C + 0.4\ D \quad (8)$$

where: A – working capital / total asset value;

B – profit before taxes and interest / total value of assets;

C – pre-tax profit / short-term debt;

D – sales volume / total asset value.

It is estimated that the accuracy of bankruptcy prediction according to this model is 92%, but over time this figure decreases.

If $Z < 0.862$, the company is potentially bankrupt.

According to several methods of bankruptcy prediction, a universal discriminant function has been built:

$$Z = 1.5\ X_1 + 0.08\ X_2 + 10\ X_3 + 5\ X_4 + 0.3\ X_5 + 0.1\ X_6 \quad (9)$$

where X_1 – cash-flow / liability;

X_2 – balance sheet currency / liability;

X_3 – profit / balance sheet currency;

X_4 – profit / revenue from sales;

X_5 – inventories / sales revenue;

X_6 –turnover of fixed capital (sales revenue / balance sheet currency).

The obtained values of Z – indicator can be interpreted as follows:

$Z > 2$ – the company is considered financially stable, and it is not threatened with bankruptcy;

$1 < Z < 2$ – financial balance (financial stability) of the company is disturbed, but in case of its transitions to anti-crisis management, it is not threatened with bankruptcy;

$0 < Z < 1$ – the company is threatened with bankruptcy if it does not take remedial action;

$Z < 0$ – the company is semi-bankrupt.

To strengthen the predictive role of models, Z-ratio can be transformed into PAS-ratio, which allows you to track the company's activities over time. When studying PAS-ratio both above and below the critical level, it is easy to determine the moments of decline and revival of the company. PAS-ratio is a relative level of the company's activity, derived on the basis of its Z-ratio for a certain year and expressed as a percentage from 1 to 100 [20, p. 21; 21, p. 90; 22, p. 121; 23, p. 18–22; 24]. For example, PAS-ratio of 50 indicates that the company's performance is assessed as satisfactory, while PAS-ratio of 10% indicates that only 10% of companies are in a worse position (unsatisfactory situation). Therefore, when calculating PAS-ratio for the company, you can then transform the absolute measure of financial condition into a relative measure of financial activity. In other words, if Z-ratio can indicate that the company is at risk, PAS-ratio reflects the historical trend and current activities in the future.

The strength of this approach is its ability to combine key characteristics of the income statement in a single representative ratio. Thus, a company that

makes big profits but is weak in terms of balance sheet can be compared to a less profitable one which balance sheet is balanced. Thus, having calculated the PAS-ratio, you can quickly assess the financial risk associated with the company. So, the approach is based on the principle that the whole is more valuable than the sum of its components.

An additional feature of this approach is the use of "risk rating" for further identification of the hidden risk. This rating is statistically determined only if the company has a negative Z-ratio and the number of years during which the company was in a risky financial situation. Using a five-point scale, in which 1 indicates "risk but a small probability of immediate trouble" and 5 means "absolute impossibility of maintaining the status quo", the manager operates ready-made tools to assess the overall balance of risks associated with customer loans. Focusing on one criterion, even a very attractive one from the point of view of theory, is not always justified in practice. Therefore, many audit firms and other companies engaged in analytical reviews, forecasting and consulting, use a system of criteria for analytical assessments, i.e. a variety of comparative qualitative methods of bankruptcy assessment. With these techniques, one can analyze those processes that cannot be described by the methods that work with a single assessment. There are the following qualitative prediction methods [20, p. 21; 21, p. 90; 22, p. 121; 23, p. 18–22; 24]: Methods by V.V. Kovalov, Argenti method (A-score), ERNST Method, and WHINNEY, Scone Method.

Methods of qualitative analysis by V.V. Kovalov. An example is the recommendations of the Auditing Committee (UK), which contain a list of critical indicators for assessing possible bankruptcy. V.V. Kovalov proposed the following two-tier system of indicators, based on the developments of the Western audit firms and adapting these developments to the domestic specifics of business.

The first group includes criteria and indicators, unfavorable current values or dynamics of change of which indicate financial complications, including bankruptcy, that are possible in the future. They include:

– significant costs that are repeated in the main production activities;

– exceed of some critical level of overdue accounts payable;

– excessive use of short-term loans as a source of financing long-term investments;

– consistently low values of liquidity ratios;

– chronic lack of return funds;

– a stable share of borrowed funds, which increases to a dangerous limit in the total amount of sources of funds, etc.

The second group includes criteria and indicators, unfavorable values of which do not give grounds to consider the current financial condition as critical. However, they point out that under certain conditions or failure to take effective action, the situation could deteriorate sharply. They include:

– loss of key employees of the management staff;

– forced stops, as well as violations of the production and technological process;

– insufficient diversification of the enterprise, i.e. excessive dependence of financial results on any specific project, type, equipment, type of assets, etc.;

– excessive bet on the expected success and profitability of the new project;

– participation of the enterprise in court proceedings with unpredictable outcome;

– loss of key counterparties;

– underestimation of technical and technological renewal of the enterprise;

– ineffective long-term agreements;

– political risk associated with the enterprise as a whole or its key units.

As for the critical values of these criteria, they should be detailed by industry, and their development can be performed after the accumulation of certain statistics.

Argenti method (A-score). According to this methodology, research begins with the assumption that there is a process that leads to bankruptcy; this process takes several years to complete.

The process can be divided into three parts:

Disadvantages. Bankrupt companies have been experiencing a number of shortcomings for years, evident long before the actual bankruptcy.

Mistakes. As a result of the accumulation of these shortcomings, the company may make a mistake that leads to bankruptcy.

Symptoms. Mistakes made by the company are starting to reveal all the known symptoms of insolvency, the impending deterioration (hidden by "creative" calculations), signs of the lack of money. These symptoms appear

in the last two or three years of bankruptcy, which leads to bankruptcy and often lasts for five-ten years. When calculating the A-score of a particular company, it is necessary to set either the number of points according to Argenti, or 0-intermediate values are not allowed. Each factor of each stage is assigned a certain number of points and calculate the addressed indicator A-score.

The practice of applying these methods using data of Ukrainian enterprises and analysis of expert opinions in this context have shown that the most popular valuation methods are based on the analysis of financial ratios. This is primarily due to the fact that comparative methods involve extensive use of expertise, and national companies either do not have free money for such research, or do not want to show their real position.

In domestic practice, these models are used little, because they do not take into account sectoral characteristics of the enterprise development and their inherent forms of business organization and features of the domestic economy in general. This is a purely theoretical nature of approaches to predicting bankruptcy. In domestic conditions, the data of such forecasts are biased and do not give grounds for practical conclusions. Similar domestic models for prediction should be developed, taking into account specifics of the industry.

Bankruptcy prediction can be performed by the employees of the enterprise itself, as well as the representatives of consulting enterprises and other specialists.

The main provisions of Methodical recommendations are aimed to identify the signs of actions on bankruptcy concealing, fictitious bankruptcy or activities that led to bankruptcy.

Methodical recommendations have been developed to provide unambiguous approaches to assessing the financial and economic condition of enterprises, identify signs of current, critical or supercritical insolvency and signs of action under the articles of the Criminal Code of Ukraine, concealment of bankruptcy, fictitious bankruptcy or bankruptcy, as well as for the timely formation of an unsatisfactory structure of the balance sheet for the implementation of preventive measures to prevent bankruptcy of enterprises.

In accordance with Methodical recommendations, the degree of insolvency of the enterprise and the moment of the solvency recovery is established. The latter is especially important, because according to the law,

rehabilitation is considered to be completed if the company has restored its solvency.

Methodical recommendations define 3 types of insolvency (or level of insolvency) [20, p. 21; 21, p. 90; 22, p. 121; 23, p. 18–22; 24]: current; critical; supercritical.

Sources of information for the calculation of economic indicators and detection of signs of insolvency or bankruptcy are the sample indicators from the financial statements of the enterprise, which are displayed in tabular form.

Financial condition of any enterprise can be characterized by current insolvency if at the moment due coincidence there is temporarily the amount of available funds, and highly liquid assets are not enough to repay current debt. This situation corresponds to the legal definition of the inability of a business entity to fulfill monetary obligations to creditors after the arranged date of their payment, including wages, as well as to fulfill obligations to pay taxes and fees (mandatory payments) through the solvency restoration.

Economic indicator of the signs of current solvency (Cs) under the presence of overdue accounts payable is the difference between the amount of cash available to the company, their equivalents and other highly liquid assets and its current liabilities, determined according to the formula:

$$C_s = F_{in} + C_{fi} + C_f - C_l \quad (10)$$

where F_{in} – long-term financial investments; C_{fi} – current financial investments; C_f – cash funds and cash equivalents; C_l – current liabilities.

A negative result of the algebraic sum of these balance sheet items indicates the current insolvency of the business entity.

Financial condition of the company, which at the beginning and end of the reporting quarter shows signs of current insolvency, corresponds to the legal definition of the debtor who is unable to meet its monetary obligations to creditors, including obligations to pay taxes and fees (mandatory payments), within three months after the deadline for their payment.

The signs of critical insolvency, which correspond to the financial state of potential bankruptcy, occur if at the beginning and the end of the reporting quarter preceding the filing of the bankruptcy case, there are signs of current insolvency, and the ratio of coverage (R_c) and ratio of provision of the owned funds (R_p) at the end of the reporting quarter are less than their regulatory values – 1.5 and 0.1, respectively.

The coverage ratio characterizes the sufficiency of working capital of the enterprise for the repayment of its debts and it is defined as the ratio of the amount of working capital to the total amount of current liabilities on bank loans, other borrowed funds and settlements with creditors:

$$R_c = \text{Current assets} / \text{Current liabilities} \quad (11)$$

The ratio of provision with the owned funds characterizes the availability of working capital of the enterprise required for its financial stability, and it is defined as the ratio of the difference between the volume of sources of the owned non-current assets to the value of current assets and equivalent assets, and the actual value of fixed assets and other productive assets stocks, unfinished construction, finished products, cash funds, receivables and other current assets.

$$R_p = (\text{Current assets} - \text{Current liabilities}) / \text{Current assets} \quad (12)$$

If at the end of the reporting quarter at least one of these ratios (R_c or R_p) exceeds its normative value or their growth has been observed during the reporting quarter, preference should be given to extrajudicial measures to restore the debtor's solvency or reorganize it in bankruptcy proceedings.

If during the period established by the debtor's rehabilitation plan, a positive indicator of current solvency and exceeding the normative value of the coverage ratio ($R_c > 1.5$) is provided under the presence of increasing profitability, the debtor's solvency can be considered restored (there are no signs of potential bankruptcy).

Return on assets is calculated as the ratio of net income to assets, the normative value is 6-8%.

Financial leverage is the ratio of the sum of long-term liabilities and short-term liabilities to assets, the normative value is less than or equal to 37, for sustainable companies [20, p. 21; 21, p. 90; 22, p. 121; 23, p. 18–22; 24].

If by the end of the year the coverage ratio is less than 1 and the enterprise has not made a profit, then its financial condition is characterized by supercritical insolvency when satisfaction of creditors' claims is possible only through the liquidation procedure.

Presence of signs of supercritical insolvency (by the end of the year $R_c < 1$ under the absence of profit) corresponds to the financial position of the debtor, when he, according to the law, must apply to the arbitral tribunal within one month to file for bankruptcy, i.e. when when satisfaction of the claims of one or more creditors leads to impossibility of fulfilling monetary obligations to other creditors.

If at the beginning of the reporting period that preceded the filing of an application to the arbitral tribunal for bankruptcy, there were no signs of supercritical insolvency, i.e. the actual coverage ratio exceeded at zero or positive profitability, this may indicate signs of fictitious bankruptcy.

Economic signs of actions leading to bankruptcy can involve such financial position of the debtor, in which the company showed no signs of supercritical insolvency before the execution of agreements entered into for selfish reasons, or other actions that may be classified as intentional, leading to persistent financial insolvency of business activity.

There may be signs of the bankruptcy concealment if at certain stages of the bankruptcy proceedings it is established that the debtor has provided inaccurate information about his property in the balance sheet or other documents indicating his financial assets, which are actually characterized by supercritical insolvency.

In order to timely reveal the tendency towards unsatisfactory balance sheet structure in a profitable business entity and take precautionary measures to prevent bankruptcy, a systematic rapid analysis of the financial position of the enterprise (financial monitoring) using Beaver ratio is carried out.

In order to predict bankruptcy, W. Beaver recommended to assess some indicators of the Beaver's system and their value for the bankruptcy prediction. They are as follows:

– Beaver ratio;
– Return on assets;
– Financial leverage;
– Ratio of the asset coverage with net working capital;
– Coverage ratio.

Normative values of Beaver ratio are divided into three groups, i.e. for sustainable companies, 5 years before bankruptcy, 1 year before bankruptcy (Table 2).

This methodology also does not reflect all aspects of the company's activities and is not a universal method for predicting bankruptcy probability. Beaver ratio is calculated as the ratio of the difference between net profit and accrued depreciation to the sum of long-term and current liabilities, according to the formula:

$$R_b = (\text{Net profit} - \text{Depreciation}) / \text{Liabilities} \quad (13)$$

Table 2

The system of indicators for bankruptcy prediction according to Beaver model

Indictor	Indicator calculation	Value of indicators		
		good condition	5 years before bankruptcy	1 year before bankruptcy
Beaver ratio	$\frac{\text{Net profit} - \text{Depreciation}}{\text{Liabilities}}$	0.4 – 0.45	0.17	- 0.15
Return on assets	$\frac{\text{Net profit}}{\text{Assets}} * 100$	6 – 8	4	- 22
Financial leverage	$\frac{\text{Liabilities}}{\text{Assets}}$	≥ 37	≥ 50	≥ 80
Maneuverability ratio	$\frac{\text{Owner' working capital current assets equity}}{\text{Assets}}$	0.4	≥ 0.3	0.06
Ratio of coverage (total solvency)	$\frac{\text{Current assets}}{}$	≥ 3.2	≥ 2	≥ 1

The feature of forming unsatisfactory balance sheet structure is the financial position of the enterprise, at which Beaver ratio has not exceed 0.2 for a long time (1.5-2 years), which reflects undesirable reduction in the share of profits intended for the development of production. This trend ultimately leads to unsatisfactory balance sheet structure, when the company begins to be in the red and its ratio of internal funds is becoming less than 0.1.

Thus, the use of methods for predicting bankruptcy in the activities of enterprises is caused by the need for specialized anti-crisis management.

The possibility of crisis management is based on the following above-mentioned points of crisis theory:

– crisis phenomenon can be managed in certain way, i.e. crises can be predicted, expected, caused, accelerated, prevented, delayed; their external manifestation and consequences can be mitigated;

– it is possible and necessary to get ready before crises;

– crisis management requires the use of special approaches, special knowledge and skills.

Implementation of the policy of anti-crisis financial management of the enterprise when there is the threat of bankruptcy involves:

1. Constant monitoring of the financial condition of the enterprise in order to identify early signs of its crisis development.

2. Determination of the scale of crisis at the enterprise.

3. Research of the main factors that have caused crisis development of the enterprise.

4. Formation of the system of goals for crisis overcoming by the enterprise, which correspond its scale.

5. Selection and use of the current internal mechanisms of financial stabilization of the enterprise, corresponding to the scale of its crisis financial condition.

6. Selection of effective forms for the enterprise rehabilitation.

7. Control over the results of measures developed to withdraw the company from the financial crisis.

4. Conclusions

Considering the essence and objectives of bankruptcy prevention, most economists share the idea of its specificity. The main differences inherent in the prevention of bankruptcy are as follows:

– specificity of the purpose of implementation, i.e. preservation of the enterprise as a business entity and restoration of its viability;

– the use of specific management tools, i.e. tools and techniques of managerial influence; management cannot be reduced, e.g. to searching for reserves to increase labour productivity, reduce costs, find new markets, restructure assets and liabilities. These measures must be carried out constantly, regardless of the state of the enterprise, although in conditions of a crisis they become anti-crisis by their direction; achievement of certain tasks requires the use of non-standard, as well as unacceptable, in normal conditions, composition of management tools;

– separation of subjects of implementation who have the appropriate professional training, powers, knowledge and skills, take responsibility for the results of their activities;

– significant resource constraints related to impossibility or difficulty of obtaining additional resources, primarily financial, as attracting financial resources in conditions of low (even negative) creditworthiness and investment attractiveness is an extremely difficult management task;

– significant time constraints due to possible aggressive actions of the company's creditors and the threat of initiating bankruptcy and limiting the capacity of the current company's management;

– focus of management efforts not only on the external manifestations of complications and problems, but also on their deep roots (causes), which is an obstacle to the crisis recurrence;

– increased riskiness of management decisions made and implemented due to a high degree of instability (stress) of the economic system;

– increase in the importance of information and analytical support for management decisions, compared to relatively greater use of analytical-and-calculation and forecasting procedures;

– focus on minimizing losses of all stakeholders, including owners, staff, creditors, the state;

– implementation of innovative solutions, a creative approach to determining the type of behavior in a crisis situation and finding the ways out;

– ensuring high efficiency of managerial influence requires higher financial and intellectual costs, and therefore it has a higher cost compared to normal condition of business operation.

Bankruptcy prevention policy is part of the overall financial strategy of the company, which involves development of the system of methods for preliminary diagnosis of the bankruptcy threat and starting the mechanisms for the company's financial recovery to ensure crisis overcoming.

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ANALYTICAL PROVISION OF LAND RESOURCES MANAGEMENT OF THE ENTERPRISE: STATE AND IMPROVEMENT

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Abstract. The purpose of the paper are issues concerning to the analytical provision of land resources. *The methodological* basis of the study are general scientific and special methods of phenomena cognition and processes in the system of analytical support of land management. The study of the current state of land relations, classification of land resources is based on the use of methods of theoretical generalization, grouping and analogy. Methods of comparison, analysis and synthesis were used to prepare proposals for improving the analytical support of land management. *Results*. The composition and structure of Ukraine's land resources, their place in Europe, property relations and land use were evaluated in the course of research. It is determined that the land area of Ukraine as of 01.01.2020 according to the State Service of Ukraine for Geodesy, Cartography and Cadastre is 60.3 million hectares. The system of views on land resources as an object of analysis, tasks and purpose of analysis, sequence of analytical operations and procedures aimed at preparing for analysis, analytical data processing and generalization of analytical information are identified and formulated. The main sources of information for the analysis of land resources of agricultural enterprises are primary documents, synthetic and analytical data. Their combination in the process of analytical procedures will increase the value of information and management decisions made on its basis. The system of indicators of land resources analysis is considered. Particular attention is paid to indicators to assess the level of intensity of use and indicators that characterize the efficiency of land use. Analyzing the set of indicators

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that characterize the state of land resources of agricultural enterprises, it is emphasized the lack of a single methodology and uniform forms of documents to ensure a complete and comprehensive study of land resources. To eliminate this problem, a holistic methodological apparatus is proposed, in which the stages of analytical work are coordinated (obtaining, processing and analyzing information), sources and channels of information, as well as tools, methods, techniques of analysis that allow to obtain appropriate results. An important aspect that contributes to the effectiveness of such work is the choice of rational approaches and methods in accordance with the objects and needs of the analysis. SWOT-analysis of agricultural land use development is presented. Based on the SWOT analysis, it can be seen that development strategies in land use should be aimed at highly efficient use of land resources, to reproduce their fertility. Due to this, high yields of crops will be obtained with minimal costs per unit of output and preservation of productive properties of land. It is stated that it is necessary to anticipate ecological and economic responsibility of landowners and land users for deterioration of soil quality parameters, combination of public and private interests for sustainable land production, use of land resources taking into account community interests, prevision of measures to restore land productivity. *Practical implication* is the scientific validity and applied orientation of the provisions, approaches and recommendations given in this study, the use of which will improve the organizational and methodological foundations of the analysis of land resources. *Value/originality*. The use of SWOT analysis in the practice of land management entities, on the one hand, will help eliminate the weaknesses of land use while strengthening its strengths, on the other hand, will fully provide opportunities to take advantage of opportunities that may arise due to action of external factors avoiding threats. SWOT analysis has a significant impact on strategic management decisions aimed at the formation of rational agricultural land use.

1. Introduction

In modern economic conditions, information on the natural, legal and economic condition of the lands of Ukraine as the main national wealth of the people becomes important. Relevant information on land is necessary for further regulation of land relations, ensuring the rational use, restoration and protection of land, determining the amount of payment for land and its

value in natural resources, control over land use and protection, economic and environmental justification of business plans and land management projects.

The specifics of recognition and use of land resources as an economic category causes peculiarities in the construction of the accounting system, which requires a competent construction of the accounting policy of the enterprise in terms of reforming land relations in Ukraine. More than a third of agricultural land is used by state enterprises, so there is an urgent need for land accounting, the ability to accurately assess their value, elimination of abuses in land lease or use rights, the organization of effective and qualitative analysis of land resources.

A significant contribution to the formation of theoretical, organizational and methodological provisions of accounting and analysis of land resources was made by such domestic scientists and researchers as: S.M. Belinska, O.M. Bradul, B.S. Huzar, M.Ia. Dem'ianenko, I.V. Zamula, V.M. Zhuk, O.V. Ilchak, H.H. Kireitsev, A.S. Krutova, N.M. Maliuha, T.V. Mashkova, T.P. Ostapchuk, S.M. Ostapchuk, P.T. Sabluk, E.O. Sysak, L.K. Suk, V.K. Savchuk, I.D. Lazaryshyna, T.O. Mulyk and others. However, the problematic issues of development of accounting and analytical support of economic relations in the field of land use, which remained unnoticed by these scientists, need their solution in order to develop a comprehensive system of accounting and analysis of land resources in terms of resource conservation.

The purpose of this study is to summarize the theoretical and practical aspects of the current system of analytical support for land management. The following tasks were solved in the course of the research: characteristics of land resources of Ukraine, assessment of the organization and methods of land resources analysis, determination of land use development strategy based on SWOT-analysis.

The methodological basis of the study are general and special methods of cognition of phenomena and processes in the system of analytical support of land management. The study of the current state of land relations, classification of land resources is based on the use of methods of theoretical generalization, grouping and analogy. Methods of comparison, analysis and synthesis were used to prepare proposals for improving the analytical support of land management.

2. General data on Ukraine's land

Land resources are an important component of the resource potential of agricultural formation, which in addition to land includes labor resources, fixed and current assets, etc. The available resource potential, its qualitative properties and rational combination in the process of economic activity are the initial prerequisite for the production of competitive products. In addition, on the basis of its use, the food, production, export, natural resources and infrastructure bases of balanced socio-economic development of the country are formed [1].

For the Ukrainian people, land has always been of great value. The importance of the earth is evidenced by the fact that it is not a product of human labor, but created by nature, and therefore at the request of man cannot increase its reserves. That is why the Constitution of Ukraine (Article 14), the Land Code of Ukraine (Article 1), the Civil Code of Ukraine (Article 373) states that land is the main national wealth and is under special protection of the state.

As of January 1, 2020, the land area of Ukraine according to the State Service of Ukraine for Geodesy, Cartography and Cadastre is 60.3 million hectares (Figure 1).

Among them: 1) agricultural lands occupied 41,310.9 thousand hectares or 68.5% of the total area of the country, including: a) arable land – 54.2% of the total area of the country or 79.1% of the area agricultural lands; b) hayfields – respectively, 3.8 and 5.5%; c) pastures – 8.8 and 12.8%; d) perennial plantings – 1.4 and 2.1%; e) fallows – 0.3% of the total area of the country or 0.5% of the area of agricultural land; 2) forests and other wooded areas – 10,686.8 thousand hectares (17.7%); 3) built-up lands – 3,767.5 thousand hectares (6.2%); 4) land under water – 2,415.4 thousand hectares (4.0%); 5) open wetlands – 973.8 thousand hectares (1.6%); 6) other lands – 1,200.5 thousand hectares (2.0%).

As evidenced by the data presented in Figure 1. Currently, Ukrainians cultivate about a third of the arable land in Europe, or 32.7 million hectares. Also, one inhabitant of Ukraine in the statistics has twice as much as one European.

As evidenced by the data presented in Figure 2, in the structure of land ownership the main amount of land is privately owned, it is about 31 million hectares, in state and municipal ownership are 10.4 million hectares. At the same time, about a third of the land, 32.7 million hectares is under arable land.

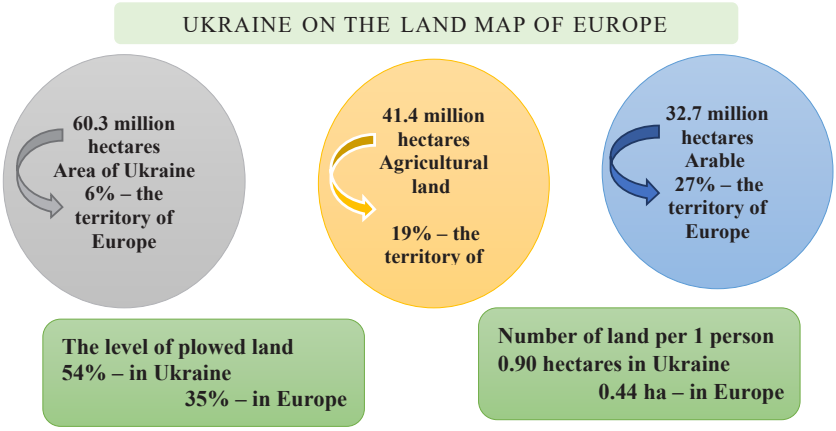

Figure 1. Ukraine on the land map of Europe

Source: formed on [3]

3. The order of organization and methods of analysis of land resources

In the economic literature, many concepts are used regarding the evaluation and monitoring of the enterprise, which facilitate the adoption of various management decisions. Namely, the terms "analysis", "analytics", "analytical activities", "analytical work", "analytical support", etc. are used [4].

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The issue of organizing and ensuring a comprehensive analysis of land resources in agricultural enterprises is an important topical issue, the importance of which is growing in the context of land reform. Accordingly, the analysis of land resources requires the development of thorough methodological support aimed at systematizing the data sets required for use in the analysis process, as well as the use of appropriate methods and techniques aimed at providing this information the necessary form [6].

Unfortunately, currently there is a rather low organizational and methodological of its implementation, in particular:

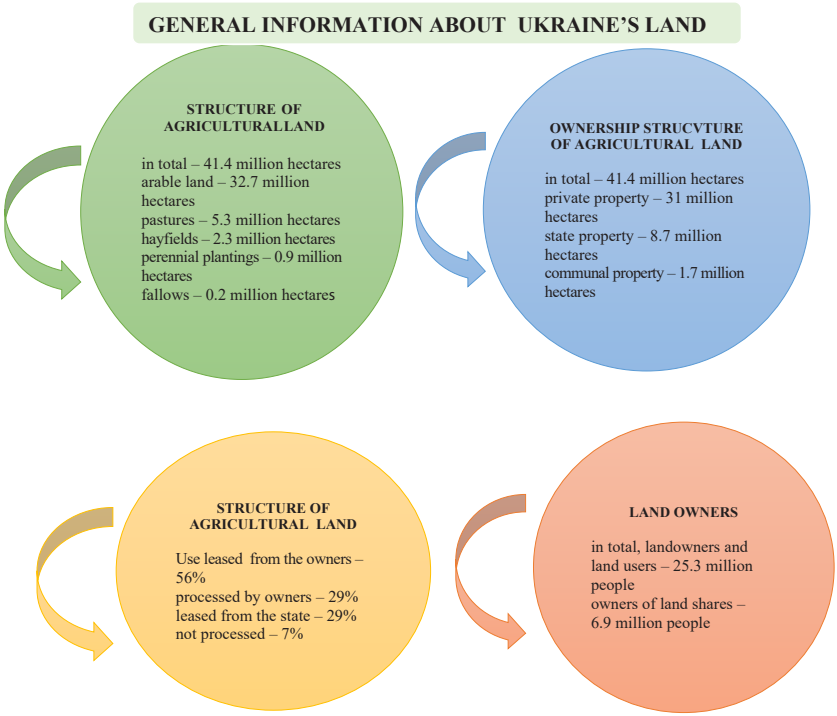

Figure 2. General data on Ukraine's land

Source: formed on [3]

– analysis of land use and production of agricultural products in farms of all forms of ownership is conducted according to the annual accounting and statistical reporting. Orientation in analytical activities on the materials of such reporting does not contribute to its effectiveness, because it makes it impossible to influence the results of activities;

– the analysis of land use is of a generalizing nature, is conducted without taking into account the economic and qualitative characteristics [quality] of soils;

– there are no methods of analysis of the land use efficiency in newly created forms of farms, existing (for large farms) are not suitable for this purpose;

– there is no long-term analysis of the transformation of land, the level of their fertility in order to determine the strategy of agricultural enterprises at all levels of government and choose the most optimal ways to ensure the required volume of production and quality of crop products;

– there is no operational analysis of the consumption of energy, material and labor costs for the production of agricultural products;

– insufficient level of use of advanced express methods and computer equipment in assessing the efficiency of land use and agricultural production.

The problem of organizing a comprehensive analysis of land resources has quite thorough methodological support, which is at the intersection of interests of different scientific fields and areas. However, the main problem of ensuring efficient and rational use of land resources in agricultural production is complex and consists in the absence of a clear information system of research and notification of subjects of land relations, shadowing of land relations in much of the land market, as well as lack of a holistic balanced system of economic analysis, able to provide the management staff of enterprises with relevant information of appropriate volume and content in accordance with the production and management tasks facing enterprises today. Accordingly, we agree with the opinion of T. Ostapchuk that "today there is no single, sufficient and effective methodology for analyzing the use of land resources of enterprises" [7].

The expediency of finding ways and methods to improve their accounting and management is due to the identification of land resources from the standpoint of their limitation. Herewith, an important task is to assess the dynamics of land resources and structures that can contribute to a better understanding of land use processes, formulating their impact on the performance results of economic entities and finding reserves to improve economic indicators.

Tasks of land resources analysis are as follows [8]:

– study of the composition and structure of land;

– detection of violations in land use;

– identification of reserves for expansion and improvement of land;

– assessment of the efficiency of land use and development of measures aimed at its improvement.

The purpose of the analysis [8]:

– comprehensively promote the fullest and most efficient use of land while constantly increasing natural fertility and preventing damage to the environment.

The most important components of the analysis of land use are [8]:

– determining their composition, size and structure and ways to improve them;

– study of the degree of use of arable land and justification of their expansion (reduction), the availability of scientifically sound crop rotations and the level of their development;

– determining the efficiency of land use and opportunities to improve it.

The formation of a methodological basis for the analysis and balancing of the system of land use indicators requires, above all, a comprehensive understanding of the object of study in all its manifestations. Diverse and equitable research of land resources creates additional opportunities for the formation of a fundamentally new vision of the problem. The basis for this technique is laid through a clear identification and structuring of the object of study. In our case, the main category – land resources, should be studied as a system that can be considered from such positions as [6]: the object of circulation; object of use; object of management; object of economic regulation (Figure 3).

The considered structuring of views on land resources as an object of analysis reveals the subsystems and areas that need research and within which reserves can be formed to improve both the resources themselves and their management systems. Herewith each of these subsystems and areas can be detailed at a lower level of knowledge, according to which, the overall purpose of the analysis of land resources needs to be specified in the form of clearly defined and structured tasks [6].

Achieving the goal of the study and solving its problems involves purposeful work, which is primarily associated with the formation of a comprehensive system of indicators. The importance of systematization in this aspect is quite accurately described by G. Andreeva and V. Andreeva, who, emphasizing the importance of the interdependence of indicators that reflect economic processes, argue the need "…that specific data in different activities were organically linked between itself in a single integrated system" [9]. O. Hutorov speaks in a similar way, noting that "the efficiency of land use cannot be characterized by any one indicator, as the process of

use land is multifaceted, determined by many natural and economic factors. In this regard a system of indicators is needed [10].

I.S. Kozubenko and D.V. Dudnik propose to use a methodology based on the use of effective indicators of efficiency and intensification of agricultural land use, which should include: natural indicators of intensification, which characterize the yield per unit of land area; natural indicators that characterize the growth of production over a period of time per unit area; economic indicators that characterize the ratio of the value of gross output from 1 hectare of land to fixed assets of the organization; economic indicators that characterize the cost of production; economic indicators that characterize the output of gross and net income per hectare of agricultural land, etc.; economic indicators that characterize the ratio of gross output per 1 ha to costs per 1 ha [11].

Based on the conducted research and generalizations, the lack of a unified approach to the formation of such a system of indicators was revealed. In most scientific papers there was a different vision not only of the set of indicators and their content, but also their different classifications and characteristics. Therefore, based on the developed sources, we propose a system of indicators of land resources analysis, formed on the basis of their impact on the object of study (Figure 5). In most of the studied scientific works there was a different vision not only of the set of indicators and their content, but also of their different classification and characteristics.

The structuring of indicators is based on the nature and methods of obtaining indicators. Thus, the indicators that characterize the structure reflect the amount of land resources and their structure in various respects relative to the general level. At the same time, they can acquire the state of quantitative, relative and cost indicators. To the same group we have included indicators of land use intensity and land supply [6].

Indicators that characterize productivity reflect the ratio of output per unit area. Herewith, some indicators of this group can be expressed through natural, and some – through variant values. Indicators that characterize efficiency include a comparison of the results obtained through the use of land resources and costs incurred. They can acquire absolute and relative values. The last group of indicators characterizes the sustainability of land use, which is revealed through environmental aspects, soil quality and rational use of nature. It contains absolute, relative and qualitative indicators [6].

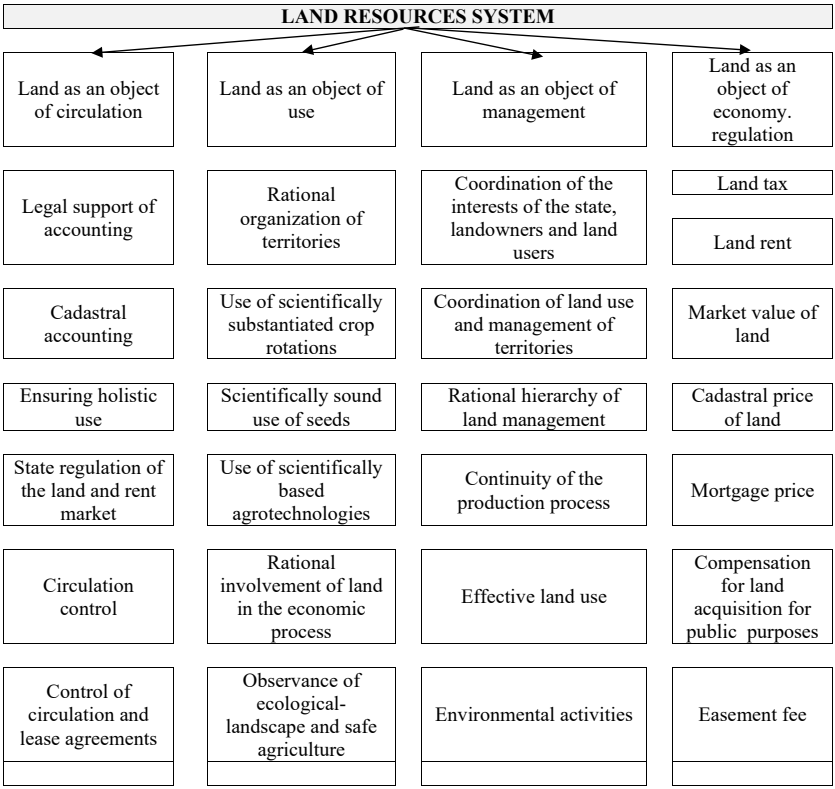

Figure 3. The system of views on land resources as an object of analysis

Source: [6]

Note that in many scientific sources [7; 15] indicators of land productivity are not allocated to a separate group. The obtained results of economic activity, based on a certain area are characterized as an indicator of efficiency (for example, the volume of gross output per 100 hectares, etc.). Moreover, Belinska S.M. believes that productivity is one of the manifestations of efficiency and characterizes its relative importance [15]. At the same time, she emphasizes the need to apply a productivity indicator in relation to resources that have a limited market position. Accordingly,

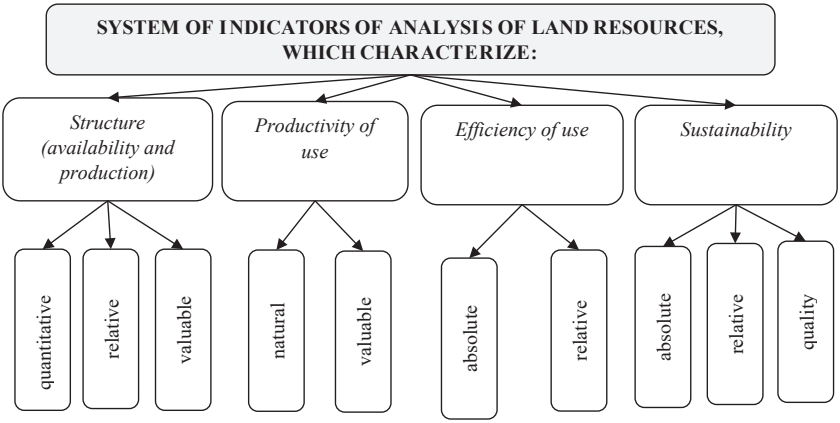

Figure 4. The structure of indicators of land resources analysis

Source: systematized on the basis of [10; 12; 13; 14]

it is proposed to logically distinguish between productivity and efficiency of land use. Herewith, productivity is calculated as the volume of return of land resources per unit area, and efficiency – as the ratio of the result obtained per unit area to the amount of cost of tangible and social labor [15].

We believe that the level of land use intensity should be determined by the following indicators (Figure 5).

When analyzing and evaluating these indicators, it should be remembered that due to the transformation of land and improving their structure, increasing (decreasing) the share of arable land, perennial cultural plantations and reclaimed lands in the total area of agricultural land, and intensive crops – in the structure of crops, increasing the reuse rate of land to optimal levels of the company's ability to increase production (other things being equal) will increase. But here it is important not to go beyond the rational limits of each of these indicators, as this may lead to deterioration of land use, loss of its fertility. For example, excessive plowing of agricultural lands in many farms has led to the intensive development of wind and water erosion with all the corresponding negative consequences [16]. living and tangible work, the effectiveness of selection, etc.

There are the following types of land use efficiency: technological, economic, social, environmental (Table 1).

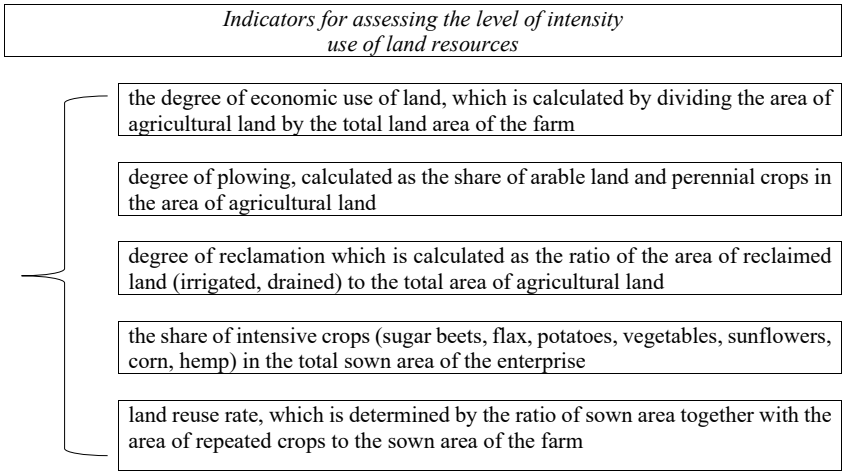

Figure 5. Indicators for assessing the level of land use intensity

Source: formed by the author based on [13]

Table 1

Indicators characterizing the land use efficiency

Types of efficiency	Indicators studied during the analysis
Technological	yield, yield of certain types of crop and livestock products per unit area of relevant land (production of milk, meat of all types per 100 hectares of agricultural land; production of grain, pork per 100 hectares of arable land), feed production (in quintals of feed units)) per 100 hectares this year lands.
Economic	gross output, cash receipts, profit from sales of agricultural products per 100 hectares of agricultural lands.
Social	the level of payment of the company's employees; the amount of wages per 1 ha of agricultural lands; rent for land share, its relation to the monetary valuation of land; timeliness of settlements with landlords.
Ecological	production of ecologically clean products, dynamics of humus content, harmful substances in the soil, prevention of erosion processes, rates of restoration of natural soil fertility, etc.

Source: formed by the author based on [13]

When assessing economic efficiency rely on:

– natural and cost indicators (Table 1).

Natural indicators include:

– crop yields;

– production of certain types of livestock products per 100 hectares of relevant land (livestock and sheep products are expected per 100 hectares of agricultural land, pigs – on arable land, poultry – on the area of cereals),

– yield in fodder units from 1 ha of individual lands

– density of cattle, per 100 ha. [16].

The cost indicators include:

– gross output;

– production of marketable products (separately crop, livestock products);

– net income per 1 ha (per 100 ha) of agricultural land;

– profit per 1 ha (per 100 ha) of agricultural land [13].

The analysis of land use efficiency indicators should be carried out in the following sequence:

– their dynamics is studied,

– implementation of the plan for their level,

– inter-farm comparative analysis is carried out;

– factors and reserves for improving the efficiency of land use are identified [16].

4. Development of agricultural land use based on SWOT-analysis

The problem of agricultural land use is key to ensuring the development of the agricultural sector of the economy, which emphasizes the need to create a favorable environment for improving the efficient use of agricultural land and ensuring the rapid growth of productive forces. The SWOT analysis matrix is a universal tool, and its subject can be any entity, economic activity or economic activity of business processes. We agree with them, although perhaps it would be worthwhile to add to these ways such as improving the planning system of agricultural land use development at the regional and local levels, after all the need for this is due to environmental goals first at regional levels, and then in the country. [17].

The crisis situation in agricultural land use is primarily related to the successful solution of the food problem, achieving the appropriate level of environmental security and determining measures to protect and increase

land fertility. It is necessary to learn in the future to use SWOT-analysis in the process of strategic planning of land use and implementation of guidelines for the development of agricultural land use [17].

Strategic planning in agricultural land use should take into account the use of agricultural land, in which it will be considered effective.

The efficiency of land use and efficient use of land resources are not identical, but they are based on the concept of rationality. Thus, Trehobchuk V. believes that the essence of rational use of agricultural land is to obtain high sustainable yields of crops while minimizing unit costs, maintaining and increasing the productive power of land as an agricultural resource, its protection and defense as part of the environment, reproduction of useful properties soil cover [18].

Mertens V. understands the rational use of land – the maximum involvement in the economic circulation of all lands and their effective use for the main purpose, creating the most favorable conditions for high productivity of agricultural land and obtaining from a unit of land the largest number of products with the lowest labor costs [19].

Klymenko A. believes that the efficient use of agricultural land is a balanced, scientifically sound, planned, taking into account the long-term interests of society, land use, according to which they get the maximum benefit with minimum costs [20].

We must agree with V. Ulanchuk and L. Alyoshkina who believe, that the efficient use of land resources in agriculture should be understood as a socio-economic category that depicts the relationship between people in the process of technological production processes related to agricultural production, in order to best meet the needs of the population in food to ensure the restoration of natural soil fertility, increase the productive potential of land resources and their use in a high level of environmental friendliness of both these resources and the environment as a whole [21].

The efficiency of agricultural land use to some extent depends on the level of profitability of agricultural enterprises, but their financial interests should not lead to a deterioration in the properties of land resources as the main means of production in agriculture [22].

Harazha O.P. believes that efficiency establishes causal relationships of production. Moreover, it provides a description of the price of achieving a certain result, and not to the result itself [23].

Thus, the problem of efficient use of agricultural land in Ukraine is becoming increasingly complicated. Today it has various aspects, the main of which are economic, organizational and environmental. The level of land use in Ukraine today is so critical that further degradation of the potential of land resources in agriculture can have catastrophic consequences, which will undoubtedly affect the overall level of food security of the country, the health of the nation.

Given the above, it is advisable to implement systems of balanced and rational land use and improvement of agricultural landscape management methods. Priority tasks in this area may be: protection of soils from erosion (construction of anti-erosion hydraulic structures), performance of hydro-ameliorative works; solving the problem of chemical reclamation of acid soils; gradual withdrawal from intensive cultivation of unproductive and degraded lands with their subsequent conservation or reclamation; ordering the existing ratio of land, first of all, reducing the share of arable land; establishing a single system of monitoring land resources, which would meet European requirements and comprehensively control environmental and agrochemical indicators and the use of soil resources using modern technologies [24].

As for the planning of measures to preserve and restore soil fertility, they are almost not implemented, which is due to both the lack of funds for the purchase of organic fertilizers and the lack of manure produced on the own farms. That is why the situation in land use is such that unproductive and degraded lands are in economic circulation. Nobody and nothing controls the use of exhausting technologies in the production and cultivation of agricultural products. Also, private landowners are not provided with material means for conducting agrochemical surveys [Smirnova S.M., Biriukova 95].

The review of the internal and external environment is an important part of the strategic development of agricultural land use. Factors of the internal environment of the enterprise are usually classified as Strength (S) or Weakness (W) and, accordingly, environmental factors can be classified as Opportunities (O) and Threats (T) [17].

The acronym SWOT was first introduced in 1963 at Harvard at a conference on business policy by Professor Kenneth Andrews. Initially, the SWOT analysis was based on the image and structuring of knowledge about the current situation and trends [25].

In 1965, four Harvard University professors, Edmund P. Learned, C. Roland Christensen, Kenneth R. Andrews, and William D. Huth, proposed the technology to use the SWOT models to develop a firm's behavior strategy. The LCAG scheme (based on the initials of the authors' surnames) was proposed, which is based on a sequence of steps leading to the choice of strategy.

Strengths;
Weaknesses;
Opportunities;
Threats.

This acronym can be represented as a table:

Table 2

The structure of the SWOT analysis table

	Positive impact	**Negative influence**
Internal environment	Strengths	Weaknesses
Environment	Opportunities	Threats

The traditional method of SWOT – analysis allows for a detailed study of the external and internal environment. The result of rational SWOT-analysis aimed at the formation of generalized information potential should be effective decisions regarding the corresponding reaction (influence) of the subject (weak, medium and strong) according to the signal (weak, medium or strong) of external environment.

A distinctive feature of this approach to SWOT-analysis at the enterprise is as follows:

1. Its construction is based on the methodology of the system-target approach, where the main attention is focused on measuring the parameters of the external and internal environment in space, time and taking into account the information potential.

2. Structuring the factors of external and internal environment that are universal for any enterprise.

3. Implementation of the synthesis of external and internal factors, which in future, will be reflected in the system of decisions.

The company's strengths are designed to ensure its rapid progress towards strategic goals, while its "weaknesses" cause inhibition. It is also

natural to take into account the opportunities and threats of the external environment, without which it is impossible to correctly determine the development scenarios of the organization.

Validity is a property of the organizational system, which in the case of synthesis with the capabilities of the external environment provides accelerated progress of the system to achieve strategic goals. Of particular interest is the formation of a "spiral of development" – a trajectory formed by "overlapping" (synthesis) of the strengths of the organizational system on the favorable capabilities of the external environment (taking into account the weaknesses of the organizational system and threats to the environment).

Weakness is a negative property of the organization, which determines its inhibition in the moving process to achieve strategic goals. Inhibition becomes essential when merging (synthesizing) the main weaknesses of the organizational system with significant threats to the environment. At the same time, the strengths of the company and the opportunities of the external environment cannot be ignored. This is how the variant of the pessimistic scenario of the organization's development is formed. Such a scenario can be transformed into a "spiral of collapse" if there is a tendency ("domino effect") to weaken opportunities and strengths, on the one hand, and increase threats to the environment in connection with the growing weaknesses of the organization.

Opportunities are trends or events in the external environment, with the right response to which the organization seeks significant progress towards its strategic goals.

Threats are trends or events in the external environment that, in the absence of an appropriate response from the organization, cause a significant deterioration in the state of the organization on the way to implementing its plans.

Since the 1990s, a fuzzy SWOT analysis has been used in the strategic planning process, which consists in dividing factors and phenomena into categories: strengths and weaknesses of the project, opportunities that open up in its implementation, and threats associated with its implementation. Traditional mathematical methods based on classical logic are intolerant of inaccuracies and biases of truth, as well as uncertainty in economic systems. In turn, the uncertainty of the system leads to increased risks of ineffective decisions, which can result in negative economic consequences. To this end, there is a need for methods based on fuzzy logic.

We will conduct a SWOT-analysis of the development of agricultural land use (Table 3).

Table 3

SWOT-analysis of agricultural land use development

Strengths	*Weak sides*
1	**2**
– Synergetic effect of the interaction of economic, environmental and social spheres; – measures to increase soil fertility, its restoration; – organic farming; – expansion of perennial grasses; – protection of soils; – automated maintenance of the state land cadastre; – effective state control over land use and protection; – land monitoring; – investment attractiveness of agriculture; – preservation and increase of flora and fauna; – ecological and landscape organization of rural areas; – implementation of scientific, technical and technological achievements; – conservation of degraded agricultural lands; – control by state bodies over compliance with current legislation; – optimization of land use by establishing economic and environmental relations; – concentration and consolidation of agricultural land uses; – creation of food clusters; – financing of land protection measures; – state support of agriculture through subsidies; – state regulation of land use; – environmentally friendly production; – compliance with environmental standards of anthropogenic pressure on land resources; – minimum tillage; – investment activities in agricultural development; – agrochemical certification of agricultural lands; – availability of ecological passports of land plots, etc.	– Tense ecological situation; – washed away, salinity, waterlogging of soils; – resource-intensive production; – violation of biological balance in nature; – lack of scientifically sound planning; – outdated land valuation data; – lack of soil protection measures; – unbalanced ratio of lands; – lack of long-term land planning; – reduction of agricultural land productivity; – unjustified transfer of land to other categories; – irrational use of land resources; – limited access to markets; – imperfect information on the state of land use management; – lack of development of an automated system of state land cadastre; – unsatisfactory budget financing of land management measures; – imperfection of state land management; – excessive plowing of the soil cover; – lack of a balanced strategy for land use development

(End of Table 3)

Opportunities	*Threats*
– Strategic land management; – production of high quality food; – ecological balance of agricultural production; – compliance with environmental safety standards; – use of plant residues as fertilizers; – optimization of the structure of sown areas of agricultural crops; – improving the legislative and regulatory framework; – creating favorable conditions for sustainable development; – economic stimulation for rational land use; – raising the level of public consciousness on land use and protection; – introduction of an effective system of informing the population; – increasing competitiveness in domestic and foreign markets; – penalties for soil contamination; – increase the profitability of agricultural production; – growth of incomes of agricultural producers; – transition to resource-saving technologies; – use of innovative biological means of pest control; – land management development; – reclamation of disturbed lands; – environmentally friendly use of land resources; – taking into account the regional features of agricultural production; – increasing the competitiveness of agricultural products; – attracting investment in the agricultural sector of the economy; – introduction of resource-saving and safe technologies; – responsibility of local authorities for evading environmental problems; – dumpless tillage	– Anthropogenic impact on land use; – processing of products without compliance with environmental requirements; – expansion of areas under humus-consuming crops; – unregulated production processes; – lack of land use and soil protection programs; – corruption schemes in the field of land lease relations; – use of pesticides and mineral fertilizers; – violation of crop rotations; – reduction of humus content in soils; – soil contamination with pesticides and chemicals; – lack of legislative support for greening of agricultural land use; – intensification of degradation processes in the soil; – pollution of lands with sewage and atmospheric emissions; – imperfection of state management of land resources and land use; – imperfect land market infrastructure; – unsatisfactory use of reclaimed lands

Source: [17; 25]

The SWOT analysis provides information that can help an agricultural enterprise use its resources and opportunities in the competitive environment in which it operates. As such, it plays an important role in the development and selection of strategy.

The SWOT-analysis technique allows to assess the company's risks and opportunities as fully and in detail as possible, to plan the current production strategy:

The analysis of the external market environment of goods or services in terms of external and internal factors iscarried out.

Based on the analysis, the strengths and weaknesses of the business, threats and market opportunities for business are formed.

The obtained parameters are entered into the SWOT-matrix for ease of analysis.

On the basis of the SWOT-matrix conclusions about necessary actions with the specified priorities of performance and terms are formed.

Classical analysis also involves the assessment of each of the factors in points relative to industry averages or in relation to the data of strategically important competing enterprises [27].

A significant list of preliminary data is needed to determine the relative importance of each of these SWOT factors. Objects within each factor must be arranged to significance, that is, the most important force will come first, then the second, and so on [28].

The development of agricultural land use should be based on a fundamentally new approach to forecasting the state of the environment – the allocation of strategic management zones and strategic economic centers. An important feature of the development of agricultural land use is the analysis of both the external environment and internal capabilities of the region. Each reference point for complex socio-economic development depending on the state of the environment. That is, several strategic alternatives should be developed taking into account possible situations in the future [17].

To successfully conduct a SWOT analysis, it is important to develop a concept of rational land use, which should be based on an objective vision of the future. Therefore, in order to implement the strategy of further development of land use, a matrix of SWOT-analysis was presented, which shows the strengths and weaknesses in agricultural land use (Table 3).

Considering the strengths as possible areas of rational land use, and the weaknesses as potential areas of action to eliminate them, it is necessary to identify priority areas for their strategic development.

In order to avoid possible mistakes in practice and get the most out of SWOT analysis, you need to follow a few basic rules:

– to specify the scope of SWOT-analysis as much as possible;

– adhere to the correctness in assigning a factor to strengths / weaknesses or opportunities / threats;

– SWOT-analysis should show the real state and prospects of the agricultural enterprise in the market, not their internal perception, so strengths and weaknesses can be considered as such only if they (or their result) are perceived by external buyers and partners;

– the quality of SWOT-analysis directly depends on the objectivity and use of diverse information;

– extensive and ambiguous wording should be avoided [17].

The introduction of SWOT analysis in the practice of land management, on the one hand, will helpto eliminate the weaknesses of land use while simultaneous strengthening its strengths, on the other hand, take full advantage of opportunities that may arise from external factors, avoiding threats.

Therefore, there is reason to believe that the SWOT analysis has a significant impact on strategic management decisions aimed at the formation of rational agricultural land use.

5. Conclusions

In the process of research the composition and structure of Ukraine's land resources, their place in Europe, property relations and land use were assessed. The sequence of analytical operations and procedures aimed at preparation for analysis, analytical data processing and generalization of analytical information is highlighted and formulated. The main sources of information for the analysis of land resources of agricultural enterprises are primary documents, synthetic and analytical data. Their combination in the process of analytical procedures will increase the value of information and management decisions made on its basis.

Analyzing the set of indicators that characterize the state of land resources of agricultural enterprises, it is emphasized the lack of a single

methodology and uniform forms of documents to ensure a complete and comprehensive study of land resources. To eliminate this problem, a holistic methodological apparatus is proposed, in which the stages of analytical work (obtaining, processing and analyzing information), sources and channels of information, as well as tools, methods, techniques of analysis that allow to obtain appropriate results are coordinated. An important aspect that contributes to the effectiveness of such work is the choice of rational approaches and methods in accordance with the objects and needs of the analysis.

SWOT-analysis of agricultural land use development is presented. Based on the SWOT analysis, it can be seen that development strategies in land use should be aimed at highly efficient use of land resources, to restore their fertility. Due to this, high yields of crops will be obtained with minimal costs per unit of output and preservation of productive properties of land.

It is indicated that it is necessary to anticipate the ecological and economic responsibility of landowners and land users for deterioration of soil quality parameters, combination of public and private interests regarding sustainable land production, use of land resources taking into account community interests, prevision of measures to restore land productivity.

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CURRENT TRENDS AND PROBLEMS OF THE MARKET OF CIVIL LIABILITY INSURANCE OF VEHICLE OWNERS AND WAYS TO SOLVE IT

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Abstract. Insurance in general and civil liability insurance, as part of it, is an infrastructure that helps increase the efficiency of all areas of business. This determines the importance of the development of all types of insurance in Ukraine, taking into account the process of Ukraine's integration into the world community. The development of insurance business in our country should be based on the study and balanced use of experience of industrialized countries with long traditions of insurance market organization, legal regulation of insurers and diversification of various types of insurance [2].

The world community, however, has invented a universal means of redress, which is the most popular type of liability insurance worldwide – civil liability insurance for owners of land vehicles. It provides for the payment of monetary compensation to the victim in the amount that would be collected from the owner of the vehicle on a civil claim in favor of a third party for damage to life and health, as well as for damage or loss of property due to an accident or other road -transport (accident) due to the fault of the insured.

Given the state and prospects of motorization in our country, as well as foreign experience in insurance, we can say with confidence that liability insurance is one of the leading areas among other types of insurance. However, in its organization and implementation there are many different problems of legal, social, economic and organizational nature.

The subject of the study is the economic relations that arise in the protection of property interests of persons injured in traffic accidents caused by the fault of the insured.

The purpose of the work is a theoretical and practical study of the features of civil liability insurance of vehicle owners and determine on this

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basis the problems and prospects for the development of motor insurance in our country.

In accordance with the set goal, the following tasks were identified: to determine the economic essence and benefits of civil liability insurance of vehicle owners; to consider the experience of foreign countries in the field of liability insurance and the possibility of its introduction in Ukraine; to analyze the current state of motor insurance in Ukraine; identify problems of development of civil liability insurance of vehicle owners in Ukraine and predict the directions of their solution, taking into account foreign experience; provide proposals to improve the efficiency of insurance activities.

The scientific novelty of the obtained results is the substantiation of theoretical and methodological bases of strategic development of civil liability insurance of vehicle owners in Ukraine, which allowed to obtain practical and theoretical results that contain scientific novelty, in particular: generalized features of comparative characteristics of liability insurance , property insurance and personal insurance and on the basis of the analysis the essential differences of liability insurance from other branches of insurance are defined that allows to state definitively that liability insurance is an independent branch of insurance; proved a specific feature of liability insurance, which is that the object of insurance is not specific personal property of a citizen or organization, as in property insurance, and the occurrence of events related to life or ability to work of a citizen who entered into a contract, which is typical for personal insurance, and liability to third parties. Thus, the direct object of liability insurance is the economic interest of potential victims, who in each insured event finds a specific monetary expression; the necessity of digitalization of the liability insurance industry is substantiated. Based on the study, it is proved that marketing innovations in motor insurance relate to new sales channels. Today, such a sales channel is the online sale of insurance products, which allows the insured to draw up a contract online, choose the functions that belong to him and pay insurance premiums. At the micro level, innovative development is seen as the process of implementing innovative solutions by insurers that help strengthen their competitiveness, create a unique insurance product for each policyholder individually, improve insurance services and more.

Practical significance of the obtained results is to develop and provide recommendations for improving the civil liability insurance of vehicle owners, taking into account the experience of foreign countries.

1. Introduction

Motor insurance is associated with profound economic and social changes taking place in society due to mass motorization, the growth of the car fleet and traffic intensity, as well as huge material losses as a result of road accidents. Road transport is an accessible, convenient and still the most dangerous mode of transport: according to the WHO, about 1.3 million people die in road accidents in the world every year – a constant number since 2007 [7].

Freight transportation is developing rapidly both within the country and in international traffic. The number of intercity bus transportation, excursion and tourist bus services is increasing, international motor tourism is growing. All this will increase the number of accidents, losses in the transportation of goods, accidents with passengers and pedestrians on highways and, accordingly, material and social losses of society, population, commercial and government agencies.

Liability insurance is the youngest branch of insurance. Its essence is that the insurer undertakes to reimburse the damage caused by the insured to a third party or group of persons.

Liability insurance does not cover own damage, but damage that the insured person caused to another person. Civil liability is of a property nature: the person who caused the damage is obliged to compensate the damage in full to the victim, ie a third party. When concluding a civil liability insurance contract, this obligation is transferred to the insurer, but the insured is not released from criminal or administrative liability for damage to a third party.

Liability insurance has emerged as an independent industry relatively recently. Currently in Ukraine this branch of insurance is just beginning to develop. Abroad, liability insurance has received much stronger development, and the percentage of premiums for this type of insurance is even higher than for property types. The reason for the development is that liability insurance provides protection of important socio-economic phenomena and aims to ensure a high standard of living and well-being of the population [3].

A special place in liability insurance is occupied by civil liability insurance. The peculiarity of civil liability insurance is that, unlike others, the sub-sector plays a dual role – on the one hand it protects the insured, because it is he who can violate their obligations, which can cause harm to others or their property, on the other parties – liability insurance protects

persons and property that are not even specified in the insurance contract from damage that the insured may cause them [1].

2. Comparative analysis of liability insurance and property and personal insurance

A specific feature of civil liability insurance is that the object of insurance is not specific personal property of a citizen or organization, as in property insurance, and the occurrence of events related to life or ability to work of a citizen who has a contract, which is typical for personal insurance and liability to third parties. Thus, the direct object of liability insurance is the economic interest of potential victims, who in each insured event finds a specific monetary expression [9].

The liability insurance mechanism is as follows (Figure 1).

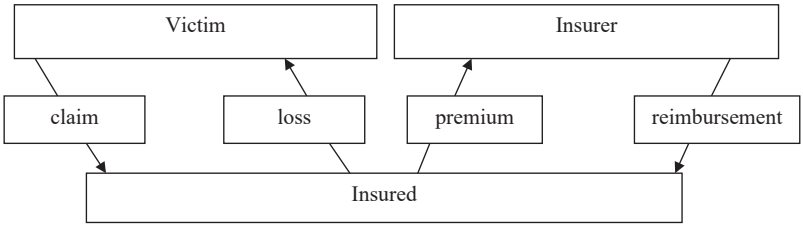

Figure 1. Liability insurance mechanism

In Ukraine, the branch of civil liability insurance, unfortunately, has not received the appropriate level of elaboration by scientists, so the information and practical base of research on the development of this topic is imperfect.

Consider the characteristics of property, personal insurance and liability insurance (Table 1).

The study of the essential features of liability insurance allows us to state that they are inherent only in this field of insurance. Therefore, liability insurance cannot be considered a type of property insurance or considered as a conglomeration of property and personal insurance. The listed features of liability insurance allow to allocate it as one of representatives of independent branch of insurance.

Thus, given all the above, liability insurance is an independent branch of insurance, which differs from both property insurance and personal insurance.

Table 1

Comparative characteristics of property insurance, personal insurance and liability insurance

Sign	Types of insurance		
	Property insurance	**Personal insurance**	**Liability insurance**
The purpose of insurance	Protection of the material condition of the insured	Protection of property interests of the insured and the insured; preventing a critical deterioration in people's living standards	insurance protection of property interests of possible perpetrators of damage, which in each given insured event finds its specific monetary expression
Insurance functions	Protecting the interests of the client (insured)	Protecting the interests of the client (insured, insured)	Protection of the interests of both the client and the average citizen (third party)
Subjects of insurance legal relations	insurer and insured (individuals and legal entities)	Insurer, policyholder and insured person (individual)	Insurer, the insured and a third party who is unknown and in whose favor the agreement is concluded
Subject of insurance	Property of the insured	Life, health, ability to work of citizens as an individual, ie his personal interests	Property, life, health, ability to work of a third party; financial position of the insured
Object	Pre-determined property (in its various forms) for a pre-determined amount; Property interests of the insured	Life, health and ability to work of citizens; Property interests of the insured and the insured	the property interest of the insured is expressed in monetary form, which is manifested in the insurance of his civil liability to third parties who may be harmed; property interests of third parties
Sum insured	The actual value of insurance facilities or part thereof	It has a mathematical definition and depends on the economic situation in the country	Reimbursement limit (reimbursement limit)

(End of Table 1)

Sign	Types of insurance		
	Property insurance	**Personal insurance**	**Liability insurance**
Property interest	Determined at the time of the contract	Determined at the time of the contract	cannot be determined at the time of concluding the insurance contract, and is only a conditional reflection of the potential amount of possible damage, while the fulfillment of the insurance obligation by the insurer does not release the insured from the need to compensate the victim directly in case of insufficiency
Indemnified damages	Material damage	Damage to the life and health of the insured	Both material damage and damage to life and health of third parties
Insurance case	Destruction or damage of the insured property	Death, loss of health and disability of the insured	The actual occurrence of liability of the insured, established by the courts or voluntarily recognized by the insured
Payment amount	In the amount of the sum insured	In the amount of the sum insured	In the amount of damage, but not more than the limit of liability of the insurer. The amount exceeding the limit of liability of the insurer is paid by the insured.
A person who receives insurance compensation	insurer	insurer or insured	The third person (or his successor) suffered from the harmful actions of the insured

Source: generated by the author [5; 6]

The development of civil liability insurance affects not only the quality of a particular insurance company, but also ultimately increase the level of socio-economic well-being of the population throughout the country and the stability of Ukraine's economic system.

It is necessary to strengthen the role of this subsector of insurance, the ways to achieve which have their own specifics, so we consider it necessary to analyze world practice and develop quality recommendations for the development and strengthening of civil liability insurance in Ukraine.

3. Current trends in motor insurance in Ukraine

An important subject of the insurance market is the state, which with the help of legal instruments regulates the activities of other participants in the insurance market. At the level of the state, market participants are insurers and insurers, which may be represented by individuals and legal entities that purchase and sell insurance products on the basis of statutory norms and standards. The situation in the insurance market, the level of its integration and demand is characterized by the volume of insurance premiums and insurance payments.

In terms of capitalization, the insurance market is second among other non-banking financial markets. The total number of insurance companies as of 31.12.2020 amounted to 210, including IC "life" – 20 companies, IC "non-life" – 190 companies (as of 31.12.2016 – 310 companies, including IC "life" – 39 companies, IC "non-life" – 271 companies) (Table 2).

The number of insurance companies has decreased significantly, as of 01.07.2021. Compared to 2016, the number of companies decreased by 129 companies, including life insurance companies by 20 companies and non-life insurance companies by 109 companies.

Road transport is an accessible, convenient and still the most dangerous mode of transport: according to the WHO, more than 1.5 million people die in road accidents in the world every year – a constant number since 2007 (Table 3).

It is also necessary to analyze the Top 10 insurers in the market of civil liability insurance of owners of land vehicles (OTSPV) in 2020 . Such insurance companies as: TAS SG, ORANTA, UPSK are the leaders in the collected insurance payments and insurance payments under contracts of civil liability insurance of owners of land vehicles. And in the insurance company ORANTA this type of insurance occupies the largest share – 63.47%.

Table 4 shows the analysis of the main indicators of civil liability insurance of owners of land vehicles (OTSPV) under internal contracts for 2015–2020.

According to Table 4, there is a clear positive trend towards an increase in the number of contracts and, as a result, the volume of collected insurance premiums for 2015–2020 is increasing.

Table 2

Number of insurance companies in Ukraine in 2016–2020 and the first half of 2021

Period	the total number of	Non-life insurance company	Life Insurance Company
As of 31.12.2016	310	271	39
As of 31.12.2017	294	261	33
As of 31.12.2018	281	251	30
As of 31.12.2019	233	210	23
As of 31.12.2020	210	190	20
As of 01.07.2021	181	162	19

Source: generated by [8]

Table 3

Accident statistics in Ukraine for 2014–2019

Indicator	2014	2015	2016	2017	2018	2019
Total accident	186225	196410	191010	153205	164193	158776
Accidents with victims: total	31281	30699	30681	26160	25365	26782
died	4908	5131	4833	4464	3970	3410
injured	38178	37519	37521	32352	31467	33613

Source: compiled according to the Road Safety Office [4]

Motor third party liability insurance is provided for the benefit of the entire population of the country, because everyone can get into an accident and be among the victims. And with the increase in the fleet, the probability of getting into a car accident increases.

In the process of formation and development of the OTSPV market, the state performs the following functions: regulation, control, stimulation, organization and protection. This is realized through mechanisms of state regulation and self-regulation (institutional regulation), which complement each other. In this case, state regulation is general, and self-regulation – specifically – mandatory, ie mandatory only for members of the association. Under certain circumstances, the state may give some powers to self-regulatory organizations .

Compulsory insurance of civil liability of owners of land vehicles is a powerful investment resource. Today, a significant part of the collected

Table 4

The main indicators of civil liability insurance of owners of land vehicles (OTSPV) under domestic contracts in 2015–2020

Indexes	2015	2016	2017	2018	2019	2020
Number of agreements entered into force, pcs.	6826118	7049462	7408257	7720277	8003279	8333824
Amount of accrued insurance payments, UAH	2970390004	3406938863	3737904765	4485983891	5089744903	6136584507
Number of claims settled by payment of insurance indemnity, pcs.	98785	119186	133394	120081	139551	147117
incl. using the European protocol, pcs.	12429	20487	30484	35593	47494	50272
Accrued amount of insurance indemnity, according to settled claims, UAH	1089581666	1405420766	1887502798	2114142130	2526624427	2851856416
in. incl. using the European protocol, pcs.	72719614	151688430	240417212	330834838	447425071	503162786
Level of payments, %	36.7%	41.3%	50.5%	47.1%	49.6%	46.5%
The share of the European protocol in payments, UAH.	6.7%	10.8%	12.7%	15.6%	17.7%	17.6%
The share of the euro protocol in payments, pcs.	12.6%	17.2%	22.9%	29.6%	34.0%	34.2%
Frequency of declared events, %	1.45%	1.89%	1.80%	1.56%	1.74%	1.77%
Average payment, UAH	435	483	505	581	636	736
Average payment, UAH	11030	11792	14150	17606	18105	19385

Source: compiled according to Natskomfinposlug [6]

premiums of insurance companies with OTSPV in accordance with existing legislation are invested in the economy of Ukraine, which provides significant support to the national economy in overcoming the investment crisis.

In many parts of the world, an injured person or the owner of the victim's property must establish the guilt of another person. If the defendant travels constantly, he is obliged by law to have an insurance policy that provides the possibility of compensation for such damages.

The main articles of European traffic law stipulate that the use of any mode of transport, coercion of another person or permission to use a vehicle on the road without an insurance policy is a criminal offense punishable by a fine or imprisonment. The insurance policy must provide unlimited liability in the event of death or injury, and property insurance indemnity, which may be subject to damages of up to USD 375,000 as a result of the use of vehicles on the road.

As the practice of insurance has shown, especially at the stage of settling claims of insured persons, victims, the logical, most mitigating mechanism for fulfilling financial obligations for insolvent insurers in motor insurance is joint and several guarantee of insurance payments on their obligations. Guarantee funds are most common in developed countries. In one form or another, they operate, in particular, in the United Kingdom, Canada, the Netherlands, the United States, France, Japan, Italy, Norway, Finland, Greece, Spain and more.

In the vast majority of countries where guarantee funds exist, reimbursement under motor insurance contracts, including voluntary property insurance (CASCO), is guaranteed on a general basis, together with other voluntary types of insurance. The only exception may be compulsory motor insurance, the insurance payments of which are provided by separate guarantee funds established in accordance with the requirements of national legislation on this type of insurance (in particular, Western, Central and Eastern Europe, North Africa, Middle East).

In Ukraine, the guarantee fund is represented in international and domestic compulsory motor insurance. In CASCO insurance, guarantee funds that cover the risks of insolvency of insurers under this type of insurance, compensate for losses to policyholders or persons entitled to receive insurance indemnity, based on the essential terms of insurance contracts and subject to restrictions that may be established by law, for example, in relation to the amount of damage or a fixed amount of guarantee compensation.

The mechanism of compensation of insurance indemnity by guarantee funds under compulsory car insurance contracts differs significantly from general guarantee schemes. First of all, this is due to the compulsory and social orientation of this type of insurance. The existence of a guarantee fund and the mandatory participation of insurers who have the right to conclude contracts of compulsory motor insurance is an unconditional requirement of insurance legislation in most countries.

State regulation of OTSPV is also an impetus for the development of the insurance market in the country as a whole. This thesis is true in world practice. For example, in Italy, the insurance market in its current form began to take shape after the introduction of OTSPV, which provoked rapid growth in the industry. Companies that have gained experience and financial strength through compulsory insurance have begun to actively expand the range of services offered by voluntary insurance, and many of them are still leaders in the Italian market.

The main reasons for the need for state regulation of the OTSPV market are as follows:

– combating the emergence of fictitious insurance companies that can harm both the insurance business and the property interests of policyholders;

– OTSPV is subject to taxation, which is a source of state budget revenues and a means of ensuring the social sphere of the country;

– OTSPV is a powerful investment resource.

At present, the OTSPV market has a number of unresolved issues. The following issues are currently the most relevant:

– low amount of payments aimed at compensating for the damage caused to the lives and health of victims;

– constant growth of unprofitable insurance operations in the absence of the possibility of automatic adjustment of tariffs for the inflation index;

– competition that threatens the financial stability of both individual ICs and the market as a whole;

– lack of qualified personnel to promote and sell insurance services;

– insurance fraud on the part of both representatives of the insurance company and insurers, etc.

All these problems hinder the development of OTSPV in Ukraine, restrain the growth of sales of insurers, narrow cash flows to insurance reserves and centralized insurance reserve funds, reduce the financial stability of the insurance company.

There are various options for solving these problems, but the main one is to develop a general market strategy of action, which will be provided by appropriate tactical measures.

Today, the existing methodological approaches to overcoming these problems in OTSPV and justifying the most appropriate areas of development of OTSPV have a number of shortcomings: they are incomplete because they do not take into account foreign experience and the effectiveness of implementation for all market participants.

4. Innovative technologies in motor insurance

At the present stage, it is impossible to do without innovation, because innovation is always associated with the demand for innovation in a particular situation and the availability of investment potential. Innovation in insurance is the main task of the insurance company. And their content is to, using the best domestic and world traditions, to create an economic, organizational system of relations between insurers and the state, users of insurance services, which could flexibly respond to all trends in consumer demand, offering modern types of insurance services to specific clients, while maintaining the availability of insurance for different segments of the population, regardless of age, occupation, income and other factors.

The current state of the insurance market requires insurers to raise standards of work through the introduction of innovative products.

The development of motor insurance in the world and in Ukraine is gaining popularity. Liability insurance for owners of land vehicles is one of the most common and popular types of liability insurance worldwide. Liability insurance for vehicle owners is mandatory in all European countries. Lack of such liability by the owner of the vehicle insurance policy is considered a serious offense punishable by a fine or even imprisonment.

Consumers of these services are aware of their importance. The widespread use of information and digital technologies provides new opportunities for the growth of additional premiums, improving the quality of customer service, better selection of insurance risks, and preventing losses. To increase the effectiveness of competition, insurers find the opportunity to receive and process telemetry information from devices and sensors, information received in streaming mode from social networks and external sources, as well as to monitor information from body devices.

The research reveals the place and role of innovations in motor insurance. Factors influencing the introduction of innovations in motor insurance are considered, innovative technologies in compulsory civil liability insurance are considered, product innovations in voluntary property insurance are analyzed, financial technologies in insurance are considered.

With the development of information technology, the growing popularity of Internet technology, increasing the availability of portable devices, the insurer is actively using innovative tools. This allows not only to develop the insurance company, but also to understand what the insured needs. Foreign experience shows that the level of innovation of the insurer is one of the main factors in increasing its competitiveness. To implement innovative solutions, insurance companies need to automate business processes, use digital technologies in obtaining, storing and processing data, have alternative sales channels, use effective marketing ideas.

In the conditions of unstable economic environment of the country this complex of types of insurance, and especially, its obligatory segment – insurance of civil liability of owners of land vehicles – is characterized by rather steady development. As a result, most innovative solutions in the domestic market are motor insurance. This trend also exists in other countries of Eastern, Central and Western Europe, where motor insurance occupies a leading position.

In domestic and foreign scientific literature, innovation means ideas and proposals that can be the basis for creating new products or significantly improve the consumer characteristics (technical, economic, etc.) of existing goods, creating new processes, services, or anything that can improve "quality of life" of humanity; the new idea must be put into practice.

Innovative solutions have become especially widespread in the financial sector of the national economy, due to:

– development of computer and telecommunication technologies which allow to minimize business processes of participants of financial branch;

– ease of implementation of theoretical solutions in practice;

– high level of customer orientation of financial services, which additionally motivates participants of the financial sector to apply innovations;

– constant change of demand factors for financial services and the structure of their supply;

– financial market regulation policy;

– high level of competition in the financial market.

Table 4

Classification of factors influencing the introduction of innovations in motor insurance

Factors	Characteristic
Economic	The introduction of innovations in motor insurance helps to minimize the costs of insurers to carry out insurance activities; reducing the cost of insurance for consumers; maximizing the profitability of the insurer and its stability
Social	The society needs to increase the efficiency of the mechanism of protection of property rights of legal entities and individuals, unconditional guarantee of insurance payments under motor insurance contracts, insurance coverage for all its subjects, regardless of the contractual relationship with the insurer. Complicating the problem is the significant loss of this type of insurance and the severity of the consequences for the victims of the accident
Technological	The development of the automotive industry, financial, information and digital technologies requires motor insurance market participants to create appropriate innovative insurance products, services and adapting their business processes
Market	Innovation as a tool of competition promotes the introduction of new products and services in the insurance market. This helps to improve the quality of insurance services and maximize customer satisfaction in insurance protection

Source: [5]

Innovations have certain characteristics in insurance, which are distinguished by the specifics of the insurance business and the uniqueness of the insurance product. They include:

– lack of patenting, which allows insurers to easily implement effective and proven solutions, ideas, technologies, borrowed from other participants in the insurance market;

– insensitivity, inseparability and risk: the insured receives the service only in the event of a certain unforeseen event;

– non-affiliation to essential services, which encourages insurers to seek flexible approaches to potential consumers and offer insurance services that could meet the needs of a wide range of policyholders;

– high social orientation: insurance provides reliable protection of property rights of the population and economic interests of the state.

Under these conditions, insurance innovations are a process or result, the implementation of which in practice makes qualitative changes in the insurer in the form of new insurance products, improving the interaction with the external environment, expanding approaches to attracting new policyholders and improving internal business processes.

At the macro level, the innovative development of insurance is ensured by extensive innovation, the use of opportunities by insurance market participants, the implementation of which requires the use of modern technologies and standards and aimed at improving the quality of insurance services, improving their availability and guaranteeing persons and victims.

At the micro level, innovative development is seen as the process of implementing innovative solutions by insurers that help strengthen their competitiveness, create a unique insurance product for each policyholder individually, improve insurance services and more.

Innovative nature is most characteristic of motor insurance as one of the socially necessary and technological types of insurance. The introduction of innovations in the field of motor insurance is influenced by economic, social, technological and market factors. Depending on the object of innovation in insurance activities, there are marketing, product, process and organizational innovations.

Marketing innovations in motor insurance relate to new sales channels. Today, such a sales channel is the online sale of insurance products, which allows the insured to draw up a contract online, choose the functions that belong to him and pay insurance premiums.

The main advantages of internet marketing are:

1. Significant savings in consumer time and simplification of interaction between the insurer and the insured.

2. Lack of borders. Any user of the Internet can access the site from anywhere in the world, it does not tie him to a particular region of the city or district. The consumer of the service can be at home, at work or on vacation and will still contact the insurance provider.

3. Ease of obtaining information and the possibility of its use for research. Moreover, both the insurer and the insured have access to the necessary information virtually immediately and anonymously.

4. Speed and convenience of adding or changing information. Insurers can promptly and timely edit information on insurance services, prices and

Table 5

Benish GUARD system

	Characteristic
General information	Information about the current location of the car, the status of the system (car guard or system inactive) and the time of receipt of the last message from the system
Location data	Exact vehicle coordinates, current speed and total mileage since system installation
Specifications	Battery charge level and charge of the safety system itself. The application also shows the ignition on, as well as closed or open car doors

Source: compiled by the authors on the basis of [6]

mechanisms for their provision. This helps to provide the consumer with only relevant information, which encourages the consumer to prefer this method of communication with the insured.

5. During the economic downturn in Ukraine, which is due to the loss of Crimea, anti-terrorist operation in eastern Ukraine, gas conflict, concentration of business in the hands of the previous government is falling incomes, and hence their costs. Insurance is not the highest priority item for households, which makes it quite vulnerable. That is why the use of Internet marketing is relevant, which reduces the cost of insurance business and thus reduce the cost of insurance services.

6. Variety of promotion channels. Thanks to the development of "digital" marketing, information about insurance services in the form of banners can be placed on any site, using a huge number of formats. Also social networks, namely: Instagram, Facebook, Telegram. Such advertising platforms are becoming increasingly popular. Posting information via the Internet allows you to track which types of advertising are effective and which are not.

Product innovations are represented mainly in voluntary property insurance (CASCO). In addition to the traditional risks (theft, damage due to an accident, destruction of vehicles, etc.), which are covered by contracts of this type of insurance, insurers may additionally offer: evacuation of the vehicle from the scene of the accident; simplification of documentary evidence of an accident, in particular the need to present a certificate from the competent authorities in case of minor damage; technical assistance on

the road; possibility to conclude a CASCO contract for half price before the first accident; voluntary insurance of civil liability of vehicle owners or insurance of passengers and driver at the price of only one CASCO.

Today, insurance telematics deserves more and more attention. In today's world, it is actively gaining momentum, as it is significantly beneficial for both insurance companies and vehicle owners.

Telematics in insurance is an opportunity to reduce the cost of the policy for a single driver. In other words, it is a special monitoring system, the main function of which is to track the specifics of driving a particular person. And if the owner of the transport adheres to the rights of the road, he may well expect to reduce the cost of CASCO.

What benefits does this bring to insurance companies? A monitoring device mounted on the vehicle encourages the driver to drive smarter. As a result, the risk of an accident is significantly reduced, which means that no insurance payments will be required.

Insurance telematics represents tangible benefits for both parties, so both insurance companies and car owners are equally interested in its installation.

Vehicle owners only have to agree to install a telematics device in the car when concluding a contract. In addition, a special application is installed on the driver's mobile phone, which allows him to also monitor the information transmitted.

Telematics in insurance works on this principle. After the consent of the owner of the vehicle, the monitoring device is installed. During the month, information is collected that determines the characteristics of the client's driving. It is evaluated on a 10-point scale. According to the results of the calculation, the owner is refunded a certain percentage of the amount paid for CASCO.

Thus, an insurance policy, the price of which is quite high, a neat driver can be inexpensive. And the device itself is provided absolutely free.

Installation of the system promises the car owner and other useful services:

– navigation function that helps to navigate the road;

– remote diagnostics of vehicle systems;

– signal transmission in case of emergency.

The number of electronic contracts of OTSPV in Ukraine in 2020 amounted to 3.1 million units, an increase of 150%.

For fleet owners, there is an added benefit of being able to control each work machine. Such monitoring nullifies all fraudulent methods of the park staff.

Modern technology has made a tremendous step forward in recent years and now it is difficult to imagine life without a smartphone and other electronic gadgets. Thus, owners of the Benish GUARD satellite system, any of the 4 configurations, in addition to the obvious advantages in the form of reliable protection against theft 24/7, can get up-to-date information about the status and location of your car directly on your smartphone using a special mobile application Olympia Tracking.

The main function of Olympia Tracking is to display information about the location and status of the car, and in the main menu you can use additional features such as creating a report for a certain period of time and viewing a complete travel history, select map type, get detailed information about the car.

The use of financial technologies (fintech-innovations) are the most modern innovations in insurance, which allow to receive insurance services anywhere, using digital information and analytical resources, Web-portals, social networks and payment systems, as well as the introduction of distributed registry technologies to store static and dynamic transaction information. Such innovations include Blockchain technologies and the operation of startups (Table 6).

It should be noted that the complete set of Benish GUARD – ULTRA in the application reflects in as much detail the movement of the vehicle: route, speed and location. A function to view the current status of the car's systems is also available.

Another type of innovation is process innovation, which consists in the introduction by insurers of automated business process management systems.

Participants in the motor insurance market have introduced an electronic policy in compulsory motor insurance, which allows to protect policyholders and accident victims from insurance fraud, minimizes the administrative costs of insurers for this type of insurance. The first company in Ukraine to sell an electronic policy was VUSO Insurance Company, which was carried out on February 7, 2018.

The Motor Transport Bureau of Ukraine has published the performance indicators of the "electronic policy" system as of October 3, 2018.

Table 6

Comparative characteristics of Blockchain technology and startups

Blockchain technology	Startups (aggregators)
Essence	
These are distributed registry technologies for storing static and dynamic transaction information without any central administration through a consensus-based mechanism for transaction authentication. This mechanism provides a reliable service, because the stored information is easily accessible to users, and the original records can not be modified due to the high level of security of this system	They focus on the distribution channels of insurance products by avoiding any mediation in the implementation of insurance services (direct sales), shift the emphasis on the dissemination of reliable information among the target group of consumers, in the right place and at the right time. Provide personalization and individualization of approaches to a particular consumer by verifying his needs in a particular insurance service. One of the simplest types of startups (by functional purpose) are aggregator sites for implementation insurance services
Opportunities	
Allow you to improve: – automation of insurance history creation and monitoring; – prompt access to certificates from government agencies; – accounting of insurance events, their instantaneous fixation; – conclusion of online insurance contracts; – examination and preliminary risk assessment; – interaction with brokers and sales network; – transparency of settlement and response to customer requests	Thanks to a standardized algorithm for charging and calculating the amount of insurance premiums under motor insurance contracts, aggregator sites provide insurers with an alternative method of attracting policyholders, which is to provide them with real-time offers from many insurers to insure their risks.
Disadvantages	
Threat of cyber risks of unauthorized interference with information systems	Aggregator sites have certain restrictions on use in circumstances where the insured's risks go beyond the unified ones (for example, a high-value exclusive or rare car with CASCO insurance). Quoting such risks requires additional traditional assessment by the insurer

Source: compiled by [6]

63,358 OTSPV contracts were concluded in electronic form, the total amount of insurance premiums for them was UAH 43.9 million. The leader in the number of concluded online contracts is VUSO Insurance Company (almost 19,500 contracts).

Today, international insurance experts pay great attention to innovative information technologies and digital transformation in the field of insurance, in particular in its most common segment – motor insurance. This contributes to increasing financial inclusion, which takes into account the interests of the most vulnerable groups in the context of ensuring their access to quality and safe insurance services.

Financial inclusion in the insurance market has three dimensions: access to insurance products and services; use of insurance services; product quality and service delivery. One of the current factors contributing to the impact of innovative information technology and digital transformation on the development of motor insurance is the active use of mobile devices, laptops with online access to information resources as a catalyst for innovative change for most insurance companies. Modern consumers of insurance services require an individual approach from the insurer, expecting to receive the service in a convenient place and time at the best price.

The widespread use of information and digital technologies provides new opportunities for the growth of additional premiums, improving the quality of customer service, better selection of insurance risks, and preventing losses. To increase the effectiveness of competition, insurers must find the opportunity to receive and process telemetry information from devices and sensors, information received in the streaming mode from social networks and external sources, as well as monitor information from body devices. Long-standing systems simply cannot ensure the completeness, efficiency and variability of such information.

Information and digital technologies have a positive impact on the development of motor insurance, but the legal issues related to the protection and processing of personal data aimed at protecting fundamental human rights and freedoms, including the right to privacy, are currently insufficiently regulated.

High level of competition in the insurance market, economic downturn in the country, consumer demand, low purchasing power, scientific and technological progress of mankind – all these are the factors that

encourage Ukrainian insurance companies to innovate in their activities. Such innovative processes not only allow insurers to create new services for existing customers, but also to attract new ones. The introduction of innovative technologies in insurance companies is a guarantee that the company is competitive and, consequently, solvent. In the future, the development of motor insurance will be influenced by various innovations. Among them, information technology and digital transformation will be of particular importance due to the active use of mobile devices, laptops with online access to information resources, fintech innovation, the functioning of social networks and payment systems, as well as the use of distributed registry technologies for storage static and dynamic information on insurance-related transactions.

In the near future, innovative technologies in the automotive industry will have a special impact on the development of motor insurance, including the operation of automated (unmanned) vehicles, active dissemination of car sharing (car sharing), the use of additional intelligent car control systems. These innovative technologies will encourage insurers to improve their insurance products, maximize the needs of policyholders, speed up the settlement of insurance cases, reduce insurance fraud and reduce the cost of insurance services related to the ownership and use of vehicles. Promising innovative solutions in motor insurance, despite their high-tech nature and a clear revolution in approaches to the organization of business processes of insurance companies, will maintain the need for existing guarantee mechanisms in this complex of types of insurance, as the vehicle as a source of increased risk the rights of both their owners and third parties – victims.

Processes of harmonization of Ukrainian insurance legislation with European regulations in the field of insurance and implementation of Western standards in the domestic insurance market will stimulate demand for innovative solutions in auto insurance that can bring efficiency, technology, profitability and reliability of Ukrainian insurers.

5. MTIBU activities in the market of civil liability insurance of owners of land vehicles

The confidence of car owners in such a modern way of registration of road accidents as the European protocol is constantly growing. Ukrainian drivers have become accustomed to using it in the event of accidents that

fall under the terms of the European protocol. We also note an almost threefold increase in the number of electronic European protocols. Last year, the participants of the accident were able to draw up an electronic European protocol not only through the MTIBU website, but also through the mobile application "My Policy", which increased the availability and convenience of the service.

The MTIBU also conducted an active awareness campaign on the benefits of the European Protocol, as we have a common position with the regulator that it is possible to increase the share of payments under it to 50% or more. This would be a significant contribution to improving the situation with traffic jams and saving the state budget.

Unfortunately, the pandemic hit the Green Card segment as expected: as a result of cross-border traffic restrictions, the number of cars crossing the border has dropped significantly, and the Green Card has fallen accordingly. The number of contracts decreased by 45%, the amount of premiums for them by 28% [7].

Most importantly, during the crisis year, we maintained the trust of OTSPV road users due to the fact that insurers quickly and efficiently settled insurance cases, as well as promptly responded to the situation and took care of the safety of employees and customers.

In the last quarter of last year, the average settlement period was shorter than it was in the first, and the number of complaints about the actions of insurers in 4 square meters. 2020 was a record low of less than 1%. What could be more convincing than these figures for the efforts made by insurance to maintain the protection of victims at the proper level, despite the pandemic.

The events of 2020 also confirmed the importance of the course taken several years ago for the active digitalization of the OTSPV industry. According to the results of last year, the number of electronic contracts of OTSPV amounted to 3.05 million units, which is 2.5 times more than in 2019. The amount of insurance payments under such contracts is UAH 2.6 billion. (+ 176%). The monthly number of contracts increased almost threefold from the beginning of the year to the end.

More than a third of the total number of OTSPV contracts are concluded in electronic form: the share of OTSPV electronic contracts in 2020 is about 37%, while in 2019 it was 15%, and in 2018 'only about 2% [8].

In 2020, much attention was paid to improving the activities of the MTIBU. The crisis situation did not become an obstacle to development, on the contrary, we saw it as a challenge. We need to work even better and at a more modern level, because it was quarantine that proved how important all the previous steps were to improve business processes and digitalize the Office. In particular, they actively introduced and learned to work in the electronic document management system, which accelerated the work of the Bureau and greatly simplified the remote exchange of documents. We are also starting to implement a quality management system based on a process approach and risk-oriented thinking that meets the requirements of ISO 9001: 2015.

MTIBU settlement procedures are automated, so the Bureau easily switched to remote settlement mode with the start of quarantine, without losing the quality and speed of work. In 2020, the MTIBU paid more than UAH 215.7 million to the victims of road accidents from the Victims Protection Fund (FZP), the total number of payments amounted to 6464 units. The number of payments decreased by 10.6% compared to the previous year, the amount of payments remained virtually unchanged (+ 1.8%). The decrease in the number of payments was solely due to a significant decrease in payments to the IC of bankruptcies and companies that left the OTSPV market without fulfilling their obligations to the victims of road accidents. Even in difficult and unpredictable circumstances, the Ukrainian MTPL market is able to maintain the quality of regulation and service, implement new projects and strategic initiatives [7].

Priorities remain unchanged: updating legislation, creating a full-fledged digital environment for motor insurance, increasing the level of protection of the interests of road accident victims.

We see that the NBU as a regulator of the non-banking financial market understands the social significance of OTSPV as a type of insurance. In particular, the issue of the need to increase the sum insured has already been raised. Therefore, there should be support from the regulator for the modernization of sectoral legislation. Let me remind you that the insurers and the Bureau prepared the text of the new bill five years ago. Our proposed document would solve all the long-standing painful problems of insurance protection of road users: raising insurance premiums to the European level, payments to victims without deductible and deductible, accelerating

payments for bankruptcies and companies that have left the market. We would also have a full-fledged legal framework for the technological transformation of the industry.

In a few months, the "ombudsman in the OTSPV" will start working on the basis of the MTIBU. The task of the ombudsman will be to monitor compliance with the legal rights and interests of policyholders and victims of road accidents, as well as to resolve pre-trial conflicts between insurers and recipients. The ombudsman will provide assistance free of charge. Any citizen who needs protection of his rights in the field of liability insurance of motor vehicle owners will be able to apply to the ombudsman [5].

This year, international insurance contracts will be signed in Ukraine in electronic form, and the Green Card insurance certificate will also be in black and white. This will allow after the conclusion of the electronic contract of international insurance to obtain a certificate in the form of a file and print it on a regular printer, including the insured himself.

Priority task for further digitalization of OTSPV introduction of remote settlement of insurance events. The pandemic has demonstrated how uncomfortable and sometimes dangerous a world can be, where "papers" have to be passed from hand to hand. The pandemic is ongoing, so a remote settlement is not only about convenience, but also about saving lives.

The regulator is ready to help with the issue of modernizing the legal and regulatory framework for the introduction of remote settlement, and many insurers can now offer proven procedures for online filing, for example, through their website.

The MTIBU is currently working on a single standard for a remote settlement procedure. We also plan to assess the prospects for strengthening the mechanism and functions of self-regulation of the MTIBU. OTSPV insurers are ready for greater responsibility for the future of the industry. Now that the legal framework for the operation of self-regulatory organizations in the non-banking financial market is being developed, it is time to consider expanding the capacity of the MTIBU to coordinate the efforts of its members to develop the industry.

Findings

Liability insurance for vehicle owners is a socially important area for the state due to the fact that with the annual increase in the number of vehicles

there is an increase in the number of accidents and victims. Material claims on the owner of the vehicle that caused the damage can be significant, and the financial situation of the perpetrator of the damage does not always allow to compensate for the damage in full.

The analysis of the practice of OTSPV allowed to offer the following as promising directions for the development of this field of insurance:

– change the approach to determining the insurance history of the car owner with OTSPV, namely to tie it to the driver, not to the car;

– review the approach to the bonus-malus system in order to financially stimulate insurance entities;

– to introduce a full-fledged automated information system with OTSPV for control over insurance history;

– centralize the fight against fraud in the field of car insurance;

– create a state register of independent technical experts;

– to gradually move from the administrative regulation of OTSPV to the formation of insurance rates based on existing demand [7].

Ukraine's insurance market in the context of civil liability insurance is imperfect. Revenues from some types of insurance are significantly higher than others and have too high levels of payments, which increases the risk of liability insurance.

Among the main problems of development of civil liability insurance in Ukraine are the following:

– strict regulation of the insurance process by the authorities of Ukraine, which is expressed in full control of all components of the insurance contract: the sum insured, the insurance rate, the list of insured events, etc.;

– Insufficient information support of Ukrainians on the obligation to conclude an insurance contract, which leads to the leveling of the importance of these types of insurance;

– despite the compulsory nature of certain types of civil liability insurance, a certain proportion of Ukrainians deliberately avoid turning to insurance companies, which reduces the socio-economic effect of this insurance sub-sector;

– low insurance rates lead to a significant gap between the tariff and payments, which reduces the willingness of insurers to offer certain types of insurance products.

However, it should be noted that these problems can be solved. To this end, several recommendations are proposed to improve the state of the sub-sector as a whole, among them:

1. Improving the effectiveness of the incentive system "bonus-malus" in the conclusion of internal insurance contracts, which will increase demand for insurance products in the industry.

2. Change in the legal framework for the abolition of part of the requirements for concluding a civil liability insurance contract, which will lead to an adequate insurance system in which all components will be calculated by the actuary to minimize the risks of the insurance market.

3. Creation and development of new insurance products in the field of civil liability, which will protect the liability of other professions, such as lawyers and financial analysts.

4. Introduction of international solvency standards Solvency II, which will improve the state of the subsector and improve the quality of insurance in general.

The gradual development of liability insurance in Ukraine is due to the fact that individuals and legal entities are beginning to increase their costs to obtain a high level of security of their lives and businesses, the need to protect their property interests from unforeseen risks is growing. The volume of collected premiums is growing, but the volume of payments is growing faster. Strengthening the role of civil liability insurance can qualitatively change the insurance market of Ukraine and bring additional funds to it. For insurance companies, improving the sub-sector is also a positive factor, as it will increase the demand for insurance services.

To improve the level of development of civil liability insurance, it is necessary to increase the demand of the sub-sector and improve the level of information provision of Ukrainians about the socio-economic effect of these types of insurance. Also a necessary component is to reduce the level of control and change the conditions of the legal framework regarding the main provisions of insurance contracts.

Conclusions

Ukraine's insurance market is on the verge of major changes and needs close attention to address many of the issues that began to emerge with the advent of economic, political and social crises. That is why at the present

stage of our lives, it is so important to study all the processes, all the wells that will help our state to fight the destructive processes in all areas.

Having conducted a detailed analysis of the functioning of motor insurance, the following conclusions can be drawn:

1. Motor insurance is a generalized concept, is a set of certain types of insurance related to the operation of vehicles that protect both property and financial liability of the insured for damage to life and health of other road users (driver and passengers of the insured transport). The historical formation of vehicle insurance dates back to the end of the eighteenth century, the country of origin of which is France. In Ukraine, this type of insurance emerged with the adoption of independence in 1991. According to scientists, car insurance as a separate industry was formed due to the emergence of the subject of insurance – the vehicle (with the growth of the fleet increases and the danger). In order for car insurance to function successfully and bring income to insurance companies (you need to understand that the UK is not a charity), it is very important to properly form insurance rates.

2. In Ukraine, the field of motor insurance is represented by such types of insurance as property and liability. In turn, these types are divided into two forms: mandatory and voluntary. Compulsory liability insurance includes insurance of civil liability of vehicle owners under internal contracts (OTSPV) and insurance of civil liability of vehicle owners under external contracts ("Green Card"). Voluntary liability insurance includes civil liability insurance of land transport owners, including carrier's liability (CAR). With regard to voluntary property insurance, in Ukraine the auto insurance industry is represented by land transport insurance, except for rail (CASCO).

3. Analyzing the general situation of this type of insurance in Ukraine, we can conclude that it occupies a significant place in the insurance market of Ukraine. Both in terms of insurance premiums and insurance payments, the share of car insurance in the insurance portfolio of Ukraine for the analyzed period is 40-45%. As for compulsory and voluntary forms of insurance, in our country it exceeds the second form, respectively, both in terms of insurance premiums and insurance payments, and the level of payments. Only in such a characteristic as the number of contracts compulsory insurance exceeds voluntary. The main reason for this situation is the nature of the insurance itself, ie compulsory. As for the more detailed description,

both in terms of insurance premiums and payments, CASCO occupies the largest share. The reason for such indicators is a large list of risks from which this type insures (on the one hand, customer interest, and on the other frequent insurance claims). The second step in premiums and payments is the insurance of civil liability of owners of land vehicles. This is due to the mandatory registration of an insurance policy for any car. The third position is occupied by the "Green Card" and in last place is the insurance of civil liability of land transport owners, including the liability of the carrier.

4. Car insurance in Ukraine, including the analyzed companies, is currently experiencing bad times and has many problems, both external and internal. Given the situation in which our state finds itself, it is necessary to really assess the whole picture that is happening.

Common problems that prevent the effective functioning of insurance and motor insurance include: imperfect regulatory and regulatory framework; financial and economic crisis; political situation in the country.

The specific problems of the car insurance market include: depletion of resources of insurance companies; conducting dumping policy by insurance companies; activities that do not meet international standards; post-Soviet stereotypes in car insurance; "Honest business" of insurance companies in vehicle insurance; fraud on the part of insurers; lack of interest of insurance companies, according to the classic compensation of losses, in serving "foreign" customers (loss settlement system; unsatisfactory condition of roads and gross violations of traffic rules by citizens.

5. It is impossible to completely eradicate the difficulties that have gripped our country in the insurance market, but it is quite possible to fight them. This is why the main driving forces of mitigating these problems were given: explanatory insurance policy among the population, introduction of innovative types of car insurance, improvement of the legal framework, support of healthy competition (prevention of dumping policy), optimization of insurance companies' cost structure, changes in the calculation of insurance payments (depreciation), the fight against fraud through innovative methods, preventive and educational and informational work among road users. With regard to more specific actions, in particular, in order to solve the problems of the MTPL, it is necessary to increase and bring to European standards insurance limits, cancel the deductible and link the policy to the driver. According to CASCO and DCV, it is possible to form

a separate guarantee fund, created by the insurance companies themselves, to balance the old car fleet, remove predatory customs clearance taxes, and create a general register for checking voluntary insurance policies.

6. As for development prospects, if domestic insurance companies can use the national potential and develop and implement the rudiments of the "new insurance" that the world offers us, they will receive the income they dream of. Such trends include the improvement of electric car insurance, the development of insurance during "carsharing", the use of telematics, Blockchain and other innovations in car insurance. Also, the modern world should think about the feasibility of motor insurance, because with the advent of alternative means of transportation, the whole system is being rebuilt.

Thus, car insurance is one of the driving elements of the progressive processes taking place in the state. Only well-considered actions of the state, which will be aimed at improving this area, rather than burdening it, will help to obtain positive results. But in addition to government policy, the activities of insurance companies are very important, which should be aimed not only at raising funds for their own pockets, but also real help to all insured.

Among the positive developments that have taken place in recent years are: the consolidation of insurance companies, the gradual increase in the volume of insurance premiums received; growth of insurers' capitalization; reducing the level of unprofitable insurance market; recovery of foreign investors, the insurance industry in Ukraine needs to be radically changed and improved, stimulated and developed by assessing its current state, as well as the social significance and strong investment potential inherent in the insurance market.

The future development of the insurance market of Ukraine will depend not only on the qualitative or quantitative composition of the market, but also on further improvement of the legal framework governing not only insurance but also all activities, including health insurance, private pension insurance, mortgage lending, insurance life, activities of banks and their impact on insurance, as well as improving the insurance culture and increasing confidence in insurers.

It is important to identify the main prospects for the development of civil liability insurance of owners of land vehicles in Ukraine, including the following:

– creation of a developed and solvent system of civil liability insurance of owners of land vehicles, able to compensate for losses from unforeseen events;

– introduction of programs to inform the population through the media about the state and prospects of the insurance market;

– to expand international cooperation in the field of information exchange on the activities of insurance companies that provide services for this type of insurance;

– increasing the effective demand for insurance services through the introduction of new incentive systems;

– opening of centers for loss settlement with an extensive network and full-scale implementation of its own information system with personalized web access of salons, banks, insurance companies to the database of intermediary companies.

Therefore, today insurers face a difficult task to increase the volume and quality of insurance services, increase the level of capitalization and financial reliability of insurance companies. Following the above-mentioned measures aimed at overcoming crisis trends, the domestic economy will be able to attract significant investment resources, strengthen the effectiveness of state supervision of insurance activities.

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MODELS OF ANALYSIS AND ASSESSMENT OF SOCIO-ECONOMIC DEVELOPMENT OF THE COUNTRIES OF THE EUROPEAN UNION

МОДЕЛІ АНАЛІЗУ ТА ОЦІНКИ СОЦІАЛЬНО-ЕКОНОМІЧНОГО РОЗВИТКУ КРАЇН ЄВРОПЕЙСЬКОГО СОЮЗУ

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Abstract. The formation of prerequisites for the sustainable development of the country as a whole and its individual regions is possible today under the increase of the natural-resource, demographic, scientific and technical, recreational, information, and socio-cultural potential, not only of the production one. All components of socio-economic potential play an essential role in determining the priorities for the transition of national and regional economic complexes to a model of sustainable synergistic development. In addition, the importance of the human factor and institutional changes in the geopolitical system of economic relations should be highlighted.

When studying the relevant issue, it is essential to take into account numerous factors of the socio-economic potential of sustainable development, both exogenous and endogenous, keeping in mind the institutional consolidation of the European integration aspirations of the Ukrainian people. The signing of the economic part of the Association Agreement between Ukraine and the European Union (hereinafter referred to as the EU) requires a documentary and realistic introduction of a set of directives relating to economic, social and environmental spheres. Given the above, it is necessary to thoroughly assess the socio-economic development of the EU countries in order to conduct an in-depth analysis

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for the formation of modern approaches to increasing the socio-economic potential of Ukraine's sustainable development, which will be a solid basis for the modernization of most domestic sectors, real decentralization, and accelerated implementation of EU standards.

The subject of the study is modern methods, models, and technologies for assessing the level of socio-economic development of the EU countries from 2010 to 2019.

The research methodology comprises general scientific methods of cognition of the objective nature of economic phenomena and processes: analysis and synthesis; statistical and temporal analysis; comparison; observation; economic-mathematical, statistical and sociological methods of analysis; methods and models for calculating group and general integral indicators; forecasting methods.

The purpose of the paper is to develop a set of models for assessing the socio-economic development of the EU countries throughout 2010–2019, which is based on the use of modern tools, methods and models for calculating group and general integral indicators of socio-economic development of the EU countries. They make it possible to comprehensively assess and conduct complex spatially-dynamic comparative analysis of the studied countries, predict their development and determine adequate benchmarks for the development of the national economy on the way to the EU.

The general conclusion is that the contribution improves the process of assessment and analysis by calculating an overall synergistic integral indicator that reflects the effectiveness of the socio-economic development of EU member states and allows making adequate forecasts and modelling different development scenarios. Thus, it is determined that in the near future this indicator will increase due to well-planned activities of the states and comprehensive monitoring and control of processes by the EU. The implementation of development measures will improve the living standards of the population and be more sustainable in crisis or other social phenomena that may adversely affect the financial condition and security of the population. Consequently, given Ukraine's plans to join the EU, it can be considered that the relevant membership will have a positive synergistic effect on the state's progress, contribute to socio-economic development, and strengthen domestic potential.

1. Вступ

Досвід передових країн та наслідки структурної і системної перебудови більшості сегментів національного господарства свідчать, що реальні зрушення в напрямі формування передумов сталого розвитку як держави в цілому, так і окремих регіонів можливі лише за умови нарощення не лише виробничого, а й природно-ресурсного, демографічного, науково-технічного, рекреаційного, інформаційного та соціально-культурного потенціалу. При виборі пріоритетів переходу національного та регіональних господарських комплексів на модель сталого розвитку суттєву роль відіграють всі складові соціально-економічного потенціалу, а також людський фактор та інституціональні зміни в системі економічних відносин. Дослідження даного питання обґрунтоване необхідністю врахування численних екзогенних та більшою мірою ендогенних чинників соціально-економічного потенціалу сталого розвитку у зв'язку з інституціональним закріпленням євроінтеграційних прагнень українського народу [3; 5; 10]. У зв'язку із підписанням економічної частини Угоди про асоціацію між Україною та Європейським Союзом (далі – ЄС) потрібна документальна і реальна імплементація у вітчизняну практику комплексу директив, що стосуються як економічної і соціальної, так й екологічної сфер життєдіяльності. Виходячи з цього, постає необхідність оцінки соціально-економічного розвитку країн ЄС з метою формування сучасних підходів до нарощення соціально-економічного потенціалу сталого розвитку України, що стане надійним підґрунтям модернізації більшості галузей національного господарства, реальної децентралізації та прискореного впровадження стандартів Європейського Союзу [28].

Таким чином, метою даної роботи є розробка комплексу моделей оцінки соціально-економічного розвитку країн ЄС впродовж з 2010–2019 років, що заснований на використанні методів та моделей розрахунку групових та загальних інтегральних показників соціально-економічного розвитку країн ЄС, за допомогою яких стає можливим здійснення оцінки та аналізу стану даних країн, прогнозування їх розвитку та визначення адекватних орієнтирів для розвитку національної економіки на шляху до ЄС.

2. Оцінка основних складових та формування основних показників соціально-економічного розвитку країн Європейського Союзу

Економічний розвиток багатьох країн і регіонів супроводжується зміною структури суспільного виробництва, зокрема, на зміну індустріальному суспільству поступово приходить постіндустріальне. Все більша частина зайнятих працює в нематеріальному секторі, менша – безпосередньо в промисловості і сільському господарстві. Традиційно країни і регіони оцінюються з погляду багатства лісом, корисними копалини, ґрунтами, кліматичними умовами, основними фондами, географічним положенням. Нові уявлення про нематеріальне виробництво як про сферу, де створюється велика частина вартості, міняють критерії оцінки багатства країн і регіонів. На перше місце висуваються такі чинники, як багатство людьми і їх кваліфікацією, управлінськими технологіями, ринковою інфраструктурою, мережею бізнесу, культурою організацій. Нові уявлення про джерела і чинники економічного розвитку дозволяють по-новому подивитися на освіту, науку, медицину, телекомунікації, навики менеджменту як на ті сфери суспільного життя, які роблять вирішальний вплив на темпи і напрям економічного розвитку країни.

Отже, можна розглядати наступні критерії і відповідні ним показники соціально-економічного розвитку [8]:

ВНП або ВВП (абсолютна величина і на душу населення) і темпи зростання цих показників;

середній рівень доходів населення і ступінь їх диференціації;

тривалість життя, рівень фізичного і психічного здоров'я людей;

рівень освіти;

рівень споживання матеріальних благ і послуг (продуктів харчування, житла, телефонних послуг), забезпеченість домашніх господарств товарами тривалого користування;

рівень охорони здоров'я (забезпеченість амбулаторіями, аптеками, лікарнями, діагностичними центрами і послугами швидкої допомоги, якість медичних послуг, що надаються);

стан навколишнього середовища;

рівність можливостей людей, розвиток малого бізнесу;

збагачення культурного життя людей.

Розроблені міжнародними організаціями підходи до оцінки економічного розвитку країн примушують при оцінці рівня розвитку розглядати не тільки об'єм виробництва, але і такі, наприклад, аспекти, як освіта, охорона здоров'я, стан навколишнього середовища, рівність можливостей в економічній сфері, особиста свобода і культура життя.

На думку А. Кузнєцова [18], механізм регулювання соціально-економічного розвитку країни – «це сукупність елементів, що поєднуються на підставі суб'єктно-об'єктних впливів, які породжено дією об'єктивних закономірностей суспільного розвитку та суб'єктивних (раціонально осмислених) розв'язань щодо його регулювання, з метою забезпечення сталого, комплексного, динамічного і збалансованого розвитку регіональної системи». Він спрямовується на забезпечення:

комплексного використання потенціалу регіону як складної соціально-економічної системи;

сталості розвитку регіональної системи, що знаходить свій прояв у здатності системи зберігати задані параметри розвитку;

збалансованості розвитку, що характеризується пропорційним розвитком елементів, які складають структуру соціально-економічної системи регіону;

динамічності розвитку, яка досягається за рахунок позитивної динаміки соціально-економічних показників;

соціальної спрямованості розвитку регіональної системи, тобто націленості кожної із підсистем на постійне підвищення добробуту населення;

правового простору, рівності умов щодо поведінки суб'єктів господарювання;

конкурентного середовища, яке характеризується рівними умовами щодо розвитку власного господарського потенціалу;

інноваційної складової розвитку регіональної системи, яка базується на використанні передових (інноваційних) технологій не тільки у виробничому процесі, а й управлінні.

При управлінні соціально-економічним розвитком доцільно виділяти всі вище перелічені відносно самостійні цілі і здійснювати моніторинг їх досягнення. Разом з моніторингом стану регіонального виробництва і динаміки грошових доходів населення необхідно відстежувати і інші найважливіші параметри економічного розвитку, напри-

клад, наявність і рівень якості шкіл, дитячих садів, інших освітніх установ і їх доступність, а також рівень освіти і кваліфікації персоналу. Наступними по важливості параметрами оцінки соціально-економічного розвитку можуть служити постачання продуктами харчування, контроль за їх якістю, дотримання прав споживачів на роздрібному ринку. Рівень фізичного і психічного здоров'я населення, тривалість життя, рівень розвитку системи охорони здоров'я і її доступність, стан навколишнього середовища, також важливі оцінні критерії соціально-економічного розвитку країни.

У поняття соціально-економічного розвитку входить і таке поняття, яке складно виміряти, як культура життя населення. Позитивна динаміка економічного розвитку можлива лише за умови збагачення культурного життя населення [25].

Соціально-економічний розвиток країни лише тоді має позитивну динаміку, коли за інших рівних умов розширюється особиста свобода кожного, у тому числі і в економічній сфері, що можливо при ефективній підтримці малого і середнього бізнесу, антимонопольних заходах, захисті прав споживачів, забезпеченні реальної свободи пересувань, яка забезпечується розвиненим ринком житла.

Загальні закономірності світового економічного розвитку дають можливість якісно оцінити передісторію і перспективу економічного розвитку того або іншого регіону, країни. За рівнем домінування галузей промисловості можна виділити регіони доіндустріальні, індустріальні і постіндустріальні. У регіонах, які знаходяться на різних стадіях розвитку, відбуваються різні за своєю суттю процеси, і до них застосовні різні рецепти управління процесом економічного розвитку. Наскільки вся інфраструктура регіону здатна прийняти нові види бізнесу і нових людей, наскільки швидко і ефективно вона може пристосуватися до нових умов. Все це визначає потенціал постіндустріального розвитку [19].

Управління соціально-економічним розвитком регіону може здійснюватися за допомогою різноманітного спектру стратегій, програм, конкретних дій і одноразових управлінських рішень, за допомогою яких місцева адміністрація прагне стимулювати розвиток економіки регіону, створити нові робочі місця, збільшити податкову базу, розширити можливості для певних видів економічної активності, в

яких зацікавлено населення регіону. Практичне вирішення проблем життєдіяльності, розвитку і соціально-економічного розвитку країни обумовлює актуальність і настійну необхідність їх системного дослідження з цілями: формування вимог державної політики регіонального розвитку; визначення вимог до перспективних форм і способів діяльності регіональних органів влади.

Головними етапами забезпечення соціально-економічного розвитку країни є: визначення цілей, вибір стратегій, розробка і реалізація цільових програм. Стратегія при цьому характеризує загальний напрям, слідуючи якому потрібно шукати шляхи досягнення цілей, або комбінацію цих напрямів, а програма розглядається як сукупність заходів, направлених на реалізацію стратегії і цілей. Таким чином, перехід до стратегій здійснюється безпосередньо від цілей, які необхідно досягти даній системі в проблемній ситуації [12].

Системний підхід зумовлює загальну схему забезпечення соціально-економічного розвитку країни, яка визначається тією принциповою особливістю, при якій об'єктом управління стає вирішення неструктурованих або слабко структурованих проблем в життєдіяльності регіону. В ході вирішення таких проблем необхідно виконати п'ять принципових завдань: дати повний опис проблемної ситуації; досліджувати можливі шляхи вирішення проблеми; розробити (вибрати) стратегії вирішення проблеми; сформувати комплекс заходів програми вирішення проблеми; розробити цільову програму і управління її реалізацією.

Перше завдання – аналіз проблемної ситуації. Воно передбачає опис основних елементів: проблемній ситуації в системі стратегічного розвитку країни, проблемної підсистеми, чинників, наслідків, зовнішніх умов, а також внутрішніх характеристик системи. Характерною особливістю аналізу проблем соціально-економічного розвитку на регіональному рівні є те, що він здійснюється в умовах обмеженої інформації про характеристики об'єктів, так або інакше пов'язаних з існуванням проблеми і її рішенням. Тому більшість кількісних оцінок, що описують структуру проблеми соціально-економічного розвитку і шляху її рішення, носитимуть експертний оцінний характер.

З позицій пропонованого підходу вся система соціально-економічного розвитку на регіональному рівні розглядається як проблемна

система, у функціонуванні підсистем якої виявлена неефективність, що виражається в низьких значеннях параметрів діяльності всієї системи [15]. Перелік і рівні цих параметрів є однією з найважливіших характеристик проблемної ситуації.

За обумовленістю виникнення проблемної ситуації існуючі проблеми можна розділити на наступні основні види:

проблеми, що виникають в результаті того, що встановлені цілі і завдання не досягаються по причинах незадовільної роботи системи і її підсистем або із-за нереальності поставлених перед системою цілей;

ситуації і проблеми, що виникають по непередбачених обставинах (стихійні лиха, навмисні деструктивні дії і інші обставини по відношенню до даної системи); конфліктні ситуації і питання, які по яких-небудь причинах не можуть бути дозволені в установленому порядку;

проблеми, що виникають у зв'язку з тим, що виявлена можливість поліпшення дії системи.

Проблеми першої групи виникають тоді, коли є недоліки в роботі системи, що заважають досягненню мети, або невідповідність цілей.

Перший випадок – діяльність системи соціально-економічного розвитку по тих або інших причинах не відповідає вимогам, що пред'являються.

У другому випадку можуть бути дві причини: перша – це зміна зовнішніх або внутрішніх умов по відношенню до даної системи і друга – це встановлені системою цілі є або легко досяжні, або ледве досяжні [14].

Проблемні ситуації, що виникають в процесі управління регіональним розвитком, і витікаючи з них проблеми і методи їх розгляду є своєрідним класом, мало вивченим теоретично. Разом з тим вони практично щодня вирішуються керівниками різних рівнів.

Представляється доцільним всі проблеми, що виникають в процесі соціально-економічного розвитку країни, за принципом їх розгляду і рішення розділити на дві великі групи: перша – проблеми, що формалізуються, базуються на аналітичному типі мислення, використанні існуючих методів; друга – що не формалізуються, вирішення яких засноване на творчому підході і мисленні.

Характерною особливістю вирішення проблем першої групи є застосування математичного апарату, логіко-математичних методів, законодавства, правил, розпоряджень, норм, використання експериментів.

Для вирішення другої групи проблем немає стандартних шляхів і готового знання. Існує багато шляхів і підходів для їх дослідження, і кількість альтернативних рішень може бути украй великою [11]. Якісь з цих рішень будуть кращі, якісь гірше, можливо, краще рішення буде знайдено в майбутньому.

Аналіз проблемної ситуації визначає формулювання проблеми, яка може бути різною в силу неоднозначності її опису через суб'єктивність характеру сприйняття даної проблемної ситуації особою або групою осіб, що обумовлене їх цілями і інтересами, а також минулим досвідом (рис. 1).

Формулювання проблеми є найбільш важливим ступенем у вирішенні проблеми соціально-економічного розвитку країни. Процес формулювання проблеми достатньо складний, оскільки на підставі поверхневого ознайомлення з проблемною ситуацією неможливо точно сформулювати проблему.

Комплексні проблеми в діяльності соціально-економічного розвитку країни характеризуються тим, що взаємини між змінними не завжди ясні або ж носять тимчасовий характер; самі змінні або погано виміряються, або зовсім не виміряються [6].

Зазвичай з кожною проблемною ситуацією пов'язано багато чинників, частина з них відома, частина – невідома. Тому різні особи, що вирішають одну і ту ж проблему, можуть вибрати з одного набору чинників вирішення даної проблеми абсолютно різні. Це може відбутися навіть у тому випадку, коли фахівці, що вирішають проблему (кожен в своїй області), володіють однаковою компетентністю. Це означає, що ніколи не можна бути повністю упевненим в бездоганності вирішення складних проблем, що виникають у сфері управління соціально-економічним розвитком. Завжди потрібна ретельна перевірка правильності і ефективності їх рішення на практиці.

При виробленні проблеми для вирішення необхідно орієнтуватися на кінцевий результат, якого хочуть досягти, враховуючи при цьому, якою ціною буде досягнутий результат, чим доведеться поступитися, які видатки доведеться понести. Дуже важливо зіставити короткострокові наслідки вирішення проблеми і довгострокові результати, які можуть значно відрізнятися як за своїм ефектом, так і за витратами. Часто негайні результати і довгострокові результати знаходяться в кон-

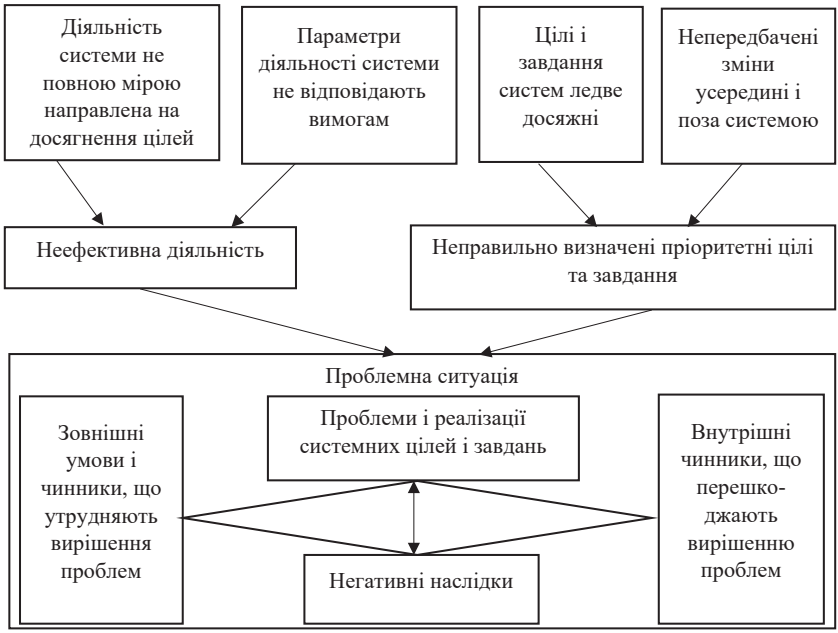


Рис. 1. Загальна схема виникнення проблемної ситуації

флікті між собою, і тому потрібно провести розумний вибір між ними або знайти оптимальний компроміс.

Виділимо основні проблеми, що виникають під час дослідження соціально-економічного розвитку системи.

Різні недоліки в управлінні соціально-економічним розвитком країни часто є наслідком недостатності або невчасності надходження необхідною для ухвалення рішень інформації, хоча загальний об'єм інформації весь час збільшується [17]. Від її надмірної великої кількості страждають перш за все керівники, оскільки саме вони ухвалюють рішення на основі тієї інформації, яку мають в своєму розпорядженні. Але справа не тільки в збільшенні об'єму інформації. У наш час зросла складність інформаційного пошуку, тобто необхідну корисну інформацію стає все важчим виділити в загальному потоці. Таким чином, в проблемі підвищення оперативності соціально-економічного розвитку виділяється підпроблема – інформаційна, яка в першу чергу стосу-

ється питання отримання керівництвом інформації щодо проблем, що вимагають ухвалення стратегічного рішення.

Також однією з найбільш актуальних продовжує залишатися проблема оцінки ефективності системи стратегічного розвитку в цілому.

Не дивлячись на певні заділи у виробленні чітких уявлень про категорію ефективності, ще не вирішено багато питань. Ключовим моментом тут є побудова системи узгоджених критеріїв і показників ефективності, що дозволяють достатньо повно оцінювати ступінь досягнення цілей захисту життєво-важливих інтересів особи, підприємства, регіону та суспільства в цілому [20].

Міжнародні організації оцінюють ступінь розвитку країн і регіонів за деякими універсальними інтегральними показниками. Одним з таких показників є індекс розвитку людини, розроблений в рамках Програми розвитку ООН. Даний показник дозволяє отримати ранги країни по висхідній від 0 до 1. При цьому для розрахунку використовуються три показники економічного розвитку: очікувана тривалість життя при народженні; інтелектуальний потенціал (письменність дорослого населення і середня тривалість навчання); величина душового доходу з урахуванням купівельної спроможності валюти і зниження граничної корисності доходу [9].

У міжрегіональному порівнянні, точно так, як і в міжнародному аналізі, можна використовувати індекс розвитку людини і інші аналогічні показники. Разом з інтегральними показниками можуть бути використані і окремі приватні показники розвитку регіону. Серед них: національний дохід на душу населення; рівень споживання окремих матеріальних благ; ступінь диференціації доходів; тривалість життя; рівень фізичного здоров'я; рівень освіти; і ін.

Критерії економічного розвитку не завжди грають роль цілей або цільових орієнтирів. Часто на передній план виступають тактичні завдання регіонального розвитку, які є необхідними умовами соціально-економічного розвитку країни. Серед таких тактичних цілей розвитку країни можна назвати: залучення нових видів бізнесу; розширення існуючого бізнесу; розвиток малого бізнесу; розвиток промисловості; розвиток сфери послуг; підвищення рівня зайнятості населення регіону.

Особливу роль у визначенні рівня економічного розвитку країни відіграють традиційні показники, що оцінюють рівень виробництва і

споживання благ і зростання цього рівня з розрахунку на душу населення (валовий національний дохід (ВНП), валовий внутрішній продукт (ВВП), реальний ВНП на душу населення, темпи зростання цих показників) [21–22].

Для оцінки динаміки розвитку доцільно використовувати показники, що оцінюють темпи економічного зростання в країні: темпи зростання душового доходу, продуктивності праці, а також темпи структурної трансформації виробництва і суспільства. Вплив на темпи економічного зростання – життєво важливе питання для економічної політики як країни в цілому, так і окремого регіону.

Однак, тільки економічні показники, якими є ВВП, душовий дохід, продуктивність праці і темпи їх зростання, не можуть повною мірою оцінити соціально-економічний розвиток країни. Не менш важливі показники тривалості життя, рівня здоров'я населення, ступені його освіти і кваліфікації, а також показники структурних змін у виробництві і суспільстві.

Величиною, яка характеризує рівень соціально-економічного розвитку територій у даному дослідженні, є значення інтегрального показника, аналогічного індексу людського розвитку, за структурою та обсягом адаптованого до статистичних даних, які характеризують різні аспекти соціального та економічного розвитку територій. В результаті опрацювання вітчизняного та зарубіжного досвіду, використання системного підходу до оцінки територій як складних соціально-економічних систем, врахування реальних можливостей отримання необхідних даних та оцінки доступних методів аналізу і прогнозування пропонується для оцінювання соціально-економічного розвитку територій в межах країн членів ЄС використовувати наступні 7 груп показників: демографічного розвитку; екологічного розвитку; економічного розвитку, енергоспоживання; соціального середовища; умов проживання; фінансового розвитку.

Після проведення детального аналізу знайдених матеріалів було знайдено основні показники які б цілому відображали становище досліджуваної групи показників (табл. 1) [1; 2; 27].

Статистичний аналіз наведених показників виконується за відомими методиками [13], однак кількість спостережень часто буває недостатньою для коректного застосування цих методик. При збіль-

Таблиця 1

Основні показники, що відображують 7 груп показників оцінювання соціально-економічного розвитку територій

Група показників	Складові групи
демографічного розвитку	рівень смертності; природний приріст населення; міграційний приріст населення
екологічного розвитку	викиди в атмосферу від стаціонарних джерел забруднення, тис. т; викиди в атмосферу від пересувних джерел забруднення, тис. т
економічного розвитку	валова продукція сільського господарства, дол. США; обсяг реалізованої продукції промисловості, дол. США; виробництво, додана вартість; імпорт товарів та послуг дол. США; обсяг реалізованих послуг, дол. США; експорт товарів та послуг, до. США.
енергоспоживання	споживання енергії (кг нафтового еквіваленту на душу населення); споживання електроенергії (кВт * год на душу населення); споживання енергії викопним паливом (% від загального обсягу); споживання відновлюваної енергії (% від загального кінцевого споживання енергії).
соціального середовища	рівень зареєстрованого безробіття, %; кількість працюючого населення працездатного віку, осіб; інші, зайняті економічною діяльністю, осіб; персонал Збройних Сил (% від загальної кількості робочої сили); умисні вбивства (на 100 000 людей); витрати на охорону здоров'я, загальна (% від ВВП); міжнародний туризм, кількість виїздів до чисельності населення; кількість лікарів усіх спеціальностей, осіб; кількість медичного персоналу, осіб; кількість лікарняних ліжок, одиниць; очікувана тривалість життя при народженні, загальна (років); охоплення дітей дошкільними закладами освіти; заробітна плата та найманих працівників, загальна (% від загальної зайнятості);
соціального середовища	кількість студентів вищих навчальних закладів, осіб; кількість учнів загальноосвітніх шкіл, осіб; всі компенсації працівникам освіти, загальна (% від загальних витрат у державних установах).

(Закінчення таблиці 1)

Група показників	Складові групи
умов проживання	фіксована передплата на телефон (на 100 осіб); наявний дохід населення, дол. США; щільність населення (люди на квадратний кілометр земельної ділянки).
фінансового розвитку	ВВП на душу населення дол. США; чисті податки на товари (поточний LCU); ВНД на душу населення дол. США; чисті податки на продукти (постійна LCU); гранти та інші доходи (% доходу); податкові надходження, дол. США; видатки на духовний і культурний розвиток, дол. США; видатки на соціальний захист населення; державні видатки на освіту, загальна (% ВВП); індекс споживчих цін (2010 р. = 100); інші видатки, дол. США; валове формування основного капіталу, дол. США; прямі іноземні інвестиції, дол. США.

шенні кількості спостережень за рахунок зменшення їх періодичності (поквартально або й помісячно) оцінювання і прогноз можна було б виконати коректно, але отримати такі дані можна лише в ручному режимі з друкованих джерел.

Часто спостерігається ситуація, при якій відповідальні стратегічні рішення у ряді випадків ухвалюються за шаблоном, на основі якісного аналізу аналогічних ситуацій у минулому або на основі «здорового глузду» [15]. Тим часом часто події, що розвиваються у сфері управління, характеризуються складністю і швидкістю зміни, і тоді шаблон при виробленні рішень стає безсилим, а покладання надії лише на «здоровий глузд» може призвести до серйозних помилок.

У таких випадках сучасна наука рекомендує удаватися до математичних моделей обґрунтування варіантів рішень, що реалізовуються за допомогою технічних обчислювальних засобів. На жаль, органи управління ще слабо оволоділи цими методами вироблення рішень, а керівники ще не прониклись довірою до них.

Використання результатів математичного моделювання дає змогу обґрунтовувати управлінські рішення під час планування розвитку територій, пов'язані з оцінюванням та прогнозуванням стану соціально-економічного розвитку шляхом обчислення змін значення інтегрального показника розвитку на основі доступних статистичних

даних; прогнозування значення інтегрального показника на майбутні періоди з урахуванням наявних в процесі розвитку тенденцій; моделювання впливу змін значень статистичних показників на значення інтегрального показника та оцінювання на цій підставі якості управлінських рішень.

Значення усіх показників отримуються в абсолютних величинах, оскільки обчислення приростів та індексів нескладно виконати в процесі обробки даних, а дані щодо рівня смертності наводяться лише у відносному виразі.

3. Розрахунок та аналіз показників соціально-економічного розвитку за допомогою групових та загальних інтегральних показників

Інтегральний показник соціально-економічного розвитку є величина, яка дозволяє виконати порівняльне оцінювання стану розвитку різних територій між собою та з узагальненим (усередненим) показником по області. Таке використання інтегрального показника передбачає оцінювання нормованих значень вхідних величин і, таким чином процедура обчислення нормованих значень є визначальною [4; 7].

Алгоритм розрахунку групового інтегрального показника включає в себе:

1) знаходження відповідних значень показника за необхідний період;

2) розрахунок мінімального значення показника за певний рік;

3) розрахунок максимального значення показника за певний рік;

4) розрахунок групового інтегрального показника в залежності від його впливу, стимулятор чи дестимулятор:

$$y_{ij}^{c} = \frac{z_{ij} - z_{min}}{z_{max} - z_{min}},$$

$$y_{ij}^{d} = 1 - \frac{z_{ij} - z_{min}}{z_{max} - z_{min}}, \qquad (1)$$

де y_{ij}^{c}, y_{ij}^{d} – стандартизоване значення і-го показника в j-й період часу,

z_{ij} – значення і-го показника в j-й період часу;

z_{min} – мінімальне значення і-го показника в j-й період часу;

z_{max} – максимальне значення і-го показника в j-й період часу.

Алгоритм розрахунку загального групового інтегрального показника включає в себе:

1) розрахунок показників групового інтегрального показника (1);

2) підбір коефіцієнтів для кожного показника в групі;

3) розрахунок сум по кожному показнику за певний рік;

4) розрахунок загального групового інтегрального показника після проведення попередніх розрахунків за формулою:

$$y_j = \frac{1}{j} * \left(p_i * \sum_{i=1}^{j} y_{ij}^c + p_i * \sum_{i=1}^{j} y_{ij}^d \right), \quad (2)$$

де Y_j – інтегральний показник соціально-економічного стану в j-й період часу;

j – кількість досліджуваних країн;

p_i – ваговий коефіцієнт і-го показника в групі.

Алгоритм розрахунку загального синтетичного інтегрального показника включає в себе:

1) розрахунок загального групового інтегрального показника (2),

2) підбір вагових коефіцієнтів для кожної аналізуємої групи;

3) розрахунок загального синтетичного інтегрального показника після проведення попередніх розрахунків за формулою:

$$Y_j = w_i * \sum_{i=1}^{j} y_j, \quad (3)$$

де Y_j – інтегральний показник соціально-економічного стану в j-й період часу,

w_i – ваговий коефіцієнт і-го показника групи.

Хоча існують інші модифікації цього алгоритму (наприклад, на основі розрахунку відхилень від середніх величин), але обчислення за формулами (1–3) забезпечують достатню диференціацію показників, і тому саме за цим алгоритмом обчислювались значення інтегрального показника у цьому дослідженні [24].

Треба відзначити, що результати обчислення інтегрального показника значною мірою залежать від способу оцінювання впливу показників на кінцевий результат. Це стосується критеріїв віднесення показників до стимуляторів чи дестимуляторів. Це питання повинно вирішуватись експертами на місцях.

Зокрема, результатом експертного оцінювання повинно бути встановлення впливу показників групи "енергоспоживання". Зростання енергоспоживання усіх носіїв є безвідносно до конкретної території та реальних умов індиферентним чинником. Однак таке зростання можна вважати стимулюючим фактором, якщо результатом цього зростання є збільшення випуску продукції, запровадження сучасних технологій чи зростання продуктивності праці.

Натомість, якщо єдиним результатом є підвищення рівня забруднення довкілля та створення умов для подальшого екстенсивного розвитку економіки, то безумовно зростання значення цих показників треба вважати дестимулюючим чинником. Отже, це питання повинно вирішуватись лише шляхом експертного оцінювання впливу цих чинників на розвиток конкретних територій.

Неоднозначним є також вплив таких показників, як міграційний приріст населення, викиди в атмосферу від стаціонарних та пересувних джерел, кількість лікарів усіх спеціальностей та медичного персоналу, кількість лікарняних ліжок та Очікувана тривалість життя при народженні, загальна.

Після розбиття показників на групи знаходимо їх валові коефіцієнти в групі та групи в цілому (табл. 2).

Критерії були обрані суб'єктивним способом, при якому вибиралися найбільш важливі критерії, що враховують ефективність групи в цілому, завдяки чому й був оцінений валовий коефіцієнт.

Далі використовуємо алгоритм розрахунку групового інтегрального показника, за допомогою якого можна оцінити зміни певної групи показників відповідно до років (табл. 3).

Також здійснимо оцінку зміни певної групи показників відповідно до країн-членів ЄС (табл. 4).

Більш наглядно щорічні зміни в кожній групі можна спостерігати на рис. 2.

Для відображення діапазонів змін інтегрованої оцінки скористаємося шкалою рівня соціально-економічного розвитку країни, згідно з якою пропонуємо розглядати 4 рівня розвитку соціально-економічної системи – високий, середній, низький та критичний. Кожному з цих рівнів відповідає свій діапазон зміни інтегрованої оцінки (табл. 5).

Таблиця 2

Перелік показників для оцінювання стану соціально-економічного розвитку країн членів ЄС

Стимулятор/ Дестимулятор	Показник	Група	Валовий коефіцієнт в групі	Валовий коефіцієнт групи
1	2	3	4	5
Д.	Рівень смертності	Демографічна	0,34	0,11
С.	Природний приріст населення		0,33	
С.	Міграційний приріст населення		0,33	
Д.	Викиди в атмосферу від стаціонарних джерел забруднення, тис. т.	Екологічна	0,40	0,11
Д.	Викиди в атмосферу від пересувних джерел забруднення, тис. т.		0,60	
С.	Валова продукція сільського господарства, дол. США	Економічна	0,20	0,11
С.	Обсяг реалізованої продукції промисловості, дол. США		0,20	
С.	Виробництво додана вартість		0,20	
С.	Імпорт товарів та послуг, дол. США		0,10	
С.	Обсяг реалізованих послуг, дол. США		0,20	
С.	Експорт товарів та послуг, дол. США		0,10	
С.	Споживання енергії (кг нафтового еквіваленту на душу населення)	Енергоспоживання	0,30	0,10

(Продовження таблиці 2)

1	2	3	4	5
С.	Споживання електроенергії (кВт * год на душу населення)	Енерго-споживання	0,30	0,10
С.	Споживання енергії викопним паливом (% від загального обсягу)		0,30	
С.	Споживання відновлюваної енергії (% від загального кінцевого споживання енергії)		0,10	
Д.	Рівень зареєстрованого безробіття, %	Соціальне середовище	0,10	0,35
С.	Кількість працюючого населення працездатного віку, осіб		0,07	
С.	Інші, зайняті економічною діяльністю, осіб		0,07	
С.	Персонал Збройних Сил (% від загальної кількості робочої сили)		0,07	
Д.	Умисні вбивства (на 100 000 людей)		0,07	
С.	Витрати на охорону здоров'я, загальна (% від ВВП)		0,03	
С.	Міжнародний туризм, кількість виїздів		0,03	

(Продовження таблиці 2)

1	2	3	4	5
С.	Кількість лікарів усіх спеціальностей, осіб	Соціальне середовище	0,07	0,35
С.	Кількість медичного персоналу, осіб		0,06	
С.	Кількість лікарняних ліжок, одиниць		0,06	
С.	Очікувана тривалість життя при народженні, загальна (років)		0,06	
С.	Охоплення дітей дошкільними закладами освіти		0,06	
С.	Заробітна плата та найманих працівників, загальна (% від загальної зайнятості)		0,06	
С.	Кількість студентів вищих навчальних закладів, осіб		0,06	
С.	Кількість учнів загальноосвітніх шкіл, осіб		0,06	
С.	Всі компенсації працівникам освіти, загальна (% від загальних витрат у державних установах)		0,07	
С.	Фіксована передплата на телефон (на 100 осіб)	Умови проживання	0,33	0,12
С.	Наявний дохід населення, дол. США		0,34	

С.	Щільність населення (люди на квадратний кілометр земельної ділянки)	Умови проживання	0,33	0,12
С.	ВВП на душу населення, дол. США	Фінансові	0,09	0,10
С.	Чисті податки на товари (поточний LCU)		0,09	
С.	ВНД на душу населення, дол. США		0,09	
С.	Чисті податки на продукти (постійна LCU)		0,06	
С.	Гранти та інші доходи (% доходу).		0,06	
С.	Податкові надходження, дол. США		0,08	
С.	Видатки на соціальний захист населення		0,06	
С.	Видатки на духовний і культурний розвиток, дол. США		0,09	
С.	Державні видатки на освіту, загальна (% ВВП)		0,09	
С.	Індекс споживчих цін (2010 р. = 100)		0,09	
С.	Інші видатки, дол. США		0,06	
С.	Валове формування основного капіталу, дол. США		0,07	
С.	Прямі іноземні інвестиції, дол. США		0,07	

Таблиця 3

Значення групового інтегрального показника впродовж 2010–2019 років

Група	Значення групового інтегрального показника									
	2010	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**
Демографічна	0,38	0,38	0,37	0,40	0,37	0,35	0,28	0,30	0,31	0,31
Екологічна	0,80	0,81	0,81	0,81	0,81	0,82	0,83	0,82	0,83	0,83
Економічна	0,17	0,17	0,17	0,16	0,16	0,16	0,16	0,16	0,16	0,16
Енергоспоживання	0,39	0,39	0,40	0,41	0,40	0,40	0,41	0,41	0,42	0,42
Соціальне середовище	0,45	0,44	0,44	0,44	0,44	0,43	0,44	0,45	0,44	0,45
Умови проживання	0,48	0,49	0,47	0,47	0,47	0,48	0,48	0,48	0,49	0,49
Фінансова	0,34	0,33	0,37	0,41	0,36	0,38	0,38	0,38	0,37	0,40

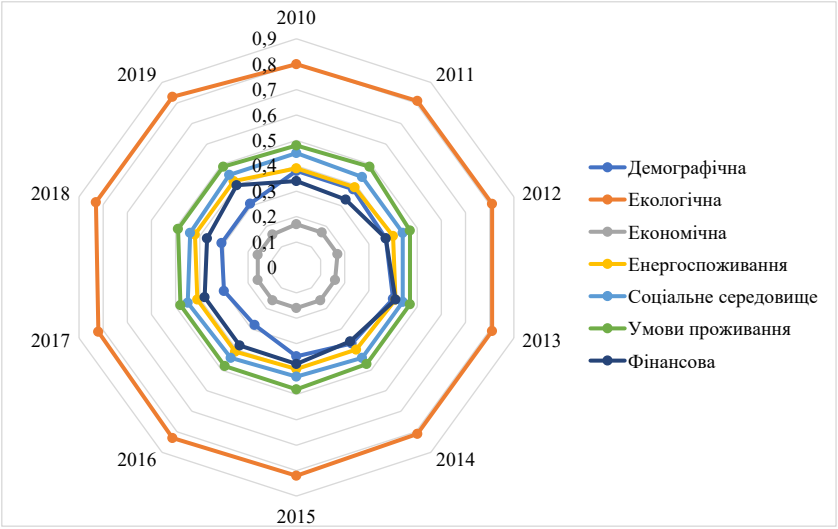


Рис. 2. Графік значень загального групового інтегрального показника по рокам (2010–2019)

Таблиця 4

Значення загального групового інтегрального та загального синергетичного показника по країнам

Країна	Демографічний	Екологічний	Економічний	Енергоспоживання	Соц. середовища	Умов проживання	Фінансовий	Загальний
Австрія	0,412	0,895	0,113	0,497	0,508	0,510	0,415	0,486
Бельгія	0,445	0,834	0,137	0,504	0,477	0,454	0,386	0,466
Болгарія	0,074	0,955	0,018	0,317	0,414	0,399	0,274	0,367
Великобританія	0,524	0,362	0,505	0,389	0,559	0,561	0,447	0,499
Угорщина	0,155	0,943	0,054	0,285	0,371	0,413	0,504	0,385
Греція	0,321	0,874	0,081	0,385	0,412	0,565	0,323	0,423
Данія	0,400	0,939	0,081	0,412	0,454	0,526	0,435	0,462
Естонія	0,357	0,991	0,004	0,270	0,299	0,467	0,338	0,370
Ірландія	0,790	0,941	0,086	0,406	0,435	0,557	0,336	0,493
Іспанія	0,429	0,527	0,419	0,361	0,440	0,520	0,344	0,438
Італія	0,297	0,414	0,566	0,380	0,574	0,439	0,380	0,470
Кіпр	0,598	0,985	0,003	0,342	0,398	0,521	0,362	0,447
Латвія	0,220	0,991	0,007	0,275	0,255	0,382	0,295	0,326
Литва	0,162	0,982	0,013	0,296	0,332	0,370	0,304	0,348
Люксембург	0,767	0,981	0,016	0,837	0,417	0,588	0,443	0,538
Мальта	0,424	0,997	0,002	0,365	0,440	0,622	0,361	0,457
Нідерланди	0,456	0,754	0,261	0,527	0,491	0,431	0,452	0,483
Німеччина	0,292	0,000	0,907	0,467	0,695	0,618	0,466	0,542
Польща	0,288	0,697	0,162	0,365	0,427	0,350	0,313	0,386
Португалія	0,277	0,916	0,061	0,343	0,435	0,502	0,337	0,418
Румунія	0,171	0,907	0,086	0,257	0,431	0,346	0,244	0,370
Словакія	0,329	0,968	0,037	0,333	0,355	0,335	0,289	0,373
Словенія	0,365	0,980	0,013	0,392	0,440	0,506	0,310	0,434
Фінляндія	0,373	0,920	0,077	0,709	0,433	0,384	0,458	0,465
Франція	0,535	0,362	0,657	0,351	0,643	0,650	0,454	0,554
Хорватія	0,273	0,971	0,018	0,310	0,372	0,491	0,306	0,389
Чехія	0,322	0,902	0,071	0,446	0,441	0,338	0,356	0,417
Швеція	0,490	0,897	0,138	0,585	0,431	0,586	0,459	0,493

Таблиця 5

Шкала ранжування регіонів відповідно до інтегрованої комплексної оцінки рівня їх соціально-економічного розвитку

Рівень соціально-економічного розвитку	Діапазон зміни інтегрованої оцінки, %
Високий	75-100
Середній	50-74
Низький	25-49
Критичний	0-24

Проводимо розрахунки згідно алгоритму знаходження загального синтетичного інтегрального показника (табл. 6) та спостерігаємо його постійні зміни (рис. 3).

Таблиця 6

Значення загального синтетичного інтегрального показника

2010	2011	2012	2013	2014	2015	2016	2017	2018	2019
0,437	0,4345	0,4368	0,4430	0,4357	0,4336	0,4308	0,4346	0,4353	0,4409

Згідно отриманих результатів можна зробити висновок, що рівень соціально-економічного розвитку відповідає низькому рівню, але за останні 4 роки помітно зростання. Це свідчить про стабільність в управлінні та постійне покращення рівня соціально-економічного розвитку.

Згідно ранжування, найкращу оцінку має група Екологічного розвитку, яка відноситься до високого рівня. Таке високе значення даного показника означає, що в даному випадку Європейський союз та його країни-члени зацікавлені в забезпеченні чистоти довкілля, яке в свою чергу буде сприяти покращенню інших груп.

Найменш ефективна економічна група. Насамперед це пов'язано з тим, що економічно дані країни забезпечені по різному, тому даний показник має таку низьку оцінку. Також це пов'язано з кризою 2008–2013, через яку світова економіка зазнала великих збитків.

Всі інші групи попали до рангу низького рівня, в основному через те, що в реальному житті 100 відсоткового розвитку досягнути неможливо. Тому на нашу думку, дані значення відображають реальну картину соціально-економічного розвитку країн Європейського Союзу в продовж 2010–2019 років.

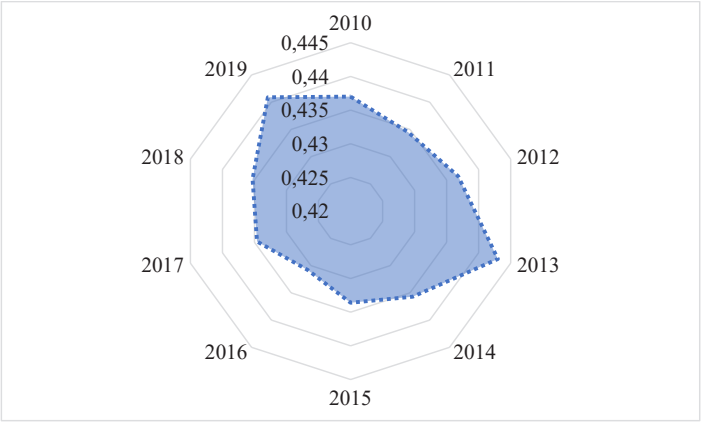


Рис. 3. Графік загального синтетичного інтегрального показника по рокам (2010–2019)

Проводимо аналогічний розрахунок використовуючи алгоритм розрахунку загального інтегрального показника, обираючи за основний елемент оцінки країни (рис. 4).

Результати розрахунку загального синергетичного інтегрального показника по країнам відображено на рис. 5.

Згідно проведеним розрахункам, можна говорити про те, що загальний синергетичний інтегральний показник по рокам займає низький рівень, хоча й поступово наближається до середнього. Незважаючи на кризові явища, ми спостерігаємо позитивну динаміку, яка відображає добре сплановані управлінські рішення. Найвищим даний показник був у 2010 році, та становив 0,44304. Найменшим же в 2016 і становить 0,43080. Такі значення говорять про те, що за період кризи було прийнято чимало рішень, які дозволили в цілому покращити становища країн-членів, але не зважаючи на все це іноді трапляються різноманітні соціальні явища, що можуть впливати на розвиток країни. Насамперед через ці причини ми спостерігаємо такі дані.

Згідно рис. 5 за останні 10 років (з 2010 по 2019) до середнього рівня соціально-економічного розвитку можна віднести Австрію, Великобританію, Ірландію, Люксембург, Німеччину, Францію та Швецію. Всі

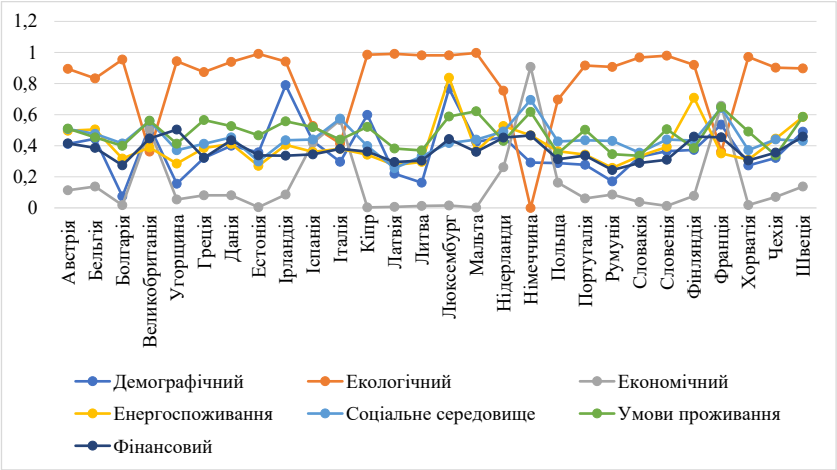


Рис. 4. Графік значень групового загального інтегрального показника по країнам

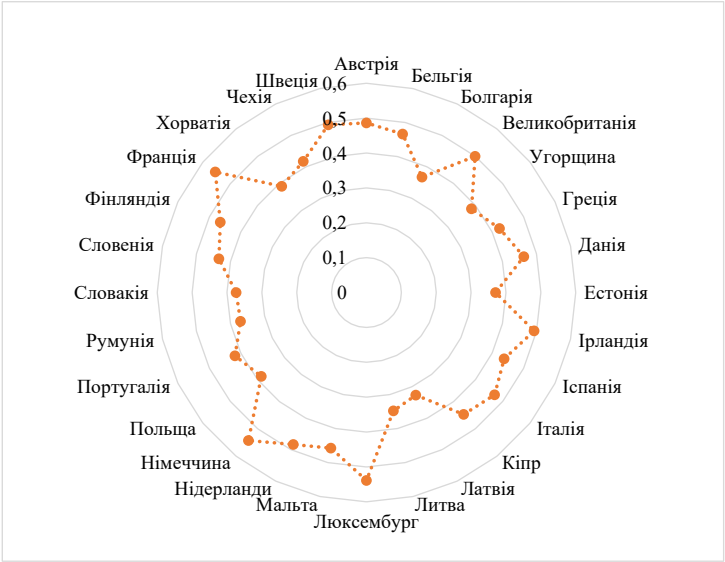


Рис. 5. Графік загального синтетичного інтегрального показника по країнам

інші можна віднести до низького рівня. Тобто, 25% усіх розглянутих країн мають середній рівень соціально-економічного розвитку.

Згідно даним синергетичним показникам можна зробити висновок, що не зважаючи на те, що 75% краї мають низький рівень, вони постійно проводять ряд реформ для покращення свого становища, та утримання стабільних позицій під час кризових явищ.

4. Прогнозування зміни становища соціально-економічного розвитку країн Європейського союзу

Зв'язок між математичною схемою моделі і реальним процесом забезпечується поєднанням у моделі інформації двох типів:

апріорі логічно обґрунтованих гіпотез щодо природи та характеру властивостей процесу, співвідношень і взаємозв'язків між ними;

емпіричних даних, які характеризують ці властивості.

Модель встановлює відповідність між сукупністю фактів і гіпотезами, імітує механізм формування закономірностей. На моделях проводяться експерименти, результати яких поширюються на реальність. Основна вимога, що ставиться до моделі, – подібність, адекватність її реальному процесу.

Логіка статистичного моделювання дозволяє умовно виділити в процесі моделювання наступні етапи:

1) характеристика мети та об'єкта моделювання;
2) розвідувальний аналіз даних;
3) математична формалізація моделі;
4) оцінювання параметрів моделі;
5) перевірка адекватності моделі;
6) аналіз та інтерпретація результатів.

На першому етапі визначаються мета та об'єкт моделювання. Мета – це кінцеве призначення моделі. Скажімо, діагностика процесу, аналіз механізму його формування, тенденцій розвитку тощо. Залежно від мети дослідження один і той самий процес можна описати різними моделями.

Об'єктом моделювання виступає статистична сукупність, в якій реалізується закономірність. Формально будь-яку сукупність можна представити у вигляді впорядкованого набору даних з параметрами n, m, T, де n – кількість елементів сукупності (j = 1, 2, ..., n), m – кількість зареєстрованих у j-го елемента ознак (i = 1, 2,..., m), T – календарний

термін періоду з певними квантами часу (рік або місяць). Отже, інформаційна одиниця об'єкта моделювання – значення і-ї ознаки у j-го елемента сукупності у t-му періоді – xijt.

Якщо сукупність вивчається в статиці, то інформація представляється матрицею n x m, якщо в динаміці, то матрицею T x m.

Характеристика об'єкта моделювання включає такі моменти:

вибір одиничного елемента сукупності – носія характерних для закономірності рис;

визначення просторових і часових меж об'єкта моделювання;

формування ознакової множини моделі.

При формуванні ознакової множини X вирішальну роль відіграють експертні оцінки значущості та інформативності окремих ознак, враховується можливість їх точного вимірювання, діапазон варіації, трудомісткість збирання інформації [23].

У статистичному моделюванні сукупність завжди розглядається як вибірка – класична чи гіпотетична. Класична вибірка – це частина реальної генеральної сукупності, відібрана для обстеження за принципами вибіркового методу. Гіпотетична генеральна сукупність оперує не кількістю елементів, а кількістю можливих наслідків функціонування об'єкта моделювання в одних і тих самих умовах. Отже, фактичні дані, навіть якщо вони є результатом суцільного обстеження сукупності, розглядаються як випадкові реалізації стохастичного, непередбачуваного процесу. Це дає підстави для ймовірнісного оцінювання результатів моделювання.

Завдання ймовірнісного оцінювання – встановити, наскільки виявлена закономірність позбавлена випадкових впливів, наскільки вона характерна для того комплексу умов, у яких функціонує об'єкт моделювання. Якісна своєрідність і неповторність статистичних сукупностей потребує інтерпретації цих оцінок щодо конкретних умов. В окремих випадках імовірнісне оцінювання результатів суцільного спостереження недоречне, скажімо, при визначенні рейтингів окремих елементів сукупності. Проте мета конкретного дослідження не може відкинути правомірність використання таких оцінок.

Розвідувальний аналіз даних передбачає:

статистичне описування об'єкта – визначення середніх, стандартних відхилень, інших характеристик розподілу;

уніфікацію типів ознак, приведення їх до одного виду;

тестування сукупності на однорідність, ідентифікацію аномальних спостережень;

відтворення пропущених даних;

оцінювання взаємозв'язків між ознаками.

Оцінювання параметрів моделі – це етап комп'ютерної обробки даних. Система MS Excel надає широкі можливості експериментування, розвідки, графічного відображення і поглибленого аналізу даних, у якій сучасні методи статистичного моделювання та прогнозування реалізовані з використанням новітніх комп'ютерних технологій.

Перевірка адекватності моделі означає оцінювання ступеня відповідності параметрів моделі характеристикам об'єкта. На цьому етапі використано різні процедури порівняння модельних висновків, перевірки статистичних гіпотез за допомогою статистичних критеріїв. Перевірка адекватності моделі має сенс лише щодо мети дослідження і не може бути абстрактною.

Заключний етап моделювання – аналіз та інтерпретація результатів – один із найскладніших і найвідповідальніших [16]. Складність його полягає у тому, що для інтерпретації результатів не існує готових алгоритмів чи рецептів. Єдина спільна для всіх моделей вимога – інтерпретація має узгоджуватися з первинними гіпотезами. Основні висновки формуються в змістовних термінах: зміст параметрів моделі, правильність гіпотез, що перевіряються, оцінювання ступеня їх вірогідності.

Отже, можна сформулювати два принципи статистичного моделювання:

– підпорядкованість меті дослідження на всіх етапах моделювання;

– забезпечення адекватності моделі.

Треба відзначити, що єдино правильної моделі не існує, особливо, якщо йдеться про такі складні об'єкти як соціально-економічні системи. Одну й ту ж залежність можна описати різними моделями. Вибір того чи іншого типу моделі залежить від мети дослідження, специфіки процесу (явища), масштабу об'єкта моделювання, наявної інформації, технічного та програмного забезпечення.

При вивченні функціональних зв'язків між показниками широко використовуються індексні моделі. Основою індексної моделі є мультиплікативний зв'язок між певною множиною показників; один з них розглядається як результат у, інші – як фактори хі.

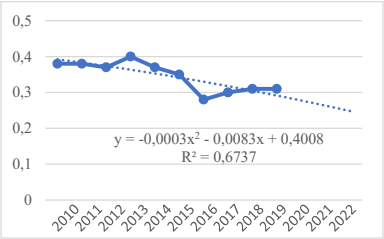
Послідовність факторів у моделі не може бути довільною, вона визначається економічним змістом показників і методикою їх розрахунку. Кожний наступний фактор-множник розраховується на одиницю попереднього, а отже, добуток будь-якої кількості факторів є змістовною величиною.

Суть економетричного моделювання полягає в побудові лінії тренду, визначенні параметрів апроксимуючого многочлена, та аналітичному обчисленні прогнозного значення [16]. Тут усе залежить від вибору способу апроксимації вхідних даних, який можна визначити лише в процесі експлуатації моделі та аналізу великої кількості спостережень і отриманих під час моделювання результатів.

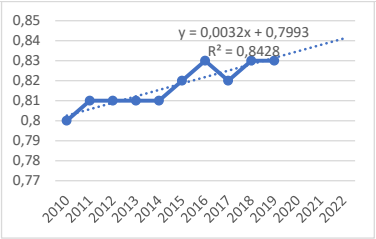
У пропонованому дослідженні були зроблені спроби прогнозування з використанням статистичних моделей. Особливого значення набувають моделі при вивченні закономірностей масових процесів, які недоступні прямому спостереженню і не піддаються експериментуванню. Передусім це стосується соціально-економічних явищ і процесів, закономірності яких формуються під впливом безлічі взаємопов'язаних факторів. Прогнозування було виконано за допомогою побудови лінії тренду та функції прогнозування в MS EXCEL. Результати проведеного прогнозу відображені на рис. 6-8 [16].

Згідно отриманих результатів спостерігаємо постійне зниження демографічного фактору, що говорить про те, що кількість населення, що проживає в країнах ЄС поступово зменшується. Через техногенне і радіоактивне забруднення атмосфери, грунтів, водойомів відбувається мутація ушкодження генів. Наслідком цього є зниження народжуваності, зростання потворності серед новонароджених, поширення спадкових хвороб тощо.

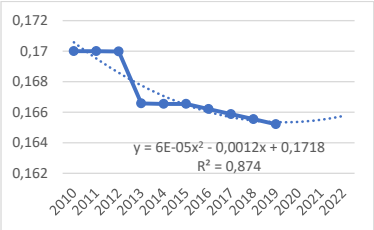
Згідно прогнозам, значення в групі екологічного фактору будуть збільшуватися, що свідчить про постійне проведення додаткових мір по зменшенню забруднення планети, розробки інноваційних технологій та механізмів, які були б екологічно-чистими, і якомога менше забруднювали повітря, ґрунти та водойми. Також для підвищення значень даної групи постійно проходить фінансування державами різноманітних досліджень по переробці сміття та предметів побуту. Додатково вводять нові обмеження стосовно викидів від підприємств, та перехід на електромобілі, які зменшать рівень викидів в повітря та повисить рівень енергоспоживання.



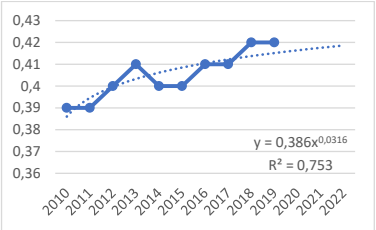
Група демографічного розвитку



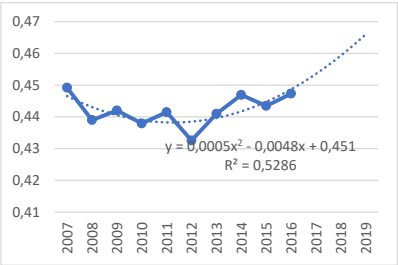
Група екологічного розвитку



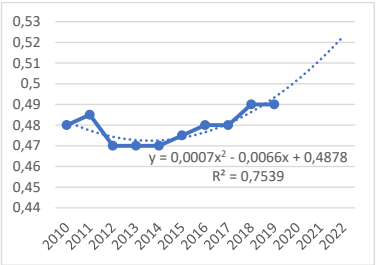
Група економічного розвитку



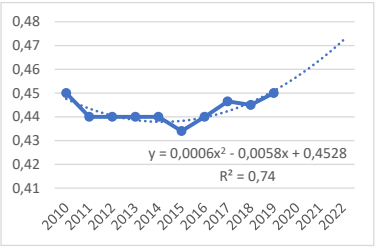
Група енергоспоживання



Група соціального середовища



Група умов проживання



Група фінансового розвитку

Рис. 6. Прогнозування з використанням апроксимації вхідних даних груп показників соціально-економічного розвитку країн ЄС

Згідно отриманих результатів прогнозу видно, що найближчим часом значення економічного фактору буде поступово збільшуватися (хоча й можливий невеликий спад). Це пов'язано з тим, що стратегія розвитку ЄС на найближчі роки направлена на збільшення експорту дорогоцінних товарів, що призводить до кращої платоспроможності країн та їх громадян, а значить і розвитку країни в цілому. Так, більшість країн-членів Європейського союзу майже повністю позбавились наслідків кризи 2008–2013 років. Навіть Греція, в якій було об'явлено дефолт на сьогоднішній день вийшла на профіцит.

Фактор умови проживання відображає наскільки ефективно діє фактор соціального середовища. Він демонструє поступовий ріст покращення умов проживання кожної людини, а саме збільшення вільних коштів на використання, зменшення щільності населення, які дозволять кожному громадянину більше споживати різноманітні блага за рахунок нових резервів накопичень.

По фактору енергоспоживання можна спостерігати постійний ріст, що характеризує постійне збільшення використання різноманітного палива в зв'язку постіндустріальним розвитком суспільства, в зв'язку з цим постійно розвиваються способи отримання відновлюваною енергії сонячної, вітрової та водної, які зможуть забезпечувати нас електроенергією, та зменшать кількість використання палива та забруднення навколишнього середовища. В основному завдяки сонячним панелям.

Уповільнений ріст фактору соціального середовища зумовлений тим, що даний фактор прямо пропорційно відображає середньостатистичний рівень життя кожної людини в країні (освіта, охорона здоров'я, соціальний захист, зайнятість і забезпечення коштами на задоволення благ). Таке зростання символізує усесторонній розвиток та підтримку держави в забезпеченні громадян всім необхідним для життя.

Стабільність фінансового фактору з незначними коливаннями відображає стабільність економічної ситуації та усестороннє регулювання з боку ЄС та інших організацій. Стабільність фінансового сектора говорить про те, що держави ЄС завдяки достатньому фінансовому забезпеченню здатні належним чином виконувати основні функції, такі як фінансове посередництво та здійснення платежів, а також протистояння кризовим явищам. Це свідчить про стабільність та подаль-

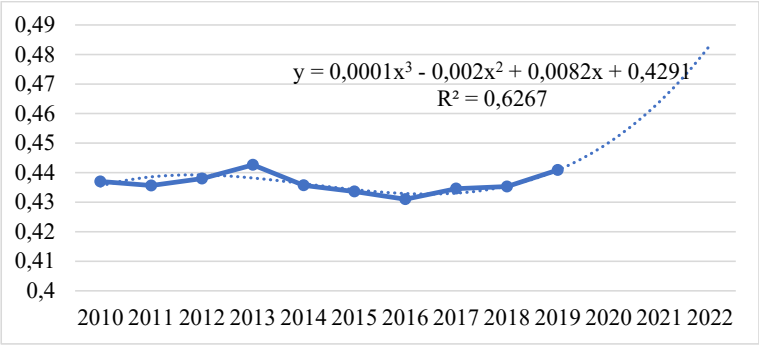


Рис. 7. Прогнозування з використанням апроксимації вхідних даних загального синергетичного інтегрального показника

ший розвиток держав не дивлячись на всі можливі зміни, як позитивні так і негативні.

Згідно проведених досліджень, можна спостерігати коливальну динаміку зміни загального синергетичного інтегрального показника. Здебільшого це пов'язано з економічним кризою, яка розпочалась в 2008 і тривала аж до 2013 року. Незважаючи на це, завдяки своєчасним діям зі сторони Євросоюзу були здійснені всі спроби до налагодження становища країн. І тепер ми спостерігаємо стабільне зростання усіх факторів (крім демографічного, зменшення якого позитивно впливає на всі інші фактори). Загальний розвиток даних країн будем сподіватися й далі буде рости (зокрема Греція, яка дуже сильно постраждала від даної кризи вже погасила головну частину свого боргу, та може далі покращувати рівень соціально-економічного розвитку далі).

На основі отриманих даних можна спостерігати ціле направлену політику Євросоюзу на забезпечення усестороннього розвитку його країн-членів, та допомоги при різноманітних подіях. Це зумовлює вважати що вступ України до Євросоюзу буде нести позитивний ефект на діяльність нашої країни не зважаючи на можливі ускладнення чи зміни. Також потрібно враховувати, що кожна група розглянутих факторів дуже важлива, так як вони представляють собою основне відображенні становища соціально-економічного розвитку, а значить і розвитку країни в цілому.

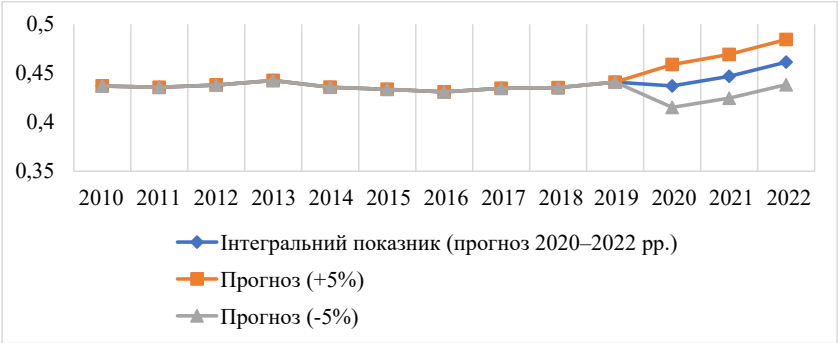


Рис. 8. Графік прогнозу загального синергетичного інтегрального показника

Формування відповідного механізму територіального управління, який повинен складатися з елементів, здатних впливати на всі складові соціально-економічної системи , основними з яких є, передусім, продуктивні сили, до яких відносяться засоби виробництва і люди як основна продуктивна сила. Ефективність використання продуктивних сил залежить від напрямів управлінського впливу та їх узгодженості. Разом з тим формування методів управління соціально-економічними процесами перебуває під впливом національних особливостей матеріального і духовного життя суспільства, які відображають міжособистісні відносини, культуру, традиції та погляди громадян.

Отже, стратегічний підхід забезпечує узгодженість дій різних гілок влади шляхом неперервного взаємного спілкування "згори-вниз" та "знизу-вгору" в межах підпорядкування, відповідальності та звітності, слід вважати, що діє Європейського союзу охоплюють та оцінюють всі можливі ризики та спрямовані на допомогу всіх їх членам у всебічному розвитку, зокрема в підвищенні рівня економічної та соціальної забезпеченості.

5. Висновки

За результатами виконаного дослідження можна зробити наступні висновки:

У вітчизняній практиці методи математичного моделювання використовуються в управлінні або для оцінювання соціально-економічного

розвитку регіонів України на національному рівні, або для оцінювання окремих аспектів територіального розвитку (економічного, екологічного, соціального), або для окремих типів територій (малі міста).

Для оцінювання соціально-економічного розвитку територій можливо і достатньо використовувати дані територіальної статистики, для чого сформовано перелік з 47 показників.

Для обчислення інтегрального показника соціально-економічного розвитку територій доцільно використовувати (з певними модифікаціями та уточненнями) методи, які застосовуються для обчислення індексу людського розвитку за методиками ООН.

Для обробки значень статистичних показників соціально-економічного розвитку територій доцільно залежно від конкретних завдань аналізу використовувати економетричні та статистичні методи.

Значення інтегрального показника соціально-економічного розвитку під час підготовки даних для подальшого використання їх в моделі соціально-економічного розвитку доцільно визначати за методикою, розробленою вітчизняними фахівцями для обчислення індексу людського розвитку. Всі інші проаналізовані методики є значно складнішими в реалізації, але не надають переваг як з погляду точності обчислень, так і з погляду швидкості їх виконання.

Використання запропонованої моделі соціально-економічного розвитку територій поки що малоефективне з огляду на складності отримання необхідних для роботи моделі актуальних даних з доступних офіційних електронних джерел. На сучасному етапі експлуатація буде пов'язана з процесом ручного наповнення бази даних з використанням друкованих та комерційних джерел, що, однак, не зменшує результативності моделі як інструменту підтримки прийняття управлінських рішень стосовно розвитку територій.

У роботі вдалося розрахувати загальний синергетичний інтегральний показник, який відображає ефективність соціально-економічного розвитку країн-членів ЄС, та спрогнозувати, що найближчим часом даний показник буде рости завдяки добре спланованої діяльності держав та все стороннього контролю з боку ЄС. Це позволить підвищити рівень життя населення та бути більш стійкими в період різноманітних криз чи інших соціальних явищ, які можуть негативно вплинути на фінансовий стан і захищеність населення. Так з огляду на плани Укра-

їни вступити до ЄС, можна вважати що це членство принесе позитивний ефект на розвиток держави в цілому, та забезпечить покращення нинішнього рівня соціально-економічного розвитку.

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ORGANIZATION AND IMPROVEMENT OF INTERNAL AUDIT IN THE ENTERPRISE MANAGEMENT SYSTEM

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Abstract. *The purpose of the paper* are the issues related to the organization and improvement of internal audit in the enterprise management system. *Methodology*. The study is based on a dialectical method using a systematic approach to knowledge of economic phenomena, processes inherent in the system of public financial control and internal audit, in particular. The research used general and special methods based on the systematic study of economic phenomena. *Results*. It is determined that internal audit is an assessment of the enterprise in order to provide its owners and management with prompt and unbiased information about the general condition of the entity and the prospects for management decisions. The reason for the development of internal audit in Ukraine was the creation of enterprises with different forms of ownership and the inability of the traditional command-and-control system to perform its functions in the transition to market conditions. Problems of formation and development of internal audit in Ukraine are, firstly, the lack of a central independent body whose competence should be the regulation of internal audit at the macro level, i.e. the development of standards, guidelines for this type of audit, and secondly, the lack of internal documents on the activities of internal auditors. According to the results of the study, the main tasks and directions of the internal audit service are considered. It is proposed to supplement the list of the main activities of the internal audit department with the following items: meeting the needs of management in terms of providing relevant reporting information on various issues arising in the process; support of external control (appropriate control measures by regulatory authorities). Three main types of audit in the public sector are described, as well as types of internal audit in international practice. The types of internal audit in foreign countries, defined in the regulations on internal audit, are

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analyzed. Directions and spheres of internal audit activity were assessed in accordance with national standards. Ways to ensure and improve the quality of internal audit have been identified. The directions of internal audit quality assessment, register of typical violations and shortcomings in the process of drafting internal documents on internal audit quality assessment, performance indicators of the internal audit service, cost of training and certification services provided by the Institute of Internal Auditors of Ukraine are described. *Practical implications* consist in the scientific validity and applied orientation of the provisions, approaches and recommendations given in this study, the use of which will improve the organizational and methodological foundations of internal audit. *Value*/*originality*. Using the model of levels of professional competence of internal auditors presented in this study on the basis of Bloom's taxonomy will allow structuring the levels of thinking and skills of internal audit specialists.

1. Introduction

In modern business conditions, when the activities of enterprises are accompanied by a variety of risks, and external control does not meet the needs of owners and managers of enterprises, there is a need to establish more effective types of control.

In such circumstances, the importance is given to audit activities, thanks to which companies can assess their situation and position and receive recommendations for further action [1].

A special place belongs to internal audit. Its purpose is to ensure the effectiveness of the management staff to protect the property interests of the enterprise, strengthen its financial position and assistance in improving the efficiency of work, as well as improving the accounting system. Internal audit is an important management function, which includes checking the correctness of accounting, analysis and control, comparison and evaluation of the actual result with the goals and objectives of the enterprise. The internal audit service is designed to improve the organization and management of production, to identify and mobilize reserves for its growth in order to improve the final results.

Given the above, there is a need to study and research the problems of internal audit and in particular areas for its improvement in the enterprise management system.

A number of well-known scientists of the world have devoted their works to the study of the theoretical foundations of auditing, in particular: Western ones – R. Adams, E. Arens, K. Mautz, D. Robertson, G. Sharaf; Russian – R. Alborov, V. Andreeva, Y. Dapylovskyi, J. Sokolov, A. Sheremet; Ukrainian – M.T. Bilukha, O.S. Borodkin, F.F. Butynets, B.I. Valuev, N.I. Dorosh, M.V. Kuzhelnyi, O.A. Petryk, N.G. Zdyrko, V.S. Rudnytskyi, B.F. Usach and others. The works of such domestic and foreign scientists as V.V. Burtsev, L. Dragun, V.M. Melnyk, L.O. Sukhareva, T.V. Fomin and other were devoted to the problems of internal audit. Despite the important scientific positions of these authors, a complete concept for improving the internal audit system has not yet been developed.

The purpose of the study is to assess issues related to the organization and improvement of internal audit in the enterprise management system. In the course of the research the following tasks were solved: assessment of the main tasks and directions of the internal audit service; consideration of types of internal audit in international practice; characteristics of directions and spheres of internal audit in accordance with national standards; identifying the ways to ensure and improve the quality of internal audit.

This study is based on a dialectical method using a systematic approach to cognition of economic phenomena, processes inherent in the system of public financial control and internal audit, in particular. The research used general and special methods based on the systematic study of economic phenomena.

2. The main tasks and directions of the internal audit service

Internal audit is an independent, objective activity of providing confidence and consulting services that should benefit the organization and improve its performance.

Internal audit helps the organization to achieve its goals by means of a systematic, ordered approach to assessing and improving the effectiveness of risk management processes, control and corporate governance. The purpose of internal audit in the modern concept, its mission is to preserve and increase the value of the enterprise by providing risk-oriented and objective audit services, consultations and professional opinion [2].

The main objects of internal audit are:

– the state of accounting, tax, management, statistical and other types of accounting of the business entity;

– compliance of approved policies and procedures with current standards;

– state of the entity's assets, conditions of their storage;

– state of settlements for taxes and fees;

– financial statements of the entity and its compliance with quality requirements;

– the system of internal control of the business entity and its condition;

– management system of the business entity and its structure;

– organization and technology of production;

– economic processes;

– labor organization and its payment system;

– labor discipline, use of working time, labor productivity;

– claims work carried out by the business entity;

– financial condition and solvency of the business entity, the level of availability of resources and their use;

– compliance of the business entity's activities with the requirements of the law,

– other normative legal acts, in particular internal ones;

– strategic development plans of the business entity, etc. [2].

Effective internal audit activities are ensured by the implementation of a set of measures and logical sequential procedures by the relevant unit, starting with planning, organization of internal audit and ending with reporting on the results of activities to the management of the institution [3].

However, the central place in this process is occupied directly by conducting internal audits and performing audit tasks.

The main task of the Internal Audit Service is defined by the law – providing the management of the state body with objective and independent conclusions and recommendations regarding:

1) conducts an assessment of:

– the effectiveness of the internal control system;

– the degree of implementation and achievement of goals set in strategic and annual plans;

– efficiency of planning and implementation of budget programs and results of their implementation, management of budget funds;

– the quality of administrative services and performance of control and supervisory functions, tasks defined by legislation;

– use and preservation of assets;

– reliability, efficiency and effectiveness of information systems and technologies;

– management of state property;

– correctness of accounting and reliability of financial and budgetary reporting;

– risks that negatively affect the performance of functions and tasks of the state body, its territorial bodies, enterprises, institutions and organizations belonging to the sphere of its management;

2) plans internal audit activities, organizes and conducts internal audits, documents their results, prepares audit reports, conclusions and recommendations, as well as monitors compliance with recommendations;

3) interacts with other structural subdivisions of the state body, its territorial body and budgetary institution, other state bodies, enterprises, their associations, institutions and organizations on internal audit;

4) submits to the head of the state body, its territorial body and budgetary institution audit reports and recommendations for making appropriate management decisions;

5) reports on the results of activities in accordance with internal audit standards;

6) performs other functions in accordance with its competence [4].

The functions of internal audit are aimed at assisting the manager in managing the process of providing appropriate assessments, guarantees and proposals for improving the internal audit system, rather than participating in the development and implementation of internal control procedures in the institution. In turn, an important condition for the successful functioning of the internal audit service in the institution is the understanding of the management (governing body) of the main activities of the unit and the set of tasks [3].

Given this, the main activities of the internal audit service are as follows (Figure 1):

It should be noted that the detection of fraud, steeling and abuse is not consistent with the direct nature of the audit. The internal auditor, if necessary, should assess the risk of fraud and the quality of the risk management, but need not be an expert in fraud detection and investigation.

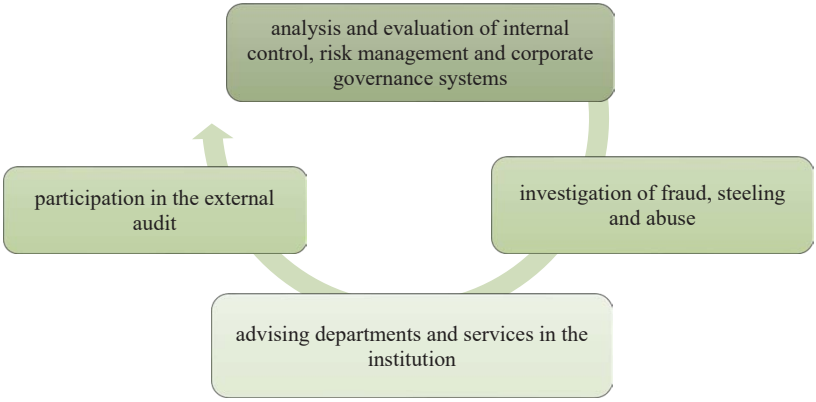

Figure 1. The main activities of the internal audit service

Source: formed by the author on the basis of [2]

When providing consulting services to the internal auditor, it is important to be objective and not to assume managerial responsibilities.

Based on the description of the main tasks and directions of the internal audit service, approved by regulations and defined by scientists in their research, we propose to supplement the list of main activities of the internal audit department with the following items [3]:

1) meeting the needs of management in terms of providing relevant reporting information on various issues arising in the process of activity;

2) support of external control (appropriate control measures by regulatory authorities).

In general, the list of tasks depends on the scope of the entity, its characteristics, as well as the understanding the purpose and functions of the internal audit body by the owners and management. In any case, the internal regulations of the entity on the organization of the internal audit unit should provide for the implementation of certain tasks [2].

Based on the tasks, internal audit is implemented through the relevant areas (types) of activities.

International standards for the professional practice of internal audit do not define specific areas of internal audit. The experience of EU countries shows that the internal audit function has a wide range of internal audits directions and its forms [3].

The actualization of a particular area of internal audit in each country is influenced by the specifics of the administrative system, features of public administration and control in the public sector.

International Standards on Auditing ISSAI provide for three main types of public sector audits (Figure 2):

The financial audit is aimed at verifying the extent to which the financial information is fully and accurately reflected in the financial reports of the audited entity and complies with current legislation. Carried out by obtaining sufficient and appropriate audit evidence to express the auditor's opinion that the financial statements do not contain material misstatements due to fraud or errors [5].

The performance audit focuses on whether intermediaries, programs and organizations operate in accordance with the principles of economy and efficiency and whether there is possibility for improvement. Activities are evaluated using appropriate criteria and other issues are analyzed. The aim is to obtain answers to key audit questions and provide (provide) recommendations for their improvement [5].

The compliance audit aims to verify the extent to which a particular subject meets the powers defined as a criterion. Compliance audits are performed by assessing the adequacy of activities, financial transactions and information the authority of those who manage the audited organization [5].

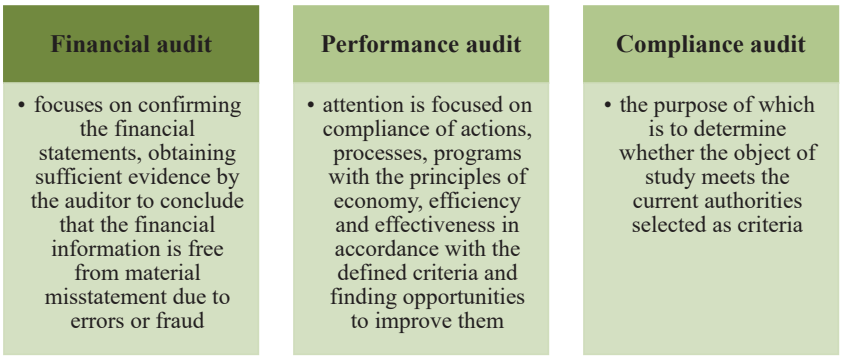

Figure 2. Types of audit in the public sector

Source: formed by the author on the basis of [6]

It is important to note that financial audit and compliance audit since 2013, according to changes in ISSAI 100, began to be considered separately, while in practice they can be applied comprehensively, because the objects of these types of audit include a study of financial and economic activities [5].

However, financial audit, performance audit and compliance audit are defined in the standards as types of public audit.

3. Types of internal audit in international practice

In international practice, the list of types of domestic is much wider (Figure 3).

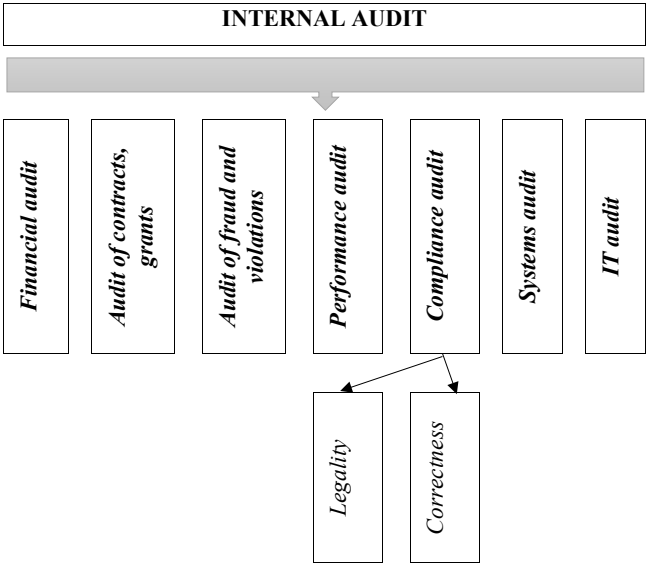

Figure 3. Types of internal audit in international practice

Source: formed by the author based on [7]

These varieties in each country can be detailed or supplemented with new ones. In particular, in some European countries the audit of IT systems is regulated as a separate area, and within the performance audit the operational audit is determined separately, the task of which is to assess the quality of internal control mechanisms within operational processes, and the

audit of systems, focusing on the effectiveness of management decisions, achieving the goals of the institution and risks that hinder the performance of functions and tasks of the institution (Table 1).

According to international practice, the areas of internal audit are not clearly distinguished and may include features of several of them.

Compliance audit is not considered as a separate area at all, but is considered a component of financial audit of legality and regularity. This type of audit is mainly popular in countries that are in the early stages of developing public sector VA activities. With the development of internal audit activities, the range of areas of internal audit and its forms is gradually expanding. In practice, financial audits can be integrated into other areas of internal audit (compliance audits or performance audits), or it is possible to apply all areas of audit at once comprehensively (comprehensive audit) [8].

Table 1

Types of internal audit in foreign countries, defined in the regulations on internal audit

Country	Financial audit	Compliance audit	Performance audit	IT audit	Systems audit
Ukraine	not legally defined				
Albania	+	+	+	+	
Bulgaria	+	+	+	+	+
United Kingdom	+	+	+	+	
Armenia	+	+	+	+	+
Georgia	+	+	+	+	+
Estonia	+	+	+	+	+
Kazakhstan	+	+	+		
Kyrgyzstan	not legally defined				
Cyprus	+	+			
Moldova	not legally defined				
Netherlands	+	+	+		
Poland	+	+	+		
Portugal	+	+	+	+	
Russian Federation	not legally defined				
Slovakia	+	+	+	+	+

Source: formed by the author based on [3]

The final decision on the appointment and application of a particular area of internal audit with the definition of its evaluation criteria is made individually in each case during the planning of internal audit activities.

4. Directions and spheres of internal audit activities in accordance with national standards

In recent years, Ukraine has identified new types of internal audit.

Examining internal audit in corporate governance, N.O. Filevska singles out strategic audit as a set of audit procedures for the collection and independent and objective assessment of the reliability of strategic information to achieve in perspective the overall strategic goal [9].

Considering that in modern conditions one of the reasons for committing economic crimes and fraud is the corruption component in the use of budget funds and property, scientists also single out anti-corruption audit [10].

Taking into account Ukraine's ranking in the world according to the Transparency International Corruption Perceptions Index (122nd out of 180 countries in 2021) [11], this area of internal audit may be relevant for the public sector (for example, internal audit of anti-corruption programs). However, this type of internal audit requires highly qualified, objective and independent human resources.

Building an effective internal audit system in the institution can be a significant obstacle to the emergence of corruption schemes.

Until recently, domestic standards for internal audit highlighted the areas of activity illustrated in Figure 4.

In accordance with the amendments to the Standards in August 2019, the areas of internal audit are no longer defined, but only the scope of internal audit is outlined, similar to ISIA 2100 "The essence of internal audit" [12] (Figure 5).

Lack of regulations and a perfect internal methodological base, in cases of lack of practical skills and relevant knowledge of internal auditors, can lead to shallow research of audit issues, without a clear qualification of the facts and the formulation of sound audit conclusions. As a result, the law does not exclude the risk that the provided conclusions and recommendations will not meet the defined main tasks of the internal audit departments.

On the other hand, bringing national standards to generally accepted international norms allows internal auditors to apply various advanced

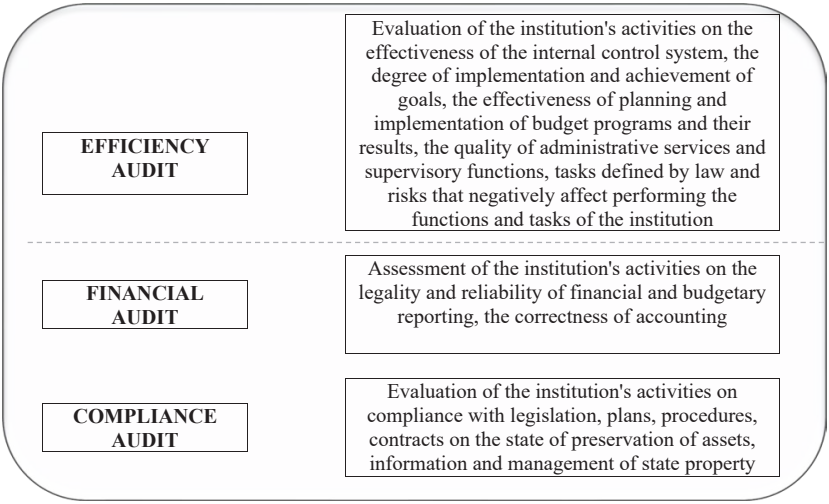

Figure 4. Areas of internal audit activities in accordance with national standards

Source: formed by the author based on [13]

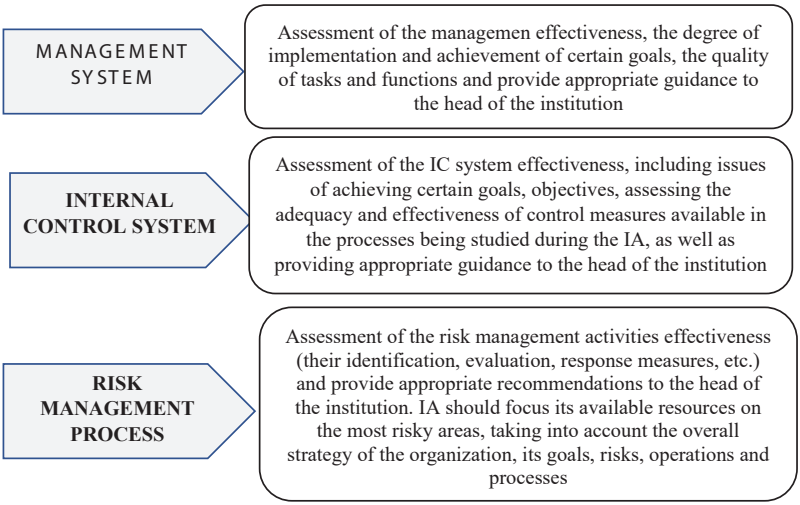

Figure 5. Areas of internal audit according to domestic standards

Source: formed by the author on the basis of [12; 13]

areas of internal audit and, taking into account world best practices, focus in the context of formation of internal audit space (universe) on research and evaluation of management systems, in particular risk management and internal control.

5. Ways to ensure and improve the quality of internal audit

The quality of internal audit is an important indicator of ensuring the effective functioning of the institution (in particular, public authorities) [3]. Low internal audit quality reduces the trust of management to the unit of internal audit and its functions in general and also makes it impossible to complete the tasks in full and, accordingly, to achieve the goal.

In this perspective, significantly increases the importance of ensuring and improving the quality of internal audit function, its efficiency, effectiveness and efficiency.

In accordance with international and domestic standards, internal audit is carried out through continuous and periodic assessments of the quality of internal audit. In addition, the functions of assessing the state of internal control and internal audit of budget managers are carried out (Figure 6).

Domestic standards allow the head of the internal audit service to determine independently the order, procedures, frequency and forms of internal audit quality assessments and requirements for the formation of a program to ensure and improve the quality of internal audit and reflect this in internal documents related to internal audit [3].

In particular, the head of the internal audit department, ensuring the standardization of general provisions and methods of conducting internal assessment of the quality of internal audit, determines:

– procedures for preparation, organization, conducting internal quality assessment of internal audit, timing and frequency of its implementation, procedure and sequence of actions, their documentation, directions of resolving controversial issues, areas of dispute resolution, the procedure for implementing the results of internal quality assessment of internal audit, reporting on evaluation results to management, others organizational aspects – forms of documents for periodic internal evaluation of the quality of internal audit, the list of issues on which such evaluation is carried out, evaluation criteria and approaches to evaluation of results;

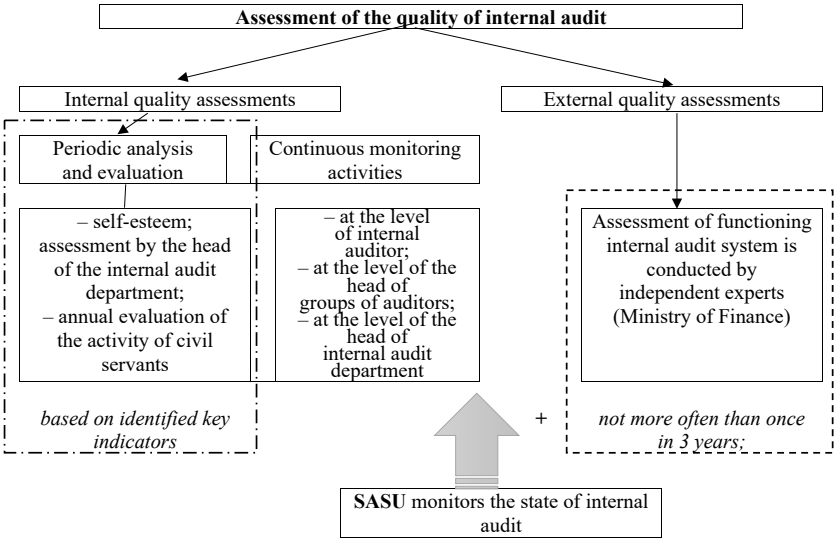

Figure 6. Directions for assessing the quality of internal audit

Source: compiled by the author on the basis of [12; 13; 14]

– requirements, procedures and forms of organization and implementation of continuous monitoring and support for the implementation of the internal audit function (powers and responsibilities for monitoring, tools for its implementation, forms for documenting the monitoring process);

– templates for drawing up a program to ensure and improve the quality of internal audit, justifying the need to determine the expected results or indicators of implementation of program activities, clear deadlines and responsible performers [15].

In the process of analysis by the Ministry of Finance of Ukraine of the regulation of aspects of internal audit quality assessment, the content of certain measures to improve the quality of internal audit and the state of consideration of regulatory requirements in the field of internal audit, the facts of non- compliance of the provisions of internal documents with the requirements to the legislation on issues of internal audit and shortcomings in the preparation of programs were revealed [3].

The list of typical violations and shortcomings regarding the assessment of the quality of internal audit, which are allowed in the development of internal documents on internal audit, and in the preparation of the program to improve the quality of internal audit are summarized in Table 2.

These problems and shortcomings indicate that the heads of internal audit departments ignore the requirements of paragraph 4 of Standard 1 "Tasks, Rights and Responsibilities" and Standard 4 "Quality Assurance and Improvement".

Table 2

Register of typical violations and shortcomings in the process of drafting internal documents on the quality assessment of internal audit [3]

№	The essence of shortcomings and non-compliance with legal requirements
1	**2**
I. On the issues of standardization of the procedure for conducting internal assessments of the quality of internal audit in the internal documents of the institution	
1	There are no provisions on the need for internal assessments of the quality of internal audit and the drafting of programs to ensure and improve the quality of internal audit, approaches and methodology for conducting such assessments are not defined
2	The internal documents define only general aspects of the need for internal audit quality assessments without specifying the procedure, methodology, criteria, forms, deadlines for conducting internal audit quality assessments, procedures for documenting and evaluating results..
3	The internal documents, which regulate the issue of conducting internal evaluations of the quality of internal audit, do not define specific criteria for the relevant evaluation, do not regulate the issues of evaluation of the results obtained.
4	The internal documents do not provide research on internal quality audits of the internal audit of the staffing of the unit, its organizational and functional independence, compliance with staff qualification requirements (criteria for evaluation are only internal regulations, planning and implementation of plans, organizational and functional aspects of audits)
5	Internal documents regulating internal quality assessments of internal audit do not provide for continuous monitoring of internal audit activities, there is no documentary evidence of its conduct.
6	The updating of internal documents regulating the issues of conducting internal assessments of the quality of internal audit in accordance with changes in the legislation on internal audit has not been provided.

(End of Table 2)

1	2
	II. Regarding the preparation of software and improving the quality of internal audit
1	Annual programming is not provided at all
2	The program does not identify measures to improve the quality of internal audit, but includes mainly rules on the activities to be carried out by the internal audit department in accordance with the law, does not take into account current problems in the internal audit function, in particular, identified during internal audit.
3	In some cases, the program does not include requirements for periodic internal evaluations
4	The measures identified in the programs do not reveal the essence of the problems and shortcomings in the implementation of the internal audit function, for the solution of which they are designed
5	The programs indicate the same identical list of measures and tasks from year to year, which may indicate, in particular, the ineffectiveness of certain measures (lack of impact of the results of such measures on improving the quality of internal audit)
6	Measures in the programs are not defined in a clear time frame for their implementation, there is no mechanism for their implementation
7	The program does not contain the expected results from the implementation of the planned measures, these indicators of the implementation of measures do not allow to assess the condition and results of the implementation of the measure
8	In fact, the drafted programs do not correspond to the form approved by internal documents
9	The program is not approved by the head of the institution

As practice shows, the effectiveness of internal audit is difficult to assess, because the result is not always quantitatively, the effectiveness depends not only directly on internal audit professionals, but also largely on the further actions of management in the implementation of auditors' conclusions. The evaluation of the obtained results directly depends on the subjective attitude to this management of the institution [3].

At the same time, standardization of relevant issues in internal documents will allow unifying approaches to conducting internal assessments of the quality of internal audit and avoiding different interpretations of evaluation results.

Each enterprise institution independently determines the key indicators and criteria for the effectiveness of the internal audit service. These

indicators are mainly typical for both internal and external evaluation, and cover such a range of internal audit issues as:

– organizational and legal principles of formation and operation of the unit;

– internal audit personnel management policy;

– the quality of standards and rules governing the activities of internal audit, which are developed by the institution;

– the process of drawing up and forming operational and strategic action plans;

– direct conduct of internal audits, the process of documenting their results;

– further implementation of conclusions and recommendations, their monitoring;

– peculiarities of interaction of the internal audit service with other units of the institution in the performance of its direct responsibilities, in particular regarding the construction of an effective system of risk management and internal control;

– issues of ensuring and improving internal audit quality assessments;

– other aspects of the process of implementation of internal audit in the institution [16].

The main indicators of the effectiveness of the internal audit service should include the following:

1) the level of implementation of the internal audit activity plan (in percent) – the ratio of actual audits to planned ones;

2) the number of audits performed per 1 auditor;

3) the percentage of coverage by audits of the total number of objects in the network (with an accent on high-risk objects);

4) the percentage of audit recommendations adopted by the management of the institution for implementation;

5) the level of implementation of recommendations provided based on the results of audits;

6) additional cost ("measured effect") for the organization according to the results of the implementation of the recommendations provided;

7) the number of complaints about the actions of internal auditors;

8) the level of understaffing of the internal audit unit;

9) the share of internal auditors who have undergone advanced training.

External assessment of the quality of internal audit carried out by the Ministry of Finance is regulated by law (order of 03.05.2017 № 480) [16].

Issues of continuous professional development and certification training are important to ensure the success of internal audit activities.

In order to improve the quality of internal audit, researchers propose a 7-step model of levels of professional competence of internal auditors based on Bloom's taxonomy [17; 18; 19] (based on the goals of learning in the cognitive sphere, expressed through the elements of learning) (Figure 7).

As can be seen, at the first initial level, the internal auditor must have the appropriate knowledge of internal audit, know the rights and responsibilities, the peculiarities of the organization and conducting internal audits.

The second stage provides that the employee understands the material, is able to summarize it, understands differences in concepts (for example, the difference between internal audit and internal control, between the risk management process in the institution and risk-oriented planning for selecting objects to the internal audit activity plan) [3].

The third stage is aimed at developing the skills of the internal auditor to apply the acquired knowledge and understand them in practice. As a result, the specialist must independently determine the methods, techniques and procedures for collecting data required for audit evidence, in accordance with the requirements of the legal framework and internal documents on internal audit [3].

Given above three levels are basic for a novice internal auditor. However, without mastering the following, he will not be able to perform the functions and responsibilities of internal audit in full.

The level of analysis requires the internal audit specialist to have the skills to understand the causal relationship when making recommendations on the results of the audit, to analyze the impact of the implementation of the recommendation for eliminating the cause of the problem. Analysis of the information collected by the internal auditor, comparison of the obtained results with the selected evaluation criteria allows to make appropriate conclusions during the audits [3].

Synthesis in this model means the possibility of generalizing the elements of knowledge on internal audit in such a way as to form a holistic and complex system, for example, when developing internal documents on internal audit, drawing up an internal audit action program, writing an audit report.

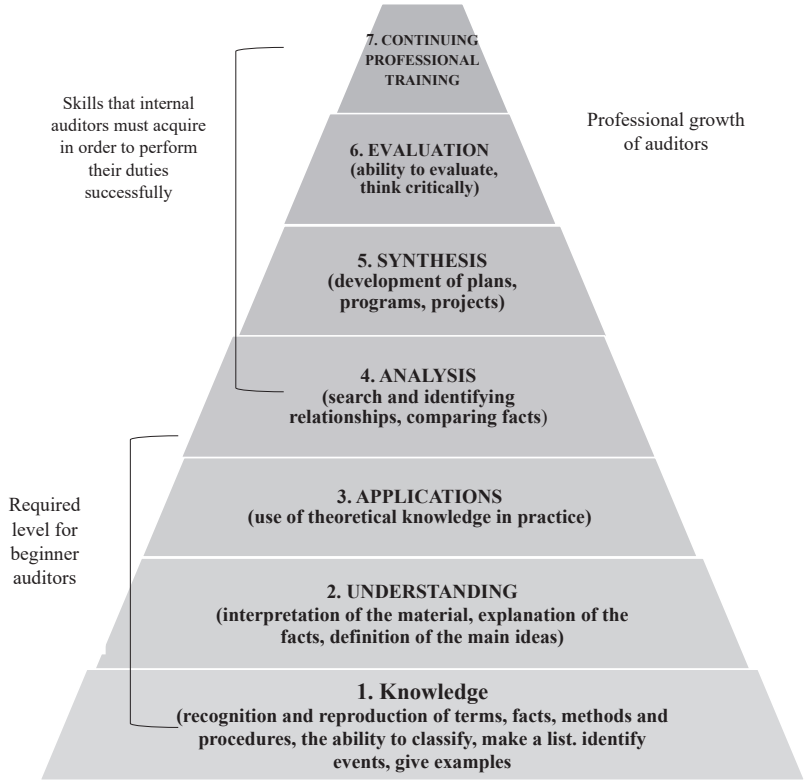

Figure 7. Model of levels of professional competence of internal auditors, built on B. Bloom's taxonomy

Source: based on [3]

The evaluation stage involves the ability to assess the sufficiency and reliability of the evidence collected during the audit, to assess the impact of a risk on the activities of the institution, to argue its confirmation or refutation, to assess the management and internal control system [3].

The final level – continuous professional training, is a key element of the model, because the availability of qualified staff is one of the prerequisites for the success of any organization, and the head of the institution together

with the head of internal audit are particularly interested in professional growth of internal auditors.

The advantages of such a model are the structuring of thinking levels and skills of internal audit specialists, the understanding of the need for critical thinking by the head of the internal audit service and directly by employees.

It is important for the formation of high-level thinking skills in internal auditors:

– provide an understanding of the necessary thinking skills;

– learn to identify causes and causal, logical connections;

– be able to critically evaluate the results of their activities [19].

The implementation of the above will contribute to the growth of professional development of employees and, accordingly, improve the quality of internal audit.

Among the factors improving the quality of internal audit is maintaining the appropriate level of qualification of internal auditors. The lack of qualified specialists in internal audit is one of the significant factors that hinders the full implementation of the internal audit function in government agencies [3].

Properly selected staff, development of their interest in the success of the enterprise will minimize the number of crimes and reduce the loss of intellectual potential of the enterprise, will provide obstacles to the disclosure of trade secrets [20].

The National Standard on Internal Audit 3 "Professional Competence and Diligence" provides for the necessary acquisition of the relevant qualification capacity by the employees of the internal audit, relevant knowledge and experience in identifying and assessing risks, especially fraud risks, in the process of application IT technologies and systems. Continuous improvement of knowledge and professional development is the direct responsibility of internal auditors [13].

If the previous version of the Internal Audit Standards provided for the improvement of skills and knowledge independently through self-education and advanced training based on the results of training activities on the necessary topics in relevant institutions, initiating mandatory training, then the new edition indicates only the general need for skills development, including self-education [3].

In contrast to domestic standards, ISIA 1210 "Professional Competence" for certification still recommends that internal auditors indicate their professional competence by passing the appropriate certification and training organized by the Institute of Internal Auditors and other professional institutions.

The cost of thematic seminars and courses held by domestic.

Institute of Internal Auditors, quite high (Table 3).

In view of this, the internal audit services of executive bodies in the conditions of limited funding, as a rule, do not have sufficient budgetary resources under CECE 2282 "Separate measures for the implementation of state (regional) programs not classified as development measures" for employees to pass certification and advanced training [3].

In practice, the main way to ensure continuous professional development of internal auditors is self-education and participation in trainings, seminars, teaching aimed at advanced training, conducted by the Department of Harmonization of Public Internal Financial Control of the Ministry of Finance of Ukraine [3].

A positive aspect is the participation of Dutch experts in these events based on bilateral cooperation between the Ministry of Finance of Ukraine and the Ministry of Finance of the Kingdom of the Netherlands.

However, a comparison of the actual number of internal auditors in the executive branch (more than 1,700 positions) with the average number of specialists for which training events organized by the Ministry of Finance (approximately 130 per year) indicate that such seminars and trainings cannot fully satisfy the need of internal audit specialists' advanced training [3].

In the Netherlands, in order to continuously improve internal audit, relevant Internal Auditor Development Programs have been developed and are in place for various categories of positions, based on the relevant IIA programs for CIA certification [21].

To implement such a program in Ukraine, we offer a program of mandatory training for internal audit services in terms of basic levels of professional development, namely: for professionals with less than 3 years of experience; specialists with more than 3 years of experience; management of the service and heads of audit groups.

In general, the profession of internal auditor requires a wide range of different knowledge and skills.

Table 3

The cost of advanced training and certification provided by the Institute of Internal Auditors of Ukraine

№	*Certification training*		
	Topics of seminars and courses	**years**	**Cost, UAH.**
1	Key success factors of the internal audit service	3	3 000 UAH
2	Best practices for conducting internal audits and registration of working papers	6	5 000 UAH
3	Basics of drawing up the Program for ensuring and improving the quality of internal audit	3	5 000 UAH
4	Basics of writing recommendations based on the results of the internal audit	3	3 000 UAH
5	Evaluation of internal audit activities. How to prepare for an external evaluation of IA function: a program to ensure the quality and improvement of IA function	12	10 000 UAH
6	The main topics of IT audit – what and how to check?	6	5 000 UAH
7	The evaluation of the effectiveness of the internal control system	6	5 000 UAH
8	Business processes: classification, regulation description, use in internal audit	6	5 000 UAH
9	Specialized course on issues internal audit, internal control and risk management	24	20 000 UAH
CIA Certification (Certified Internal Auditor)			
1	Certificate registration fee	$230 without discount $115 for members of IIA	
2	Registration fee for the 1st exam	$395 without discount $280 for members of IIA	
3	– for the 2nd and 3rd exams	$345 without discount $230 for members of IIA	
4	Membership fee	equivalent $60 for a year	
5	One-time membership fee	equivalent $25	

Source: [3]

In order to perform the duties successfully, an internal audit specialist must, in addition to knowledge in the field of audit (organization, principles of operation, methods and approaches), have sufficient communication and organizational skills, have conceptual tools for management processes and be knowledgeable in the field of accounting, finance, IT, law, procurement, etc. [3].

Financial support for any sector of the economy provides part of the funding from budget allocations. The components of the salary (salary, surcharge for the rank of civil servant, for years of service) are determined by the relevant resolutions of the Cabinet of Ministers of Ukraine on wages. However, as practice shows, in the absence of vacancies in a separate structural unit of internal audit of the regional state administration, due to which additional budget savings are possible, the salary of an internal audit specialist may be even lower than a specialist of another structural unit or apparatus of regional state administration. This is certainly a significant risk for attracting and retaining specialists of the appropriate level of qualification and as a consequence of ensuring the appropriate quality of internal audit.

Given the relatively high requirements for the qualifications of internal audit specialists, the wage level and material incentives, the staff of this service should promote the recruitment of highly qualified employees.

6. Conclusions

Thus, internal audit is an assessment of the activities of the enterprise in order to provide its owners and management with prompt and unbiased information about the general condition of the entity and the prospects for management decisions. We believe that internal audit should be subordinated to the owners of the company, but the information the internal auditors will provide them, in parallel, should also be provided to management. The reason for the development of internal audit in Ukraine was the creation of enterprises with different forms of ownership and the inability of the traditional command-and-administrative system to perform its functions in the transition to market conditions.

Problems of formation and development of internal audit in Ukraine are, firstly, the lack of a central independent body whose competence should be the regulation of internal audit at the macro level, ie the development of

standards, guidelines for this type of audit, and secondly, the lack of internal documents on activities of internal auditors.

It is determined that improving the quality of internal audit is provided in the process of continuous professional development and training of employees. Using the presented 7-level model of levels of internal auditors' professional competence, based on Bloom's taxonomy will allow to structure the thinking levels and skills of internal audit specialists, understand the need for critical thinking by the head of the internal audit department and directly by employees. In the process of research to facilitate the recruitment of highly qualified employees, the need to ensure an appropriate wage level and material incentives for employees of internal audit services was proved, which is justified by rather high requirements for qualification of internal audit specialists and the level of tasks assigned to the unit.

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ACCOUNTING AND TAXATION OF THE ACTIVITY RESULTS OF ENTERPRISES

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Abstract. The financial condition of an entity depends on many factors, the most important of which is financial independence, which is the guarantor of a positive financial result, ie profit.

The object of research is the system of accounting and taxation of performance. The subject of the research is theoretical-methodical and scientific-practical principles of accounting and taxation of financial results of enterprises by its types.

Theoretical and methodical bases of scientific research became general scientific and special methods: abstract-logical (for theoretical generalizations of research results and formulation of conclusions); statistical research, in particular, comparisons (to analyze the financial performance of a limited liability company); tabular (for clarity of presentation of the material), grouping (to summarize the results of the study), hypotheses and assumptions (to justify their own opinion).

The information base of the research was the legislative and bylaws of Ukraine, financial statements of the business entity, publications in periodicals, monographs, works of domestic authors, Internet resources.

The purpose of the research is to substantiate the content of financial results as an accounting category and to disclose the practice of their accounting and taxation in order to make proposals to improve the accounting support for the formation of results of activities.

In order to manage financial results, the internal and external factors influencing their formation are characterized.

According to the results of a thorough study of the legal framework and scientific opinions expressed his opinion on the essence of the studied category: financial results – is the final indicator of the enterprise, which is

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determined by comparing income and expenses by its types and manifests itself as net profit (positive result) or uncovered loss).

Two basic approaches to the calculation of financial results of the enterprise, which have some variations in different countries, are revealed.

It is proved that the correctness of the formation of the financial result of the enterprise depends on the reliability and objectivity of recognition, evaluation, classification and methods of accounting for its constituent components – income and expenses, in terms of classification features of economic activity.

The classification groups of income and expenses are revealed and the method of their accounting is characterized. The complexity of accounting for the financial result of the activity is clarified. Modern approaches to determining financial results do not ensure the quality of information needed to make management decisions. Today there is some inconsistency in the classification of activities and sub-accounts of accounting, which are formed and determined financial results. This, in turn, makes it impossible to assess business risks and make objective decisions.

In order to ensure the formation of objective information for the analysis of the results of the enterprise and rational decisions, it is proposed to determine the only classification characteristics of the results of its activities and clearly define the composition of sub-accounts to account 79 «Financial results».

It is proposed to develop a clear mechanism for determining the income tax and assigning it to financial results – to specific sub-accounts of account 79 «Financial results».

1. Introduction

Businesses operate in order to meet the needs of stakeholders and obtain a positive financial result. The financial result will be the main reflection of the efficiency of economic activity. The formation of financial results of enterprises is directly due to their operating activities, which are related to the production and sale of products, goods, services and works. That is, the definition of financial results for each company has its own industry specifics. In modern business conditions, the formation of financial results is influenced by a number of socio-economic factors.

Theoretical and practical bases of accounting and taxation of performance are revealed in the works of domestic scientists: Vakulchyk O.M.

[3], Havrylenko O.Ye. [4], Dombrovska N.R. [6], Zadorozhnyi Z.M. [7], Ishchenko Ya.P. [9], Koval N.I. [9], Melen O.V. [11], Moroz Yu.Yu. [14], Selivanova N.M. [24], Protasova Ye.V. [3], as well as the author's own research [9; 21].

Given the scientific achievements of scientists, it should be noted the lack of a common understanding of the nature of financial results and clarity in the methodology of their accounting and taxation.

The purpose of the research is to substantiate the content of financial results as an accounting category and to disclose the practice of their accounting and taxation in order to make proposals to improve the accounting support for the formation of results of activities.

2. The economic essence of financial results

Different groups of stakeholders are interested in the final financial result of the company and in the objective information about the financial results. Owners (founders, participants, shareholders) are interested in gaining income on corporate rights and increasing corporate rights, which directly depend on the amount of income of the investment object. The financial reward of employees of the enterprise also depends on the effectiveness of the enterprise. Realization of intentions of cooperation of contractors with the enterprise in the market environment also depends on indicators of its profitability. An interested party in the profitability of enterprises is the state in the face of tax authorities, as part of the profits of the enterprise through the mechanism of taxation is available to the state [9, p. 258].

The topic of accounting for financial results is always relevant and controversial for many scholars in the field of accounting and business management. Studying scientific publications on this topic, there is a lack of uniform interpretation of the concept of «financial results», mainly considered the concepts of «profit», «loss», «income» and «expenses».

«Financial result» has many different interpretations. The content depends on the purposes studied in the process of economic activity, on the category of user of accounting data for which the financial result was identified, and on the set of accounting techniques possessed by one or another accounting system [11, p. 1386].

The essence of financial results in the general economic sense is characterized as a result of comparing revenues of the reporting period with costs. Also, income can be equated to the consumer value of products, and costs – with their actual value [2, p. 34].

Financial results are an indicator of the effectiveness of economic activity of the organization, which is calculated by comparing income and expenses, which is in the form of profit or loss [3, p. 163].

Successful, in our opinion, is the definition: financial results – a monetary indicator of the effectiveness of economic activity of the entity by comparing certain income and expenses incurred to obtain them, which can be presented in the form of profit or loss [15, p. 21].

The set of the most significant factors influencing the formation of financial results of economic entities is divided into internal and external (Figure 1).

It is obvious that the management of financial results involves the study and use of those factors that most significantly affect the results of economic and financial activities of the enterprise and the adoption and implementation of such decisions that would increase revenue and reduce costs [25, p. 165].

The financial result in the modern sense is considered as:

1) change in the amount (increase or decrease) of equity;

2) profit or loss;

3) change in the value of net assets of the enterprise;

4) the result of comparing income and expenses;

5) additional value created in the process of production and implementation of financial and credit transactions;

6) the result of the statutory activities of the enterprise (revenue minus the cost of production and sales);

7) the price of capital and other factors of production [23, p. 118].

It is almost impossible to cover and reveal the whole essence of the economic content of financial results in one holistic concept. After all, all views and opinions explain a certain aspect of the concept of financial results and deserve attention. But concluding, we can say that the comparison of income with expenses in a certain period reveals the general economic content of financial results [2, p. 35].

Based on the above, it can be argued that the main elements of the financial result are income and expenses.

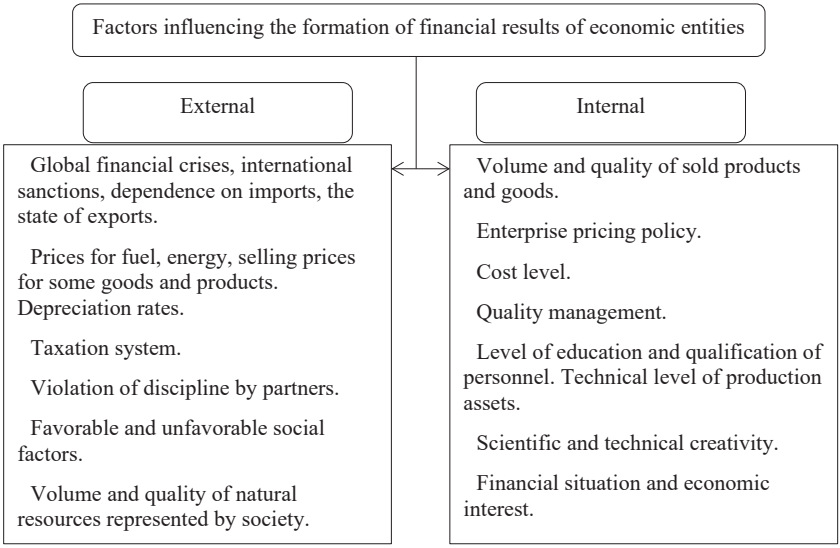

Figure 1. Factors influencing the formation of financial results of economic entities

Source: [1, p. 1294]

This is due to the fact that no normative document contains a definition of this category. Instead, the National Regulation (Standard) of Accounting (NP (S) BU) 1 «General requirements for financial reporting», contains its integral components:

– income – an increase in economic benefits in the form of an increase in assets or a decrease in liabilities, which leads to an increase in equity (except for the gaccountth of capital through contributions from owners);

– costs – a decrease in economic benefits in the form of a decrease in assets or an increase in liabilities, which leads to a decrease in equity (except for a decrease in capital due to its withdrawal or distribution by owners);

– profit – the amount by which income exceeds the associated costs;

– loss – the excess of the amount of costs over the amount of income for which these costs were incurred [17].

Scholars are right that profit is a part of income from various activities of the enterprise (main, other operating, investment, financial and other),

which remains after covering the costs incurred to obtain this income, and loss – part of the costs that exceeds the income from various activities of the enterprise (main, other operating, investment, financial and other), to obtain which these costs were incurred [4, p. 35].

Thus, in the concept of accounting, the financial result can be characterized from three positions:

1) as the difference between the magnitude of income and operating expenses for the comparable reporting period;

2) as a change in the amount of resources of the enterprise during the reporting period;

3) as an increase in equity for the relevant reporting period.

Given the conditioned and own research [monograph income], it is proposed to define the concept of «financial results» to combine three components – the essence, content and form of manifestation (Figure 2).

Thus, financial results are the final indicator of the enterprise, which is determined by comparing income and expenses by its types and is manifested as net profit (positive result) or uncovered loss (negative result).

The correctness of the financial result of the enterprise depends on the reliability and objectivity of recognition, evaluation, classification and methods of accounting for its constituent components – income and expenses, in terms of classification features of economic activity.

It is worth noting that income and expenses are important and at the same time complex categories of the economy. The problem of interpretation, evaluation and recognition is not unique to domestic accounting practice.

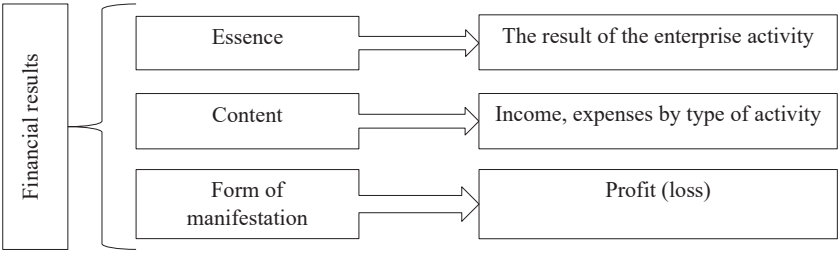

Figure 2. The concept of financial results for accounting purposes

Source: author's interpretation

Thus, on January 1, 2018, International Financial Reporting Standard (IFRS) 15 "Income from Contracts with Clients" came into force, replacing International Accounting Standard 18 "Income". IFRS 15 defines: income is an increase in economic benefits during the reporting period in the form of income or an improvement in assets or a decrease in liabilities, which leads to an increase in equity, except for an increase in equity associated with contributions from equity participants [13].

The definition of revenue in the National Accounting Regulation (NAR) 1 "General Financial Reporting Requirements" is similar to the interpretation of revenue proposed in IFRS 15 "Revenue from Contracts with Customers". According to NP (S) BU 1, income is interpreted as an increase in economic benefits in the form of inflows of assets or a decrease in liabilities that lead to an increase in equity (excluding capital gaccountth due to owners' contributions) [17].

However, NP (S) BA 15 «Income» stipulates that income is recognized when an asset increases or a liability decreases, which causes an increase in equity (except for capital gaccountth due to contributions from participants of the enterprise), provided that the assessment income can be reliably determined [18].

Therefore, the determination of income according to international and national accounting standards is related to the receipt of economic benefits.

According to the Law of Ukraine «On Accounting and Financial Reporting in Ukraine», economic benefit is a potential opportunity for an enterprise to receive cash from the use of assets [22].

Each entity incurs appropriate costs to generate revenue. Therefore, they are no less important component of the financial result and.

It should be noted that there is no separate standard that regulates the definition and procedure for recognizing costs in International Accounting Standards. Instead, the definition of costs is given in the Conceptual Basis of Financial Reporting, according to which costs are a decrease in assets or an increase in liabilities, resulting in a decrease in equity, except as a result of distribution to holders of equity requirements [10]. Analyzing NP (S) BA 1, there is an almost identical interpretation of costs: costs – a decrease in economic benefits in the form of a decrease in assets or increase in liabilities, which leads to a decrease in equity (except for a decrease in capital due to its withdrawal or distribution by owners) [17]. Costs are

recognized in accounting as a decrease in assets or an increase in liabilities, provided that these costs can be measured reliably [19].

The term «expenditures» is related to the term «cost». However, they are not identical and need to be distinguished.

In this regard, it is reasonable to say that the cost of production is an independent economic category, which expresses a complex system of economic relations between economic entities in the process of production and circulation of products. At the same time, the cost as an indicator of economic activity shows the costs of a particular enterprise for the production and sale of certain products in cash, which gives grounds to draw conclusions about the effectiveness of the production potential of the business entity [6, p. 136].

Given the provisions of these regulations, it can be argued that the receipt or reduction of economic benefits depends on the nature of operations (Table 1).

Today there are two basic approaches to calculating the financial results of the enterprise, which have some variations in different countries:

1) the method of comparing income and expenses (cost-output method) – involves determining the profit (loss) in accordance with the principle of accrual and compliance of income and expenses, ie as the difference between income and expenses of the reporting period. This method involves comparing income with the costs incurred to obtain this income.

2) the method of comparing capital (or the method of changing net assets) – involves determining the increase in equity in the reporting period as the difference between the amount of equity at the end and beginning of the reporting period, ie calculates the difference, and if equity increases at the end of the reporting period the company makes a profit, and if on the contrary – a loss [11, p. 1387].

Usually the calculation of the financial result is carried out by the method of «cost – output». The financial result for the reporting period is determined by comparing the income of the reporting period and the costs incurred to obtain these revenues. In this case, income and expenses are reflected in the date of their occurrence, and not on the date of receipt or payment of funds.

Given the above, we analyze the financial performance of the agricultural enterprise (Table 2).

Table 1

Operations that cause receipts or reductions of economic benefits

Receipts	Reduction
receipt of cash from the sale of goods (works, services, other current assets)	transfer of funds for the purchase of goods (works, services)
cash inflows in the form of interest, dividends, etc.	payment of dividends, interest on the use of assets
repayment of receivables by buyers	the emergence of accounts payable to counterparties

Source: substantiated by the author

Table 2

Analysis of financial results of Khmilnytske LLC

Indexes	2018, thousand UAH	2019, thousand UAH.	2020, thousand UAH	Deviation, +/-, thousand UAH	
				2020/2018	2020/2019
Net income from sales of products (goods, works, services)	1690937	781959	944144	-746793	+162185
Cost of goods sold	1675741	742178	993821	-681920	+251643
Gross profit Gross loss	15781	39781	49677	+65458	+89458
Other operating income	3200932	159692	285574	-2915358	+125882
Administrative expenses	21635	22313	21057	-578	-1256
Selling expenses	103901	92352	83921	-19980	-8431
Other operating expenses	74271	47133	69057	-5214	+21924
Financial result from operating activities: profit	136321	37675	61862	-74459	+24187
Other financial income	25226	6128	214	-25012	-5914
Financial expenses	88520	97722	83921	-4599	-13851
Pre-tax financial result: profit loss	73027	53919	21845	+94872	-32074
Net profit Net loss	73027	53919	21845	+94872	-32074

Source: according to the company's financial statements

According to Table 2, the following conclusions can be drawn: the main part of the financial result is related to operating activities; there is a negative financial result – loss; loss is associated with a decrease in net sales revenue and an increase in the cost of goods sold.

Note that the financial result is not only the final performance of the company for the year, but also information for further management decisions.

Therefore, it is important for users of financial statements to know not only the amount of profit or loss, but also what activities (operating, financial, investment) results.

3. Classification of financial results by type of activity

Determining the financial result of the activity must take into account the classification of income and expenses.

Recognized income is classified in accounting by the following groups [18]:

– income (revenue) from sales of products (goods, works, services) – is the total income (revenue) from sales of products, goods, works or services without deducting discounts, refunds of previously sold goods and indirect taxes and fees, value added tax cost, excise duty, etc.);

– net income from sales of products (goods, works, services) – is determined by deducting from income from sales of products, goods, works, services, discounts, the value of returned previously sold goods, income under contracts owned by customers (principals, etc.), and taxes and fees;

– other operating income – include the amount of other income from operating activities of the enterprise, except for net income from sales of products (goods, works, services;

– financial income – includes dividends, interest and other income received from financial. investments (except for income, which is accounted for using the equity method);

– other income – includes income from the sale of financial investments; income from non-operating exchange differences and other income that arises in the course of economic activity, but not related to the operating activities of the enterprise.

Recognized by the company costs in accounting are classified into the following groups [19]:

– cost of goods sold (goods, works, services) – consists of the production cost of products (works, services), which was sold during the reporting period, unallocated fixed overhead costs and excessive production costs;

– overhead costs – costs of production management;

– administrative costs – include the following general expenses for the maintenance and management of the enterprise;

– marketing costs – costs associated with the sale (marketing) of products (goods, works, services);

– other operating costs – include costs of depreciation of inventories, maintenance of socio-cultural facilities, recognized fines, penalties, penalties, etc.;

– financial expenses – interest expenses (for the use of loans received, for bonds issued, for financial leases, etc.) and other expenses of the enterprise related to boraccountings;

– other costs – costs that arise during the activity (except for financial costs), but not directly related to the production and / or sale of products (goods, works, services).

Accordingly, when determining the financial results, a comparison of income and expenses of each activity (Table 3).

At the same time, NP (S) BA 1 defines ordinary activities and main activities. Thus, ordinary activity – any main activity of the enterprise, as well as operations that provide it or arise as a result of its activities, and the main activity – that associated with the production or sale of products (goods, works, services) that is the main purpose of the enterprise and provides the bulk of its income [17].

That is, the guiding indicator of the main activity is the product of a separate production process, which completes the complex production process.

In order to determine the informativeness of data on the results of business entities, we describe the procedure for forming the financial result in the «Statement of financial performance» («Statement of comprehensive income») (Table 4).

Given the results of the study, we can note the diversity in the comparison of income and expenses and attributed them to the relevant activities. In the form of the «Report on financial results» the results from financial and investment activity are not separated by separate articles. This in turn

Table 3

Classification of financial results by the type of activity

Income	Costs
Operating activities – the main activities of the enterprise, as well as other activities that are not investment or financial activities	
income (revenue) from sales of products (goods, works, services) (account 70); other operating income (account 71)	cost of goods sold (goods, works, services) (account 90); overhead costs (account 91); administrative expenses (account 92); selling expenses (account 93); other operating expenses (account 94)
Investment activity – the acquisition and sale of non-current assets, as well as those financial investments that are not part of the cash equivalents (cash)	
income from participation in capital (account 72); other income (account 74)	losses from equity participation (account 96); other expenses (account 97)
Financial activity – an activity that leads to changes in the size and composition of equity and debt capital of the enterprise	
other financial income (account 73)	other financial expenses (account 95)

Source: formed by the author for [8; 17]

raises many controversial issues in the practice of accounting for financial results. Note that the calculation of the financial result must be organically integrated with the information system of accounting accounts.

Currently, the system of accounting accounts to reflect the financial result provides for the use of the following accounts [8]:

1) Accounts of class 7 «Income and results of activities» are designed to summarize information on income from operating, investing and financing activities of the enterprise. The composition of income and the procedure for their recognition are determined by the relevant provisions (standards) of accounting. The accounts of this class during the reporting year on the loan reflects the amount of total income together with the amount of indirect taxes, fees (mandatory payments) included in the sale price, debit – monthly reflection of the appropriate amount of indirect taxes, fees (mandatory payments), annual or monthly transfer of the amount of net income to account 79 «Financial results» [8].

2) To summarize information on operating, investing, financing and other ordinary activities, enterprises use Class 9 “Operating Expenses”

Table 4

The order of formation of the financial result and total income in the «Statement of financial performance» («Statement of total income»)

Section I. Financial results	
Net income from sales of products (goods, works, services) (series 2000)	– Cost of goods sold (goods, works, services) (account 2050
=	
Gross profit (series 2090) / loss (series 2095)	
+ other operating income (account 2120)	– administrative expenses (account 2130) – selling expenses (account 2150) – other operating expenses (account 2180)
=	
Financial result from operating activities: profit (series 2190) / loss (series 2195)	
+ income from participation in capital (number 2200) + other financial income (series 2220) + other income (number 2240)	– financial costs (number 2250) – losses from equity participation (account 2255) – other expenses (account 2270)
=	
Financial result before tax: profit (account 2290) / loss (account 2295)	
+ income tax income (number 2300) + profit from discontinued operations after tax (account 2305)	– income tax expenses (account. 2300) – loss from discontinued operations after taxation (account. 2305)
=	
Net financial result: profit (series 2350) / loss (series 2355)	
Section II. Total income	
Revaluation (revaluation) of non-current assets (account 2400) + revaluation (revaluation) of financial instruments (account 2405) + accumulated exchange differences (account 2410) + share of other total income of associates and joint ventures (account 2415) + other total income (account 2445)	
=	
Other aggregate income before tax (account 2450)	
	– income tax related to other comprehensive income (no. 2455)
=	
Other total income after tax (account 2460)	
+ net financial result (profit) (account 2350)	– net financial result (loss) (number 2355)
=	
Total income	

Source: generated by the author for [12]

Accounts of the Chart of Accounts for Assets, Capital, Liabilities and Business Operations of Enterprises and Organizations. The debit of accounts of this class reflects the amount of expenses, the credit – writing off the amount of expenses at the end of the reporting year or monthly to account 79 «Financial results» [8].

3) At the same time, business entities have the right to use only accounts of class 8 «Expenses by elements» (without the use of accounts of class 9 «Operating expenses») to summarize information on the costs of the enterprise. They debit the sub-accounts of account 79 «Financial results» amounts from the credit of accounts 23 «Production» and accounts of class 8 «Expenses by elements» in the order of closing these accounts [8].

4) Account 79 «Financial results» is used to reflect financial results. This account contains three sub-accounts: 791 «Result of operating activities»; 792 «Result of financial transactions»; 793 «Result of other ordinary activities». The credit of account 79 «Financial results» reflects the amounts in the order of closing the accounts of income, the debit – the amounts in the order of closing the accounts of expenses, as well as the appropriate amount of accrued income tax. The balance of the account at its closing is debited to account 44 «Retained earnings (uncovered losses)» [8].

Thus, the credit of account 79 «Financial results» in the order of closing the accounts reflects income, the debit – expenses.

After determining the pre-tax financial result, the accountant must calculate and debit the amount of income tax on account 79 «Financial results», if the entity is a payer of such tax.

Sub-account 641 «Tax calculations» in the context of the analytical account «Income tax calculations» is assigned to account for income tax calculations. The credit of the analytical account «Calculations for income tax» reflects the accrual of income tax, the debit – transfers to the budget.

Account 98 «Income Tax» is also used. This account records the amount of income tax expenses, which consists of current income tax, taking into account the deferred tax liability and deferred tax asset and is determined in accordance with NP (S) BU 17 «Income Tax». The debit of the account reflects the accrued amounts of income tax, the credit – inclusion in the financial results of account 79 «Financial results» [8].

In addition, the chart of accounts for the conduct of operations to reflect income tax designated a number of other accounts, namely [8]:

– 17 – in the case of accrual of current income tax with the reflection of deferred tax assets;

– 54 – in the case of accrual of current income tax due to the write-off of previously accrued deferred tax liabilities.

Accounts 17 and 54 are designed to reflect the temporary difference between the amount of income tax arising from the mismatch between the amount of income from accounting and income that is subject to taxation. These accounts will be available only to those economic entities that, in accordance with the Tax Code of Ukraine, are required to adjust the financial result according to accounting data for tax differences that may arise in connection with determining the tax base according to tax calculations.

Therefore, the «Financial results» finally formed on account 79 are debited to account 44 «Retained earnings (uncovered losses)» by the following accounting entries:

– when making a profit: debit 79 credit 441 «Retained earnings»;

– upon receipt of loss: debit 442 «Uncovered losses» credit 79.

It is objective to believe that the final financial result (profit or loss) of the enterprise consists of the financial result from operations that are the subject of its core business, other operating, financial and investment and which together constitute ordinary activities, as well as extraordinary events [14, p. 138].

The above material confirms the complexity of accounting for the financial result of activities. Modern approaches to determining financial results do not ensure the quality of information needed to make management decisions. Today there is a certain inconsistency in the classification of activities and sub-accounts of accounting, which are formed and determined financial results (Table 5). This, in turn, makes it impossible to assess business risks and make objective decisions.

The generalized data in Table 5 show that income and losses from equity participation are written off to the sub-account «Results of financial transactions», although in essence they relate to investment activities. Therefore, there are different opinions about the objectivity of the formation of information on sub-accounts 792 and 793.

Research outlines a number of shortcomings in the system of accounting for financial results and substantiates approaches to their improvement.

There is no consensus among scholars on the reflection in the accounts

Table 5

Methods of accounting for the financial result of the enterprise in accordance with the requirements of the Instruction on the application of the chart of accounts

Activity	Display in accounting accounts	
	Debit	**Credit**
791 «Results of operating activities»	70 «Income from sales», 71 «Other operating income»	791 «Financial results»
	791 «Financial results»	90 «Cost of sales», 91 «Overhead costs», 92 «Administrative costs», 93 «Sales costs», 94 «Other operating expenses»
	791 «Financial results» (for enterprises that use only 8th class accounts)	23 «Production», 80 «Material costs», 81 «Labor costs», 82 «Contributions to social activities», 83 «Depreciation», 84 «Other operating expenses»
792 «Results of financial transactions»	72 «Income from equity participation», 73 «Other financial income»	792 «Result of financial transactions»
	792 «Result of financial transactions»	95 «Financial expenses», 96 «Losses from equity participation»
	792 «Result of financial transactions» (for enterprises that use only Class 8 accounts	85 «Other expenses» (in terms of financial expenses)
793 «Result of other activities» Activity	74 Other income	793 «Result of other activities»
	793 «Result of other activities»	97 «Other expenses»
	793 «Result of other activities» (for enterprises that use only 8th class accounts)	85 «Other expenses» (in part of expenses related to investment and other activities)

Source: generated by [8]

of income, expenses and financial performance of the enterprise. However, all the authors have an unequivocal opinion on the need to detail the accounting on accounts 79 «Financial results» and 44 Retained earnings (uncovered losses) [24, p. 47].

Moroz Yu.Yu. proposes to make changes to the composition of its sub-accounts of account 79 «Financial results»: 791 «Result of operating activities», 792 «Result of other operating activities», 793 «Result of financial activities», 794 «Result of investment activities», 795 «Result of extraordinary events», that is necessary to eliminate inconsistencies between the needs for information on activities and the existing method of its formation [14, p. 139].

Another approach is proposed [7, p. 232] to carry out in the context of the following sub-accounts and analytical accounts of the first order:

– 791 «Financial result from operating activities»;
– 7911 «Financial result from operating activities»;
– 7912 «Financial result from other operating activities»;
– 792 «Financial result from financial activities»;
– 793 «Financial result from investing activities»;
– 7931 «Financial result from equity participation»;
– 7932 «Financial result from other investment activities».

According to the authors, this approach will help to more accurately determine the financial results of individual activities.

With regard to income and expenses, and accordingly the results of their comparison, resulting from unforeseen (extraordinary) transactions, income is reflected in sub-account 746 «Other income», and expenses – in sub-account 977 «Other operating expenses». There are no clear regulations in the accounting standards and instructions to the chart of accounts.

The reason for this in 2013 was the removal from the Chart of Accounts and Instructions for its application of accounts 75 «Extraordinary income» and 99 «Extraordinary expenses», as well as the removal from the name of sub-account 746 «Other income from ordinary activities» words «from ordinary activities «, And from sub-account 977 «Other expenses of ordinary activities» – the words «ordinary». It should be noted that the explanations given in the new titles of sub-accounts 746 «Other income» and 977 «Other operating expenses» were not changed. That is, the explanations do not say that these sub-accounts summarize extraordinary income and extraordinary

expenses, respectively. This fact often in practice leads to unclear situations that cannot be legally resolved [7, p. 230].

In this regard, scientists propose to account for costs and revenues related to emergencies, not only on accounts 97 «Other expenses» and 74 «Other income», but also on accounts 94 «Other operating expenses» and 71 «Other operating income» in the event that current assets («Inventories», «IBE», etc.) also became unusable during the emergency. The financial result of such events will be reflected in the relevant sub-account 791 «Result of operating activities», and not in sub-account 793 «Result of other ordinary activities» [7, p. 235].

Another feature of the formation of the financial result is its determination by agricultural enterprises, which is related to the norms of NP (S) BA 30 «Biological assets». Accordingly, the financial result includes: the financial result from the initial recognition of agricultural products and additional biological assets; financial result from the sale of inventories – agricultural products and biological assets, which are valued at fair value less costs to sell; the financial result from changes in the fair value of biological assets at the balance sheet date, which are measured at fair value less costs to sell.

In this regard, the opinion of scientists is correct [5, p. 69] that the general method of determining financial results does not quite correspond to the real model of market economy in the country. After all, the financial result for farmers is to be determined not after the sale of agricultural products, but immediately after its receipt from production. In all other sectors of the economy, the financial result is determined at the stage of sale, not production.

In the practice of accounting, the method provided by NP (S) BA 30 leads to the conditionality of determining the financial results of agricultural enterprises, as it is mostly calculated financial result from the main activity, ie from the sale of direct product.

Among the problematic issues is the lack of in the instructional materials on accounting the procedure for allocating income tax (sub-account 981) on financial results – on specific sub-accounts of account 79 [16, p. 1015].

In this regard, scientists see the definition of income tax for each activity separately: 981 «Income tax on operating activities»; 982 «Income tax on financial activities»; 983 «Income tax on investment activities» [7, p. 232].

The proposal of scientists is positive, because by deducting income tax from the financial results of each of these three activities, we get a net profit from these activities. This indicator will fully characterize the effectiveness of each of the activities of the enterprise.

According to the results of the study, it is once again confirmed that the information base for the management of financial results are accounting accounts.

5. Conclusions

The magnitude of the financial result determines the possibility of further development of the enterprise and creates a margin of financial stability, which allows the company to respond quickly to changes in market conditions. Therefore, the correct accounting of results by type of activity is of fundamental importance for assessing the financial and economic activities of the enterprise.

Characteristic essential features of income and expenses of the enterprise create the basis for their classification and grouping by individual articles of the Statement of financial performance. However, the study of accounting for financial results in practice raises many controversial issues, including the incompatibility between the characteristics of activities, income, expenses and the formation of financial results.

Having analyzed the theoretical foundations of the formation, accounting and taxation of financial results of enterprises, it can be noted that the procedure for accounting on account 79 «Financial results», which accumulates information about financial results, does not allow prompt, complete and objective coverage of business results. activities.

In order to improve the accounting support for the formation of financial results, we offer:

1. At the legislative level to consolidate the interpretation of the category «financial results»: financial results – is the final indicator of the enterprise, which is determined by comparing income and expenses by its types and manifests itself as net profit (positive result) or uncovered loss (negative result). This will provide an understanding of the nature of the studied category in its essence, content and form of manifestation.

2. To determine the only classification characteristics of the results of activities by its types with a clear definition of the composition of sub-

accounts: 791 «Financial result from operating activities», 792 «Financial result from other operating activities», 792 «Financial result from financial activities»; 793 «Financial result from investing activities». This will ensure the formation of objective information to analyze the results of the enterprise and make rational decisions.

3. To develop a mechanism for determining the income tax and assign it to financial results – to specific sub-accounts of account 79 «Financial results».

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THE NECESSITY OF ORIGIN, ECONOMIC CONTENT AND THE ESSENCE OF TAX CONTROL

НЕОБХІДНІСТЬ ВИНИКНЕННЯ, ЕКОНОМІЧНИЙ ЗМІСТ ТА СУТЬ ПОДАТКОВОГО КОНТРОЛЮ

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Changes in tax legislation, the introduction of digital technologies have necessitated theoretical research and disclosure of the content of the definition of «tax control». The subject of the study is the economic content of the definition of «tax control» in terms of expanding information flows and digital data processing technologies.

The necessity, role and essence of control are considered. Emphasis is placed on the fact that financial relations cannot exist without proper state financial control, the importance of which is manifested in one of the important functions of the financial management process, which ensures the sound functioning of the entire financial system.

The purpose of the article is to substantiate the need, importance and essence of tax control in a situation where there is a constant reform of control activities of the state in general and tax control in particular, which requires systematic analysis and generalization.

It is proved that tax control, as a separate type of activity, has all the features of financial control and at the same time it has specific features that are manifested in a narrower area – the implementation of tax legislation of Ukraine. However, it is noted that both sides of tax control are in a relationship.

The legislative definition of the term «tax control» is considered as a guide, which should greatly simplify the process of assessing the activities of tax authorities to mobilize taxes and fees to the budgets of all levels. However, every year there are changes associated with the transformation of the economy, new tools of tax control, so in our opinion, tax control in the current conditions of the TCU is considered as an independent area of

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mandatory public financial control, the main purpose of which is control of compliance with tax legislation in the field of taxes and fees, which is implemented by conducting in-house, documentary and factual inspections of business entities and the implementation of digital tools of tax control to prevent and eliminate violations of tax discipline.

The research methodology is the theoretical generalization and implementation of a consistent analysis of conceptual approaches to the interpretation of the definition of «tax control» in regulations and scientific papers. It is noted that tax control, as a specific area of public financial control, is given considerable attention in scientific sources and regulations of Ukraine and other countries, along with this it is justified that the relevance of this issue sphere of tax control, the number of forms, methods and ways of its implementation is increasing, and in the conditions of digitalization the procedures for its implementation are being improved, the legislative regulation of taxation is constantly changing, and hence of tax control. The concept of «tax control» has been clarified, which at the theoretical level allows to expand its functional purpose in accordance with the practical activities of tax authorities.

The process of formation and development of tax control in Ukraine is not completed, which is due to further improvement of the taxation system. The process of tax control is considered as a set of stages of its implementation, depending on the purpose, objectives and scale. The stage of tax control is a part of the process that has its stages. Stages of tax control are characterized by a number of components.

In the domestic scientific opinion there is a wide range of approaches to the functions of tax control, each of which deserves attention, however, in our opinion, the functions of tax control should be unified and considered in two directions, namely: basic (fiscal, regulatory, preventive and control) and additional (accounting, analytical and legal).

The conclusion of the study is: the author's consideration of the main theoretical aspects of the concepts of «control», «public financial control» and «tax control» as part of public financial control; theoretical analysis of different approaches to the interpretation of the definition of «control», «tax control»; research of the stage of state financial control and tax control; determining the stages of formation of tax control and the main and additional functions of tax control, which will ultimately contribute to further research and development of the theory of tax control.

1. Вступ

Дієвим засобом державного регулювання розвитку економіки в умовах ринкових відносин виступають податки, які є основним бюджетоутворюючим джерелом та приймають безпосередню участь у розподілі доходів одержаних юридичними і фізичними особами. Реалізація фіскальної функції держави здійснюється через податкову політику – систему заходів щодо вирішення певних завдань, поставлених перед суспільством, за допомогою податкової системи країни. Податкова система України включає такі складові: систему оподаткування (перелік податків і зборів та механізм їх розрахунку і справляння до бюджетів усіх рівнів) та систему організації контролю за адмініструванням податків і зборів. Як одна, так і друга складові податкової системи мають стрижневе значення у формуванні доходів бюджету країни. Щодо другої складової – податкового контролю, вона виступає завершальною стадією процесу управління та підґрунтям для прийняття управлінських рішень.

Стаття 67 Конституції України закріплює обов'язок кожного громадянина сплачувати податки і збори в порядку і розмірах, встановлених законом [1]. Платники податків постійно знаходять різні способи приховання об'єктів оподаткування (скрутки ПДВ та конвертації, заробітна плата у конвертах, збитки державних підприємств, офшори тощо), що має негативний вплив на формування доходів Державного бюджету України. Так за підсумками результатів дослідження та проведеного підрахунку експертами Офісу простих рішень та результатів встановлено, що станом на 2021 р. бюджет України втратив понад 37 млрд дол. США внаслідок корупційних дій [2]. Обсяги тіньової економіки в Україні за останні 11 років варіюються в межах від 36% (у 2010 р.) до 30% (у 2020 р.) обсягу офіційного ВВП [3]. Таким чином, значна кількість правопорушень, у тому числі ухилення від спати податків – становлять економічну загрозу державі. На шляху попередження та зупинення податкових правопорушень стоїть податковий контроль.

Метою дослідження є обґрунтування необхідності, значення та сутності податкового контролю в умовах, коли здійснюється постійне реформування контрольної діяльності держави в цілому та податкового контролю зокрема, яке потребує системного аналізу та узагальнення.

2. Податковий контроль в системі державного фінансового контролю

Дослідження поняття «податковий контроль», як явища економічної науки необхідно проводити у контексті понять контроль, фінансовий контроль та еволюції сутності податковий контроль.

Термін «контроль» має французьке походження: controle – перевірка або спостереження з метою перевірки. Французьке controle утворилось від латинського contra – протидія і role – ступінь впливу, значення, участь у чомусь. У такому розумінні термін «контроль» означає перевірку або спостереження з метою протидії чомусь небажаному в суспільстві.

Контроль – це об'єктивна необхідність і виступає однією з чотирьох головних управлінських функцій та є фундаментом процесу управління. Ні планування, ні створення організаційних структур, ні мотивацію не можна розглядати у відриві від контролю. Контроль за результатами сприяє поліпшенню та оптимізації процесів. Держава нормально функціонує та розвивається за умови чітко організованої системи контролю за виробництвом, розподілом та перерозподілом Валового внутрішнього продукту. Поряд з цим ефективність функціонування суб'єктів господарювання залежить від здійснення контролю за дотриманням законів, рішень, розпоряджень. Контроль набуває важливого значення в сучасних умовах, так як за результатами контролю встановлюється ефективність прийнятих рішень, їх доцільність, ступінь виконання, за допомогою контролю держава захищає інтереси споживачів, виявляються причини та винні особи з метою усунення негативних тенденцій, проводяться заходи щодо збереження державного майна, здійснюється ефективне використання виділених бюджетних коштів, поліпшується фінансовий стан суб'єкту господарювання, поповнюються доходи державного бюджету.

Поняття «контроль в управлінні» необхідно розглядати у трьох основних аспектах:

– як систематичну та конструктивну діяльність керівників та органів управління, одну з управлінських функцій, тобто контроль як діяльність;

– як підсумкову стадію процесу управління, серцевиною якої є механізм зворотного зв'язку;

– як складову процесу розробки, прийняття та реалізації управлінських рішень.

Контроль як функція управління підпорядковується вирішенню завдань системи управління. В зазначеній функції контроль виступає завершальним етапом управлінської діяльності. Він проявляється на стадії перевірки виконання раніше прийнятих рішень і одночасно виступає інформаційною базою для прийняття нових рішень. Контроль як функція управління здійснюється майже всіма державними органами та їх посадовими особами.

Контроль є обов'язковим елементом будь-якої галузі державного управління. Основним міжнародним нормативним документом у сфері державного фінансового контролю є Лімської декларації керівних принципів контролю, де ст. 1 цього документа визначено, що організація контролю є обов'язковим елементом управління суспільними фінансовими коштами, оскільки таке управління тягне за собою відповідальність перед суспільством. Саме об'єктивні потреби держави та органів місцевого самоврядування у грошових коштах вимагають забезпечення повного і своєчасного їх надходження у вигляді податків і зборів (інших обов'язковим платежів) до бюджетів та державних цільових фондів.

Теоретичне дослідження податкового контролю доречно розпочати з визначення поняття «контроль». Для цього доцільно вдатися до етимологічного тлумачення даної категорії, яке зводиться до того, що контроль є перевірка, а також постійне спостереження з метою перевірки та нагляду.

Великий тлумачний словник української мови подає трактування дефініції контроль у двох аспектах: перевірка, облік діяльності кого-, чого-небудь; нагляд за кимось, чимось; контролювати – перевіряти кого-, що-небудь [4]

У фінансово-економічному словнику робиться акцент на те, що термін «контроль» походить від латинського «controle» – «перевірка» та визначено його як «дії, пов'язані з перевіркою, контролюванням» [5]. У Вільній енциклопедії Вікіпедії контроль розглядається як нагляд за об'єктом і підтримання його функціонування згідно із встановленими принципами через загальне порівняння фактичного стану об'єкту із станом, який необхідно забезпечити. А також як одна із основних функцій системи управління. Під контролем розуміється система спостереження і перевірки процесу функціонування і фактичного стану керованого об'єкту [6]. У юридичній енциклопедії, контроль тракту-

ється як перевірка виконання законів, рішень тощо. Є однією з найважливіших функцій державного управління [7].

У науковій літературі контроль розглядають як одну із форм управлінської діяльності. Зокрема, наголошується, що контроль є завершальним її етапом, що дозволяє співставити досягнуті результати з запланованими. На думку В.Г. Афанасьєва, контроль − це діяльність зі спостереження і перевірки відповідності процесу функціонування об'єкта прийнятим управлінським рішенням – законам, планам, нормам, стандартам, правилам, наказам і т.д.; виявленню результатів впливу суб'єкта на об'єкт, допущених відхилень від вимог управлінських рішень, від принципів організації та регулювання [8, с. 125]. Таке визначення не є безперечним, однак воно цілком може бути прийняте за основу, оскільки носить загальний характер і підходить для всіх видів і напрямів контролю, включаючи як державний, так і недержавний.

Бондаренко Н.О. також не допускає існування будь-якого виду управління без чітко організованої системи контролю, тому що не можна ефективно управляти, не перевіряючи виконання поставлених вимог та не виявляючи фактичного стану на управлінських об'єктах. У цьому значенні контроль, який є самостійною функцією управління, виступає засобом установлення зворотних зв'язків, завдяки чому керівний орган (суб'єкт управління) може простежити хід виконання прийнятих рішень [9, с. 72].

Контроль є обов'язковим елементом будь-якої сфери державного управління. У ст. 1 Лімської декларації керівних принципів контролю зазначається, що організація контролю є обов'язковим елементом управління суспільними фінансовими коштами [10], оскільки таке управління тягне за собою відповідальність перед суспільством. Саме об'єктивні потреби держави та органів місцевого самоврядування у грошових коштах вимагають забезпечення повного і своєчасного їх надходження у вигляді податків і зборів до бюджетів усіх рівнів. На даний час не існує єдиного підходу до трактування дефініції «контроль», що обумовлено розглядом даної категорії крізь призму різних наукових поглядів. Однак на нашу думку, найбільш влучним є наступне визначення «контролю»: контроль – це система спостереження і перевірки процесу функціонування об'єкту контролю заздалегідь встановленим параметрам з метою виявлення відхилень.

Особливе місце в системі контролю посідає державний контроль. Складовою державного контролю є фінансовий контроль, який виступає важливим засобом забезпечення законності та доцільності фінансової діяльності органами державної влади і місцевого самоуправління, підприємствами, установами, організаціями.

Щодо понять «фінансовий контроль» та «державний контроль», то за певними параметрами (обсяг, зміст) вони певним чином перетинаються. Похідним від цих двох категорій є поняття «державний фінансовий контроль», який є видом державного контролю і різновидом фінансового контролю за його суб'єктним складом. Державний фінансовий контроль здійснюють органи державної влади, в системі яких є спеціалізовані державні органи фінансового контролю. Державний фінансовий контроль є невід'ємною складовою системи управління державними фінансами.

Аналогічно дефініції «контроль», дефініція «державний фінансовий контроль» трактується великою кількістю науковців, які іноді суперечать один одному та призводять до неоднозначного розуміння цієї категорії.

А Порол ло Є.В. звертає увагу на те, що необхідність стабілізації фінансової системи, забезпечення сталого надходження бюджетних доходів, дотримання податкової дисципліни як умови якісного виконання зобов'язань перед державою фізичними та юридичними особами зумовила відокремлення особливого напряму державного фінансового контролю – податковий контроль [11, с. 6].

Ми стверджуємо, що податковий контроль належить до владного контролю, оскільки з одного боку він здійснюється державними органами контролю, які наділені певними владними повноваженнями стосовно підконтрольних суб'єктів, а з іншого боку фінанси як економічна категорія характеризується не тільки розподільчою, але і контрольною функціями. У зв'язку з цим податковий контроль є одним із різновидів державного фінансового контролю. Податковий контроль відрізняється від інших видів державного фінансового контролю тим, що він регулюється специфічними нормами законодавства, його об'єктом виступають різні види податків, організація функціонування системи сплати податків та податкові правовідносини в цілому.

Із зародженням держави виникли податки, які в подальшому привели до виникнення податкового контролю. Так, на думку Яро-

шенко Ф.О., Павленко В.Л., у стародавні часи початковою формою податкового контролю був облік платників податків та їх майна [12], а вже у XIX ст. продовжився процес законотворчої діяльності у сфері оподаткування й контролю та створювалися податкові органи. В сучасних умовах господарювання відбувається розширення сфери податкового контролю, збільшується кількість форм, методів і способів його здійснення, а в умовах цифровізації удосконалюються процедури його проведення, постійно змінюється законодавче регулювання оподаткування, а звідси і податкового контролю.

Суть податкового контролю, його призначення, місце у системі державного фінансового контролю досліджують українські вчені-економісти, а саме: В. Андрущенко, В. Борейко, В. Вишневський, Л. Воронова, М. Войнаренко, А. Даниленко, І. Криницький, В. Федосов, Т. Кушнарьова, Ю. Соловйова, О. Савченко, В. Онищенко, А. Поддєрьогін, Н. Хмелевська, Д. Рева, М. Свердан, В. Ревун, А. Сігаєв, Л. Тарангул, Н. Маринів, П. Буряк, Б. Карпінський, Н. Залуцька, В. Білінський та інші. Незважаючи на значну кількість публікацій та розробок, вивчення сутності податкового контролю є актуальною проблемою оскільки, в сучасних умовах господарювання відбувається розширення сфери податкового контролю, збільшується кількість форм, методів і способів його здійснення, а в умовах цифровізації удосконалюються процедури його проведення, постійно змінюється законодавче регулювання оподаткування, а звідси і податкового контролю.

Податковий контроль розглядається під двома кутами зору: як елемент державного управління податковою системою та як відокремлена, основна форма адміністрування податків. Податковому контролю, як відокремленому виду діяльності притаманні всі риси фінансового контролю, і одночасно він має специфічні риси, які проявляються у більш вузькій сфері спрямування – діяльність щодо виконання податкового законодавства України. Проте, обидві сторони податкового контролю знаходяться у взаємному зв'язку.

Здійснення податкового контролю в Україні має правове підґрунтя – Податковий кодекс України від 02.12.2010 р. № 2755-VI (редакція станом від 25.11.2021 р.) (далі – кодекс, ПКУ) і безпосередньо його глави 5-8, якими визначено сутність, способи здійснення та оформлення його результатів. У пп. 61.1 ст. 61 ПКУ наводиться законодавча

дефініція даного правового інституту. У силу зазначеної норми податковим контролем визнається система заходів, що вживаються уповноваженими органами з контролю за дотриманням платниками податків законодавства про податки і збори в порядку, встановленому кодексом [13]. Податковий контроль проводиться посадовими особами податкових органів у межах своєї компетенції за допомогою податкових перевірок даних обліку і звітності, проведення фактичних перевірок та огляду приміщень та територій, що використовуються для отримання доходу (прибутку), отримання письмових пояснень від платників податків, податкових агентів, а також в інших формах, передбачених кодексом.

З метою дослідження змісту податкового контролю в Україні доречно провести аналіз існуючих підходів до визначення податкового контролю та обґрунтувати його, як спеціального виду державного фінансового контролю, визначити етапи його становлення, розкрити процес організації його здійснення.

Початок дослідження вимагає обґрунтування категорії «податковий контроль» оскільки податковому контролю відводиться особливий статус у складі державного фінансового контролю, що здійснюється у сфері оподаткування. Крім того податковому контролю присутній динамічний процес.

Термін податковий контроль походить з англ. (tax control), що в буквальному сенсі означає контроль за правильністю сплати податків і зборів юридичними і фізичними особами. У спеціальній економічній та правовій літературі немає єдиної думки щодо трактування змісту поняття «податковий контроль» (таблиця 1).

На основі аналізу визначення поняття «податковий контроль», представлених у таблиці 1 можна зробити такі висновки: по-перше, податковий контроль – це діяльність податкових органів, особлива діяльність, система заходів, система дій тощо; по-друге, податковий контроль має своє спрямування – перевірка дотримання законодавства щодо нарахування та сплати податків; третє, податковий контроль передбачає визначення фактичного розміру порушень та притягнення винних.

Крім того важливо розглянути трактування терміну «податковий контроль» у нормативних актах України та інших країн, у яких (табл. 2).

Таблиця 1

Сутність дефініції «податковий контроль» у науковій літературі

Автор / джерело	Трактування
В.А. Онищенко [14]	Діяльність посадових осіб органів податкової служби щодо спостереження за відповідністю організації обліку об'єктів оподаткування платниками податків, методики обчислення й сплати податків і податкових платежів за чинними нормативно-законодавчими актами, виявлення відхилень, допущених у ході виконання норм податкового законодавства, та визначення впливу наслідків порушень на податкові зобов'язання.
В.П. Завгородній [15]	Розглядає податковий контроль у двох аспектах: як функцію чи елемент державного управління і як особливу діяльність щодо виконання податкового законодавства України.
М.П. Кучерявенко [16]	Спеціальний державний контроль, який являє собою діяльність податкових органів та їх посадових осіб по перевірці виконання вимог податкового законодавства особами, які реалізують податкові зобов'язання чи забезпечують цю реалізацію.
Д.М. Рева [17]	Один з видів фінансового контролю, що здійснюється у сфері державного управління оподаткуванням і являє собою діяльність уповноважених державою органів по перевірці дотримання вимог чинного законодавства особами, на яких покладено податковий обов'язок, виявленню порушень встановлених вимог та відновленню порушених прав держави та територіальних громад.
П.Ю. Буряк, Б.А. Карпінський, Н.С. Залуцька, В.З. Бєлінський [18]	Діяльність податкових органів щодо спостереження за відповідністю процесу організації платниками податків обліку об'єктів оподаткування, методики обчислення й сплати податків і податкових платежів за чинними нормативно-правовими актами сфери оподаткування, виявлення відхилень, допущених у ході виконання норм податкового законодавства та визначення впливу наслідків порушень на податкові зобов'язання.
А.П. Чередніченко [20]	Система дій та заходів в управлінні фінансами країни, які спрямовані на забезпечення додержання суб'єктами господарювання чинного законодавства з оподаткування з метою наповнення фінансовими ресурсами бюджетів усіх рівнів і державних цільових фондів.

(Продовження таблиці 1)

Автор / джерело	Трактування
Ю.О. Соловйова [19]	Визначення податкового контролю розглядає через визначення його мети – контролю за правопорядком у податковій сфері, що виражається в такому: загальні податково-правові заборони не порушуються; правовий статус платників податків та осіб, які сприяють виконанню податкового обов'язку, не порушується; учасники податкових правовідносин неухильно виконують покладені на них юридичні обов'язки, та їм реально гарантовано здійснення їхніх суб'єктивних прав; у разі порушення податкової норми наступає відповідна міра юридичної відповідальності.
Г.В. Дмитренко [21]	Податковий контроль – особливий вид державного фінансового контролю, що здійснюється на стадії формування державних грошових фондів спеціально уповноваженими суб'єктами (органами державної податкової служби та іншими контролюючими органами), спрямований на забезпечення додержання податкового законодавства платниками податків, податковими агентами та іншими суб'єктами, що забезпечують реалізацію податкового обов'язку, виявлення і попередження податкових правопорушень, а також притягнення винних осіб до юридичної відповідальності.
Т.В. Калінеску, В.О. Горецька-Гармаш, В.В. Демидович [22]	Податковий контроль – багатоаспектна міжгалузева система спостереження державних контролюючих органів за фінансово-господарською діяльністю платників податків із метою об'єктивного забезпечення заданого рівня формування бюджету й установлення її відповідно вимогам чинного законодавства.
М.І. Мельник [23]	Податковий контроль є частиною державного фінансового контролю, суть якого полягає у встановленні фактичного стану дотримання вимог чинного податкового законодавства на підконтрольному об'єкті. У всі часи існування системи оподаткування податковий контроль був невід'ємним інструментом фінансової політики держави, умовою підвищення ефективності адміністрування податків.
П.К. Бечко, Н.В. Лиса [24]	Податковий контроль – процес, що забезпечує досягнення намічених цілей, завдань та планових параметрів, у тому числі шляхом застосування фінансових санкцій, який передбачає виявлення відхилень між фактично досягнутими результатами за певний період від запланованих, а також вживання заходів, спрямованих на їх усунення.

(Закінчення таблиці 1)

Автор / джерело	Трактування
Л.А. Савченко, Л.М. Касьяненко [25]	Діяльність, що полягає у перевірці правильності справляння податків та інших обов'язкових платежів, виявленні та аналізі порушень, а також у забезпеченні вдосконалення роботи власне державного органу.
В.А. Валігура [26]	Податковий контроль можна визначати, як систему спостереження (моніторингу) за діяльністю платників податків з метою недопущення порушень податкового законодавства, оперативного виявлення та усунення таких порушень.

Таблиця 2

Трактування терміну «податковий контроль» у нормативних актах України та інших країн

Нормативний акт	Трактування
Податковий кодекс України [13]	Система заходів, що вживаються контролюючими органами з метою контролю правильності нарахування, повноти і своєчасності сплати податків і зборів, а також дотримання законодавства з питань проведення розрахункових та касових операцій, патентування, ліцензування та іншого законодавства, контроль за дотриманням якого покладено на контролюючі органи.
Податковий кодекс Республіки Білорусь [27]	Податковим контролем визнається система заходів по контролю за дотриманням податного законодавства, що здійснюється посадовими особами податкових органів в межах їх повноважень у вигляді: обліку платників (інших зобов'язаних осіб); проведення перевірок. Проведення перевірок податковими органами здійснюється із застосуванням у межах їх компетенції методів та способів, встановлених Міністерством з податків і зборів.
Податковий кодекс Республіки Вірменії [28]	Податковий контроль – це державний контроль за виконанням вимог правових актів, що наділяють податковий орган повноваженнями щодо контролю, – сукупність передбачених Кодексом дій податкового органу (його посадових осіб) у межах повноважень, відведених податковому органу.
Податковий кодекс Азербайджанської Республіки	Податковий контроль проводиться податковими органами в цілях забезпечення повного і своєчасного стягнення податків. Податковий контроль виступає єдиною системою контролю за обліком платників податків і об'єктів оподаткування, а також за дотриманням законодавства про податки
Податковий кодекс Республіки Таджикистан	Податковий контроль представляє собою форму здійснення податковими органами державного контролю, виконання норм податкового законодавства Республіки Таджикистан, інших законів Республіки Таджикистан, контроль виконання яких покладено на податкові органи

Отже, за інформацією наведеною у табл. 2 можна зробити такі висновки: по-перше, визначення терміну «податковий контроль» за ПК України та республіки Білорусь – це система заходів, що здійснюються посадовими особами органів податкового контролю щодо дотримання норм податкового законодавства цих держав, у ПК республіки Вірменії уточняється, що це державний контроль, який також здійснюють органи податкового контрою в межах свої повноважень. У ПК Азербайджанської Республіки встановлено, хто наділений повноваженнями по податковому контролю та, визначено, що в країні діє єдина система контролю за обліком платників податків, об'єктів оподаткування та дотримання податкового законодавства. Дещо незрозумілим є визначення «податкового контролю» за ПК Республіки Таджикистан, де термін «податковий контроль» визначено як форму здійснення податковим органом державного контролю. Поряд з цим доречно зазначити, що у нормативних актах таких країн як Литва, Естонія, Грузія та ін. замість трактування дефініції «податковий контроль» наводиться визначення терміну «податкова перевірка».

Звичайно, законодавче визначення терміну «податковий контроль» необхідно розглядати як дороговказ, який повинен значно спростити процес оцінки діяльності податкових органів щодо мобілізації податків і зборів до бюджетів усіх рівнів. Однак, кожного року виникають зміни, пов'язані із трансформацією економіки, з'являються нові інструменти податкового контролю, тому на нашу думку, «податковий контроль» в сучасних умовах дії ПКУ необхідно розглядати як самостійний напрям обов'язкового державного фінансового контролю, основне призначення якого полягає у контролі дотримання податкового законодавства в галузі податків і зборів, що реалізується шляхом проведення камеральних, документальних та фактичних перевірок суб'єктів господарювання та імплементування цифрових інструментів податного контролю з метою попередження та ліквідації порушень податкової дисципліни.

3. Етапи становлення та стадії проведення податкового контролю

Дослідження суті податкового контролю доцільно розглядати через етапи його становлення та розвитку. Проведення економічних реформ

з метою розвитку ринкових відносин в Україні стали підвалинами розбудови податкової системи та її складової податкового контролю.

Початком законодавчого закріплення функцій податкового контролю в Україні вважається 1990 рік, коли на основі Закону України «Про державну податкову службу» від 04.12.1990 р. № 509-XII почали функціонувати податкові органи в особі Державної податкової інспекції, головним завданням якої було забезпечення додержання податкового законодавства, повний облік платників податків та інших обов'язкових платежів до бюджету, здійснення контролю за правильністю обчислення та сплати цих платежів. Цим же Законом України встановлюється проведення податкових перевірок. До цього часу Україна не мала власних законодавчих актів з питань оподаткування, і в цілому, податкова система формувалася Радою Міністрів СРСР.

Другий етап розвитку податкового контролю настав з прийняттям Законів України «Про оподаткування прибутку підприємств» від 22.05.1997 р. № 283/97-ВР; «Про податок на додану вартість» 03.04.1997 р. № 168/97-ВР; «Про порядок погашення зобов'язань платників податків перед бюджетами і державними цільовими фондами» від 21.12.2000 р. № 2181 та інших нормативних актів. Введення в дію вищевказаних Законів України супроводжувалося видачою низки інших нормативних документів: Інструкції про порядок застосування і стягнення сум штрафних (фінансових) санкцій органами Державної податкової служби, затвердженою наказом ДПА України від 17.03.2001 р. № 30; Інструкції про порядок нарахування і погашення пені, затвердженою наказом ДПА України від 01.03.2001 р. № 77; Наказу ДПА України «Про організацію контрольно-перевірочної роботи» від 25.09.1997 р № 356; Наказу ДПА України «Про взаємодію між підрозділами органів державної податкової служби України під час організації документальних перевірок юридичних осіб» від 25.09.1997 р. № 356; Наказу ДПА України «Про затвердження форм актів перевірок» від 31.01.2003 р. № 50; листів Державної податкової адміністрації України: «Про проведення перевірок від 28.03.1996 р. № 16, «Про перелік платежів і розмір пені» від 10.031997 р. № 19, «Про проведення документальних перевірок» від 03.021998 р. № 10, «Про проведення документальних перевірок суб'єктів підприємницької діяльності» від 10.02.1998 р. № 1228 та інших нормативних актів.

Наявність значної кількості нормативних документів, постійних змін і доповнень до них вимагало удосконалення адміністрування податків і зборів та удосконалення процесу здійснення податкового контролю. Третій етап становлення податкового контролю припадає на прийняття і запровадження ПК України, до якого на сьогоднішній день внесена велику кількість змін і доповнень, що приводить до ускладнення застосування норм податкового законодавства, їх суперечливості у трактуванні, а отже порушується принцип стабільності податкового законодавства, який було анонсовано під час його прийняття. Розділ 2 «Адміністрування податків, зборів (обов'язкових платежів) ст. 41 «Контролюючі органи та органи стягнення» та глави з 5 по 8 ПК України, які регулюють податковий контроль в нашій державі.

Отже, кожний наступний етап становлення та розвитку податкового контролю відрізняється від попереднього тим, що відбувається процес удосконалення податкового механізму, що пов'язано з виникненням складних та масштабних господарських операцій, а звідси виникають нові способи податкового контролю; розвивається система органів державного управління й податкового контролю як її складової. Етапи становлення та розвитку податкового контролю в Україні узагальнимо у таблиці 3.

Періодизація становлення податкового контролю в Україні, аналіз економічної наукової думки свідчать, що залишається ще багато дискусійних та практично не вирішених питань, які стосуються поняття процесу та стадій податкового контролю. Переважна більшість науковців виділяє наступні стадії контролю:

– підготовчу чи організаційну стадію;

– проведення контролю або технологічну;

– оформлення результатів контролю або результативну стадію;

– прийняття рішень та контроль їх виконання або інспекційна стадія.

Автори А.М. Кузьмінський, В.В. Сопко, В.П. Завгородній [31] виділяють наступні етапи проведення контролю: підготовчий, здійснення контролю, узагальнення результатів контролю. На думку Б. Ф. Усача [32], у теорії і практиці контрольно-ревізійної діяльності є такі етапи:

– планування ревізії;

– підготовка, складання завдання (програми) проведення ревізії;

– організація роботи на місці (об'єкті) ревізії;

– документальна і фактична перевірка;

Таблиця 3

Етапи становлення та розвитку податкового контролю

Назва етапу	Коротка характеристика
До 1990 р.	Спадщина планово-регульованої бюджетної системи колишнього СРСР.
1990–1996 рр.	Прийняття Закону України «Про державну податкову службу». У ст. 2 «Завдання органів державної податкової служби» цього Закону України серед найперших завдань висувається здійснення контролю за додержанням податкового законодавства, правильністю обчислення, повнотою і своєчасністю сплати до бюджетів, державних цільових фондів податків і зборів (обов'язкових платежів), а також неподаткових доходів, установлених законодавством.
1997–2010 рр.	Прийняття значної кількості нормативних актів щодо контролю податків, зборів і платежів.
2010 р. і до сьогодні	Прийняття ПК України, яким визначено способи проведення податкового контролю, компетенцію контролюючих органів, повноваження і обов'язки їх посадових осіб під час здійснення податкового контролю та інших нормативних актів. Систематичне внесення змін і доповнень до ПК України.

– систематизація матеріалів і складання акту ревізії, висновків і пропозицій;

– узгодження і обговорення наслідків ревізії;

– затвердження матеріалів ревізії;

– контроль за виконанням рішень, прийнятих за матеріалами ревізії.

Таким чином, Б.Ф. Усач розширив процес проведення ревізії, а саме передбачивши узгодження і затвердження матеріалів контролю. Враховуючи вищезазначене, процес державного фінансового контролю можна відобразити наступним чином (рис. 1).

На нашу думку, процес податкового контролю необхідно розглядати, як певну сукупність стадій його проведення залежно від поставленої мети, завдань та масштабу. Контрольно-перевірочна робота в органах Державної податкової служби України (далі – ДПСУ) не відрізняється від загальноприйнятої у контролі практики проведення перевірок, однак є певні особливості на яких нами акцентується увага. Весь процес податкового контролю можна розподілити на такі шість взаємопов'язаних стадій (табл. 3).

Податковий контроль розпочинається із взяття на облік платників податків у органах ДПСУ. Відповідно до п. 63.3 ст. 63 ПК України з метою проведення податкового контролю платники податків підлягають реєстрації або взяттю на облік у контролюючих органах за місцезнаходженням юридичних осіб, відокремлених підрозділів юридичних осіб, місцем проживання особи (основне місце обліку), а також за місцем розташування (реєстрації) їх підрозділів, рухомого та нерухомого майна, об'єктів оподаткування або об'єктів, які пов'язані з оподаткуванням або через які провадиться діяльність (неосновне місце обліку). Взяття на облік за неосновним місцем обліку платників податків здійснюється згідно з нормами розділу VII Порядку обліку платників податків і зборів, затвердженого наказом Міністерства фінансів України від 09.12.2011 р. № 1588 та унесеними змінами, які затвердило Міністерство фінансів України від 24.06.2020 р. № 323 «Про затвердження Змін до Порядку обліку платників податків і зборів». Система обліку та реєстрації платників податків надає інформацію для всіх процесів контрольних заходів, планування, аналізу та регулювання.

Наступний етап – це організація і підготовка до проведення перевірки (доперевірочна робота). Доперевірочна робота в органі ДПС розпочинається після того як сформований план-графік документальних перевірок на поточний рік. Податкові перевірки проводяться за результатами проведеного аналізу фінансово-господарської діяльності з урахуванням визначених ризиків або в поле зору потрапляють платники податків, господарська діяльність яких вже є підозрілою з точки зору податкових органів. Особливістю податкових перевірок є те, що тільки планові документальні перевірки проводяться на підставі попередження платника податку за 10 днів про планову перевірку, решта перевірок – камеральна та фактична проводяться без будь-якого спеціального рішення.

Підставою для допуску посадових осіб ДПС є виданий наказ, копія якого вручається платнику податків та письмове повідомлення оформлене за десять днів до дня проведення зазначеної перевірки, де зазначається дата початку проведення такої перевірки.

До початку проведення податкового контролю податковий інспектор повинен ознайомитися з діяльністю суб'єкта господарювання, що підлягає поточному контролю. Інформаційною базою є як внутрішні, так і зовнішні джерела. До внутрішніх джерел інформації відносяться:

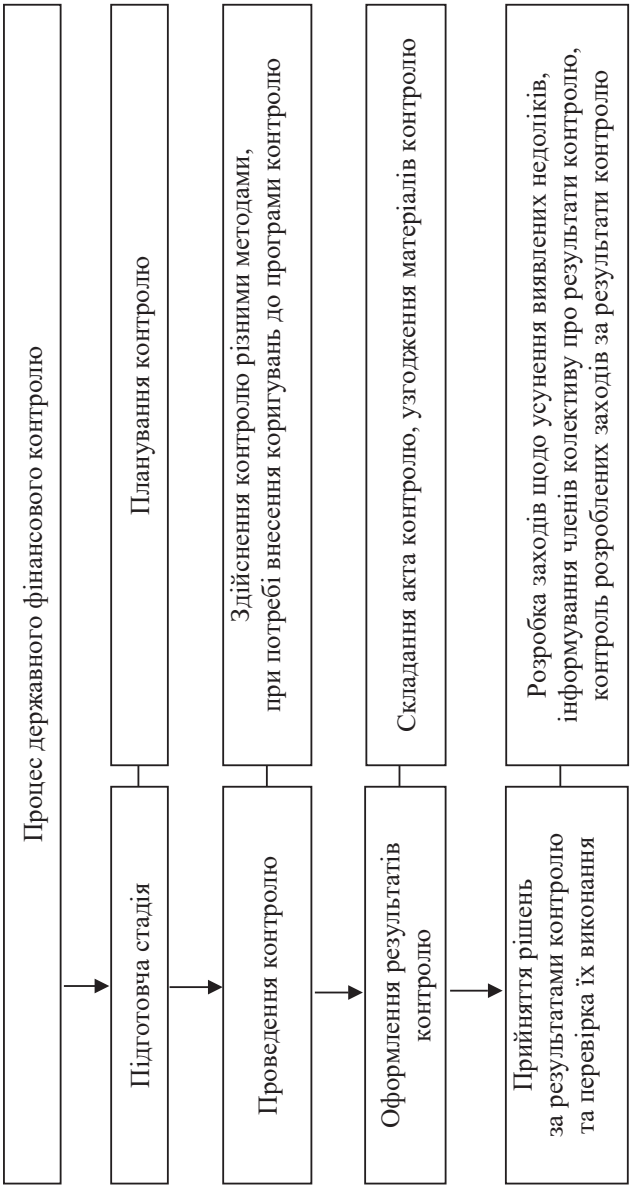

Рис. 1. Процес державного фінансового контролю

Рис. 2. Процес податкового контролю

акти попередніх податкових перевірок, декларації, результати камеральних перевірок поданих декларацій та фінансових звітів, аудиторські звіти зовнішніх незалежних аудиторів. Зовнішні джерела інформації – це інформація, яка оприлюднена в засобах масової інформації, мережі Інтернет, дані надані митними органами, банківськими установами.

Поряд з цим, податковий інспектор повинен підготувати письмові запити до органів державної влади з метою отримання відомостей, які стосуються перевірки. Такі запити направляються до органу статистики, виконавчих органів у галузі екології, водного господарства, з питань земельних ресурсів, виконавчих органів місцевих рад, органів Державтоінспекції, бюро технічної інвентаризації та інших.

Зібрана інформація необхідна для проведення аналізу діяльності суб'єкта перевірки, встановлення фактичних обсягів викидів, розміщення відходів, спожитої води тощо. Відповідно до даних звітності з'ясовується наявність основних засобів підприємства, проводиться вивчення технологічного процесу виробництва (необхідна кількість води, енергії, етикеток, сировини тощо). Отримані письмові відповіді на надіслані запити в обов'язковому порядку звіряються з даними, що містяться в базах даних автоматизованих систем податкової служби. Зібрана податковим інспектором інформація про платника податків дозволяє йому правильно визначити напрями перевірки, зменшити ризик не виявлення фактів порушень податкового законодавства, підвищити якість проведення податкового контролю, ґрунтовно скласти програму майбутньої перевірки та розробити заходи контролю. Програма перевірки включає перелік питань, що підлягають перевірці податковим інспектором, строк їх виконання, термін закінчення перевірки.

Проведення заходів контролю (перевірочна робота) – це один із відповідальних стадій податкового контролю. Стадія проведення податкового контролю включає: документальну перевірку бухгалтерських первинних документів, регістрів фінансового обліку та податкової звітності. Дослідження наданої для перевірки інформації у переважній більшості необхідно проводити використовуючи документальні прийоми (зустрічну перевірка, за змістом, логічну тощо) та аналітичні процедури. Причому охопити документальними перевірками необхідно не окремого платника, а всіх, хто причетний до можливої схеми ухилення від сплати податків. Поєднання прийомів документального контролю з

прийомами економічного аналізу дозволяє виявляти порушення норм чинного законодавства, зробити висновок щодо обґрунтованості декларування збитків або мінімізації та ухилення від сплати податків.

Наступним етапом проводиться оформлення результатів податкового контролю та складання підсумкових документів за результатами перевірки. Результати податкової перевірки оформляються довідкою (за відсутності порушень) чи актом, що визначено у ст. 86 ПКУ. Однак, необхідно врахувати, що Законом України від 16.01.2020 р. № 466-IX «Про внесення змін до ПКУ щодо вдосконалення адміністрування податків, усунення технічних та логічних неузгодженостей у податковому законодавстві», внесені зміни до ст. 86 Податкового кодексу України «Оформлення результатів перевірок» в частині порядку оформлення результатів перевірок. Надано визначення «акт перевірки», «довідка перевірки», «матеріали перевірки». В свою чергу, ДПСУ своїм наказом від 25.02.2021 р. № 244 «Про затвердження Зразка форми акту (довідки) документальної планової (позапланової) виїзної перевірки податкового, валютного та іншого законодавства, контроль за дотриманням якого покладено на контролюючі органи, та Методичних рекомендацій щодо оформлення матеріалів документальних перевірок» надає рекомендації щодо змісту та оформлення акту (довідки) податкової перевірки, тобто не містить нових правових норм, не встановлює новий порядок оформлення документальних перевірок, оскільки зазначені норми вже встановлені ПКУ та нормативно-правовими актами, розробленими відповідно до ПКУ.

Якщо платник податків не погоджується з висновками, викладеними в акті перевірки, він має право подати свої заперечення, додаткові документи й пояснення, у тому числі має право подати документи, які підтверджують відсутність вини чи наявність пом'якшувальних обставин або обставин, які звільняють від фінансової відповідальності. Свої заперечення платник податків повинен подати протягом 10 робочих днів. Заперечення щодо викладених фактів у акті податкової перевірки розглядає комісія контролюючого органу з розгляду заперечень і пояснень до акту перевірки. Ця комісія є постійно діючим колегіальним органом, а склад затверджується наказом керівника.

Рішення, яке приймається за результатами податкового контролю, в обов'язковому порядку заноситься в особисту справу платника подат-

ків – це п'ятий етап перевірки. Особиста справа платника податків повинна містити всю інформацію про причину, хід і результати перевірки, а також фіксувати процес прийняття ним акту перевірки. Статтею 58 п. 58.1 ПКУ визначено, що контролюючий орган надсилає (вручає) платнику податків податкове повідомлення-рішення, якщо сума грошового зобов'язання платника податків, передбаченого податковим або іншим законодавством, контроль за дотриманням якого покладено на контролюючі органи, розраховується контролюючим органом відповідно до ст. 54 ПКУ. До повідомлення-рішення додається розрахунок податкового зобов'язання та штрафних (фінансових) санкцій. Відповідно п.58.1.2 п.58.1 статті 58 ПКУ повідомлення-рішення має містити мотивувальну частину. Вищезгаданим Законом України № 466 доповнено п. 58.2 ст. 58 ПКУ абзацом першим та визначено, що форма та порядок надіслання податкового повідомлення-рішення визначаються центральним органом виконавчої влади, що забезпечує формування та реалізує державну фінансову політику.

Завершується процес податкового контролю здійсненням контролю за виконанням прийнятих ним рішень та обміном інформацією з уповноваженими особами. Контроль виконання прийнятих рішень застосовується до тих платників податків, які не сплачують суму податкового чи грошового зобов'язання. Його проводять підрозділи, які здійснювали перевірку та структурний підрозділ стягнення податкової заборгованості. Згідно зі ст. 59 п. 59.1 ПКУ у разі коли у платника податків виник податковий борг, контролюючий орган надсилає (вручає) йому податкову вимогу в порядку, визначеному для надсилання (вручення) податкового повідомлення-рішення. За визначенням п.п.14.1.153 п.14.1 ст.14 ПКУ, податкова вимога – це письмова вимога контролюючого органу до платника податку щодо погашення суми податкового боргу [13]. Податкова вимога формується лише за узгодженими сумами податкових зобов'язань, які не сплачені платником податків в установлені терміни. Податкова вимога формується на підставі облікових даних з карток особових рахунків платників податків, які ведуться у ДПС або на підставі поданого іншого контролюючого органу про здійснення заходів з погашення податкового боргу.

Структурний підрозділ стягнення податкового боргу ДПС формує і направляє податкову вимогу платнику податків. Податкова вимога

вручається особисто юридичній особі під розписку або направляється поштовим відправленням з повідомленням про вручення. Після вручення податкової вимоги платнику податків структурний підрозділ, до функцій якого входить реєстрація вхідної та вихідної кореспонденції, передає корінець такої податкової вимоги з відміткою про вручення структурному підрозділу стягнення податкової заборгованості.

Таблиця 4

Функції податкового контролю

Функції податкового контролю	**Короткий зміст**
Основні функції податкового контролю	
Фіскальна	Наповнення доходів бюджету.
Регулююча	Полягає у забезпеченні сприяння економічної активності платників податків і зборів шляхом згладжування їх конкурентних переваг і майнового стану, що в кінцевому результаті дозволяє позитивно вирішувати завдання розвитку економіки, зменшувати соціальну напругу, яка виникає через диспропорціями в рівні доходів населення.
Превентивна	Попередження порушень у сфері оподаткування та ухилення від сплати податків і зборів, що у свою чергу, сприяє підвищенню рівня податкової дисципліни платників податків.
Контрольна	Це основна функція податкового контролю, мета якої полягає у проведені різних контрольних заходів та оцінка їх ефективності з метою вироблення заходів націлених на подальше удосконалення.
Додаткові функції податкового контролю	
Облікова	Передбачає проведення контрольних заходів під час взяття на облік платників податків з метою створення умов для здійснення контролюючими органами контролю за правильністю нарахування, своєчасністю і повнотою сплати податків, нарахованих фінансових санкцій, дотримання податкового та іншого законодавства.
Аналітична	Полягає у дослідженні фактів, узагальненні інформації, виявленні різного роду порушень.
Законності	Зміст цієї функції полягає по-перше, у правильності прийняття рішень за результатами контролю; друге, припинення неправомірних дій платників податків, винних у порушеннях податкового законодавства, шляхом притягнення до адміністративної чи кримінальної відповідальності.

Суть податкового контролю необхідно розглядати крізь призму функцій, які він виконує. Існує багато підходів до розкриття змісту функцій податкового контролю, однак, на нашу думку, доречно виділити основні та додаткові (табл. 4).

4. Висновки

Суть податкового контролю, його призначення, місце у системі державного фінансового контролю досліджують українські вчені-економісти. Водночас, віддаючи належне напрацюванням науковців, зазначимо, що незважаючи на різноплановість наукових результатів у межах цієї проблематики, ряд питань залишаються малодослідженими. Передусім, це стосується вивчення сутності податкового контролю що є актуальною проблемою сьогодення оскільки, в сучасних умовах господарювання відбувається розширення сфери податкового контролю, збільшується кількість форм, методів і способів його здійснення. Крім того в умовах цифровізації удосконалюються процедури його проведення, постійно змінюється та доповнюється законодавче регулювання оподаткування і податкового контролю. Значущість і логічна незавершеність висвітлення в наукових працях зумовили проведення дослідження виникнення, змісту і суті податкового контролю.

На підставі дослідження нормативно-законодавчих актів, теоретичних та практичних напрацювань у сфері податкового контролю запропоновано авторське визначення «податковий контроль». Під податковим контролем необхідно розуміти самостійний напрям державного фінансового контролю, основне призначення якого полягає у контролі дотримання податкового, валютного та іншого законодавства в сфері податків і зборів та реалізується шляхом проведення камеральних, документальних та фактичних перевірок суб'єктів господарювання. Наведене уточнення визначення «податковий контроль» надає закінченості зв'язку в ланцюжку понять «мета – законодавство – метод – суб'єкт» та сприяє подальшому розвитку теоретичних напрацювань у сфері податкового контролю.

Процес становлення і розвитку податкового контролю в Україні не завершений, що пов'язано з подальшим удосконаленням системи оподаткування. Доведено, що процес податкового контролю необхідно розглядати, як певну сукупність стадій його проведення залежно від поставленої мети, завдань та масштабу. Стадії податкового контролю –

це частина процесу, які мають свої етапи. Етапи податкового контролю характеризуються низкою відповідних складових елементів.

У вітчизняній науковій думці існує досить широкий спектр підходів щодо функцій податкового контролю, кожен з яких заслуговує на увагу, однак, на наш погляд, функції податкового контролю доцільно уніфікувати і розглядати у двох напрямах, а саме: основні (фіскальна, регулююча, превентивна, та контрольна) й додаткові (облікова, аналітична та законності), що в остаточному підсумку сприятиме подальшому проведенню наукових досліджень та розвитку теорії податкового контролю в Україні.

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ANALYTICAL TOOLS OF FINANCIAL RESULTS IN THE CONDITIONS OF RISK-ORIENTED MANAGEMENT

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Abstract. *The purpose* of the article is to substantiate theoretical provisions and practical foundations for improving the organization and methods of economic analysis of the formation of financial results in the conditions of risk-oriented management. *Methodology*. Methods of theoretical generalization and concretization, Internet resources have been used in this study. *Results*. There have been distinguished some approaches to the analysis of financial results of enterprises in such areas as the assessment of the level, dynamics and structure of financial results and indicators forming them, i.e. income and expenses; analysis of the financial results of operating activities as the main activity of the enterprise; determination of the influence of key factors on the formation of the financial result of the business entity and profitability analysis. The stages of analysis of financial results, tools for their implementation, the results obtained and possible management decisions are revealed. Analytical evaluation provides an opportunity to generate a significant amount of information necessary for the implementation of management decisions on the formation, distribution and use of financial results. A conceptual approach to implementation of analytical evaluation of financial results is proposed, which will help the company's management to identify unusual transactions or events, as well as amounts, indicators and trends that may indicate atypical circumstances in the formation, distribution and use of financial results. Budgeting of financial results in the conditions of risk-oriented management is

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substantiated. Formation, dynamics and change of financial results and profitability of "Kurland LLC" are analyzed. Interconnectedness of the components and coherence of the main tasks and objectives of economic analysis of profits in risk-oriented management, strategic analysis and adaptive financial mechanism aimed to ensure profitability of enterprises are revealed. It is proposed to carry out the forecast value of financial results at the enterprise taking into account various factors of influence, including those caused by risks, by means of the correlation-regression analysis. *Practical implications.* A formed mechanism of risk management identification is the basis of formation of the system of measures from the standpoint of managers of various hierarchical levels as well as realization of operative administrative influence on operations with the increased degree of risk. *Value*/*originality*. Risk-oriented approach to the organization of economic analysis of profits enables to identify both external and internal risks, identify key ones, develop an appropriate management model to neutralize, reduce impact and prevent them. The study of peculiarities of the budgeting system under conditions of risk-oriented management has revealed the need to develop a single effective coordinated budgeting system in order to achieve competitive advantages in the market, in accordance with the requirements of the modern concept of integrated management. The use of correlation-regression analysis enables to identify the nature of changes in the financial results caused by the effect of factors of influence, both together and separately with each factor identified.

1. Organizational aspects of the analysis of financial results in terms of risk-oriented management

Qualitative analysis of the financial results of the enterprise is of great importance in the current conditions of development and improvement of market relations in Ukraine. Its implementation affects the right decision on capital management, minimizes the financial risks of the enterprise, helps to increase the efficiency of its activities, the most rational use of material, labor, and financial resources. To make effective management decisions it is necessary to combine factors, namely: reliable information about the results of the enterprise, which is formed taking into account the specifics of management and its organizational structure; use of modern methods of financial analysis; formation of objective conclusions about the general condition of the enterprise

and determination of ways to solve certain problems. Therefore, there is a need to highlight the most important indicators of the impact on profits and the feasibility of making appropriate management decisions.

The need for qualitative financial analysis is especially relevant in cases where the company is unable to properly assess its financial condition, which in the future creates serious obstacles to its effective operation.

The methodological basis for the analysis of financial results in terms of risk-oriented management is accepted for all enterprises, regardless of organizational and legal form and form of ownership, the model of their formation and use.

The study of approaches to the analysis of financial results of the enterprise showed that most authors in the analytical evaluation of financial results of the enterprise carry out in such areas as assessment of the level, dynamics, and structure of financial results and indicators that form them, ie income and expenses; analysis of the financial result from operating activities as the main activity of the enterprise; determining the impact of key factors on the formation of the financial result of the entity and the analysis of profitability (Table 1).

It should be noted that in the process of analyzing financial results, an important factor is the information base, ie the initial data for the analysis. In modern conditions, the information base for the analysis of profit and profitability are business plan; financial plan; form № 1 «Balance Sheet» (Statement of financial position); form № 2 «Statement of financial performance» (Statement of comprehensive income); form 3 «Statement of cash flows» (by direct, indirect methods); Form № 4 "Statement of Equity" (Statement of Changes in Equity); enterprise tax return; marketing research materials [8].

In the analysis of financial results of the enterprise can be used a variety of techniques, methods, and models analysis. Their number and range depend on specific goals and objectives. At the same time, it remains unclear which method of analysis is the most accepted in practice, which provides a comprehensive analysis of financial results of the enterprise, to justify effective management decisions to improve the financial policy of the enterprise aimed at its development. The analysis of the scientific literature gives grounds to claim that most scientists prefer horizontal, vertical, and coefficient analysis (84,6%) [9]. However, in order to obtain quality indicators, it is advisable to conduct phased monitoring of financial

Table 1

Some approaches to the analysis of financial results of enterprises

Author, source	Areas of analysis of financial results
1	2
Mulyk T.O. [1]	Vertical and horizontal and trend analysis of financial results of the enterprise
Yarish P.M., Kasianova Yu.V. [2]	1. Mathematical and statistical methods of research of financial results: economic methods, methods of economic cybernetics and optimal programming, methods of research of operations, and the theory of decision-making. 2. CVP analysis and the concept of financial leverage.
Bilyk M.D., Prytuliak N.M., Pavlovska O.V., Nevmerzhytska M.Yu. [3]	1. Vertical and horizontal analysis of financial results of the enterprise. 2. Factor analysis of profit. 3. Analysis of profitability indicators. 4. Factor analysis of profitability indicators. 5. The direct-cost system as a theoretical basis for cost analysis and profit optimization. 6. Analysis of profit increase reserves.
Tomchuk O.F. [4; 5]	1. Vertical and horizontal and trend analysis of financial results of the enterprise. 2. Analysis of relative indicators (coefficients), factor analysis.
Shkolnyk I.O. [6]	1. Assessment of the dynamics and composition of financial results. 2. Factor analysis of operating profit. 3. Analysis of the relationship between costs, production, and profits. 4. Analysis of the profitability of the enterprise.
Mochalina Z.M., Pospielov O.V. [7]	1. Structural and dynamic analysis of financial results, including income and expenses. 2. Factor analysis of financial results. 3. Coefficient analysis of financial results. 4. Analysis of profitability indicators.

Source: [1–7]

results. The essence of the above monitoring is to combine at different stages of analysis of a range of different methods, namely: coefficient method, methods of horizontal and vertical comparative analysis, the method of basic substitutions, the method of relative differences; as well as methods of correlation and regression analysis, which allow not only to analyze the balance sheet items of the enterprise but also to make a

comparative analysis of a number of enterprises in a particular industry or those engaged in similar activities. Such comparisons should be made not only for the reporting period but also for a number of years, which reflects a fairly long period of activity of the enterprise. This allows you to identify trends in the development of the enterprise for the future, which is of great importance in practice, as companies carry out both long-term and medium-term and current planning of their activities. Thus, this approach provides a comprehensive analysis of the enterprise, the ability to identify trends in its development, the reasons for changes in income, expenses, indicators of profit. Compare indicators with industry average data and make optimal management decisions to improve the efficiency of the enterprise.

Stages of analysis of financial results, tools for their implementation, results obtained and possible management decisions are presented in Table 2.

Table 2

Stages of analysis of financial results, tools for their implementation, results obtained, and possible management decisions

Stages	Tools	The results obtained	Management decisions
1	2	3	4
Analysis of the main indicators of efficiency financial area	Coefficient method, comparative method, methods of horizontal and vertical comparative analysis	The state of financial activity and financial capabilities of the enterprise	Increasing the competitiveness of the enterprise
Analysis of the main indicators of the production area		The degree of suitability of fixed assets in production, the level of use of fixed assets and materials in the profitability of the enterprise	Identification of reserves for further improvement of production efficiency, modernization of fixed assets in production
Analysis of the main indicators of enterprise development		Status of production and financial results; identifying prospects for development and consolidating market positions	Determining the competitive position of the enterprise within a specific regional market of relevant products, introduction of new products to the market, search for new segments

(End of Table 2)

1	2	3	4
Cost analysis by elements of operating costs	Methods of vertical and horizontal comparative analysis	Change during the period of the number of production costs included in the cost of production	Reduction of production costs, which are included in the cost of production
Analysis of the structure of the balance sheet	Methods of vertical and horizontal comparative analysis	The magnitude of changes that have occurred during the analyzed period and determine the consequences	Determining changes in the analyzed period relative to the base period or business plan, identifying factors that led to changes
Analysis of the financial condition of the enterprise	Coefficient method, horizontal comparative analysis	The level of financial results that determine the capabilities of the enterprise	Search for alternative solutions that take full advantage of the enterprise
Product profitability analysis	Method of basic substitutions	Evaluation of efficiency and rational use of invested funds	Making adjustments to the strategic plan
Analysis of development trends	Trend analysis method	Determining changes in the economic policy of the enterprise for more than 2 consecutive years	Determining the quality of the enterprise for a certain period, determining ways to normalize the enterprise
Construction of economic and mathematical models			
Construction of a linear multifactor regression economic-mathematical model	Methods of correlation and regression analysis	Identification of general patterns and relationships between net income and influencing factors	Attracting investment
Formation of conclusions about the general condition of the enterprise, allocation of the most important indicators of influence on profits, and expediency of acceptance of the corresponding administrative decisions			

Source: [10]

Analysis of the data in the table shows that most often in the analysis of indicators of financial and production sphere, cost by elements of operating costs, balance sheet structure, the general financial condition of the enterprise using methods of vertical and horizontal comparative analysis.

Thus, the important tool for analyzing the financial performance of enterprises is analytical evaluation in the form of techniques and methods of analysis. This estimate is used at different stages of the study of the formation, distribution, and use of financial results for:

– primary processing of collected information (verification, grouping, systematization);

– study of the state and patterns of costs, revenues, and calculation of financial results;

– determining the impact of factors on the performance of enterprises;

– calculation of unused and promising reserves to increase efficiency;

– generalization of analysis results;

– substantiation of budgets and scenarios of enterprise development and management decisions.

The use of analytical assessment provides an opportunity to generate a significant amount of information necessary for management decisions on the formation, distribution, and use of financial results. The purpose of the study of the use of methodological tools of economic analysis in the process of analytical support of financial results of enterprises is the formation of common theoretical positions and the development of universal recommendations for the use of analytical evaluation of procedures during the formation of information base.

In Figure 1 shows a conceptual approach to the use of analytical evaluation of financial results.

Various financial ratios, which show the financial proportions between different reporting items, also help to assess the financial statements of the enterprise, namely: indicators of efficiency of production activities; indicators of business activity; liquidity indicators; indicators of financial stability. Depending on the specific goals and objectives, you can perform a financial analysis of varying degrees of detail.

We believe that the use of analytical assessment in the formation of the analytical base of financial results should assist the company's management in identifying unusual transactions or events, as well as amounts, indicators,

and trends that may indicate atypical circumstances in the formation, distribution, and use of financial results.

At the same time, it is not necessary to reduce the analysis to the study of a set or list of indicators of economic efficiency and their deviations, because neither the indicators nor their dynamics are evidence of a violation

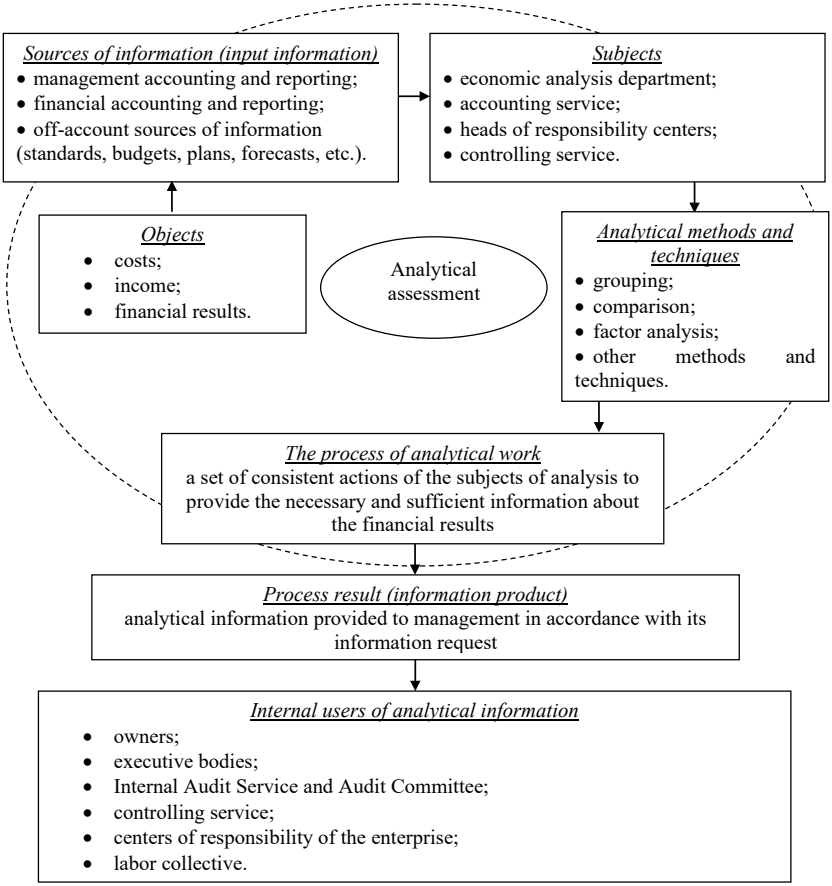

Figure 1. Conceptual approach to the use of analytical evaluation of financial results

Source: suggested by the author

of the normal course of financial results. The priority for the purposes of economic analysis itself is to focus on the study of causal relationships of economic phenomena and processes and forecasting their future values. This allows you to find bottlenecks and identify areas that need monitoring.

Adequate assessment of the formation of the company's profit for the purpose of analytical support of financial results is due to the optimal choice of methodological approach to its implementation. It should be noted that the method of analysis is a set of methods, techniques used for systematic, consistent, the most appropriate practical analytical work. This will make it possible to critically assess the financial results of the enterprise both in statics for a certain period and in dynamics – for a number of periods, will identify «pain points» in financial activities and ways to more efficiently using financial resources, their rational allocation.

Timely and unbiased analysis of financial results helps to increase the efficiency of enterprises, the most appropriate and effective use of fixed assets, material, labor, and financial resources, eliminating additional costs. And the results of the analysis create objective conditions for increasing the effectiveness of management decisions, as well as obtaining reasoned accounting and analytical information for planning and forecasting financial results [11].

An important source of reserves for the growth of profitability of LLC «Kurland» is the optimization of the structure of marketable products, ie the growth of the share of those types of products that bring more profit to the company. However, the lack of free production of the required volumes by type of agricultural production leads to changes in market conditions and, accordingly, to a significant annual change in the price of the same type of product.

The formation of financial results depends entirely on the goals of the enterprise. If the company aims at high rates of development, increases sales, and conquers a significant part of the market, the purpose of the formation of financial results is a high rate of their growth. If the company stabilizes its activities, is satisfied with the minimum level of profitability or even unprofitable activities, the management of financial results should be focused on obtaining such a system that provides current solvency. And if the activities of the owners are based on the interests of the owners, the target guidelines for the formation of the final financial results are indicators such as return on investment or equity.

In order to increase the economic efficiency of production of LLC «Kurland» it is necessary to update the material and technical base of the enterprise by leasing the purchase of equipment; attracting loans for profitable projects that can bring the company a high income; reducing the equity deficit by accelerating its turnover by reducing excess inventories, work in progress, production and commercial cycle.

Economic conditions in Ukraine and LLC «Kurland» in particular are characterized by crises, increased competition, the existence and spread of information wars, which necessitate the introduction of new methods of enterprise management to ensure its effective functioning. In such conditions, the urgent task is to identify the risks of economic activity in order to develop appropriate management models. Determining the nature of probable risks, assessing their impact on the enterprise, pre-developed anti-crisis tools is one of the important tasks of business planning.

Risk management is considered a central part of the strategic management of the organization, whose task is to identify risks and manage them. At the same time, risk management as a single risk management system should include a program of control over the implementation of tasks, evaluation of the effectiveness of measures, as well as an incentive system at all levels of the organization.

The formation of a risk management system at the enterprise begins with the definition of risk management objectives at the enterprise and the identification of risks that should be subordinated to the above objectives.

The choice of a specific method of risk identification is determined by the specifics of economic activity, the scale of change, the peculiarities of the system of organization of the risk management process at the enterprise.

Thus, a significant advantage of monitoring is to provide a comprehensive analysis of financial results, clarity of dynamics and changes in indicators that are analyzed, the effective choice of management decisions based on analytical data. Properly chosen method of analysis of financial results can be the foundation for obtaining reliable indicators, and, as a result, the most efficient use of financial resources, compliance with settlement and credit discipline, achieving a rational ratio of own and investment funds, financial forecasting for effective operation in the future.

Analysis of the financial and economic results of LLC «Kurland» is a necessary condition for effective management of income and expenses in

order to increase profits and increase profitability. The future performance of the company depends on how well the analysis of financial results is carried out, the main factors that provide it are determined.

A risk-oriented approach to the organization of economic analysis of profits allows you to identify both external and internal risks, identify key ones, develop an appropriate management model to neutralize, reduce impact and prevent. Thus, risk identification deals with finding, listing, and describing risk elements. The latter include sources of risks or dangers, possible threats, events, consequences, and probabilities. Identification – one of the most important stages of the process of risk management allows the distribution of events, causes, consequences by classes, groups, categories, in which one group includes objects that have a common feature. This distribution in relation to the goals of society creates an information field to combat adverse events.

2. Budgeting of financial results in the conditions of risk-oriented management

Modern globalization processes have a significant impact on the activities of the entity, as well as produce new, more stringent requirements for resource planning and management. This necessitates the creation of a single effective coordinated budgeting system in order to achieve competitive advantages in the market, the need to optimize and reduce overhead costs, which is a requirement of the modern concept of integrated management.

In recent years, budgeting has become the most popular management technology among domestic businesses. Management, in general, understands the importance of using budgeting in business management, but in its development and implementation often faces problems of various kinds. A significant number of issues arise when establishing a single budgeting system in corporations or industrial and financial groups because in this case, it is necessary to consolidate multilevel accounting systems, take into account industry specifics, specifics of production activities, and many other related factors.

Hnylytska L.V. [12, p. 89] notes that in only 2% of cases risk identification is based on credentials, due to the fact that the risk management process is mainly carried out by managers whose conclusions are based only on personal experience and intuition.

Under such conditions, it is useful to build a model that would characterize all major economic processes in the enterprise and contain: the structure of hierarchical subordination, sources of resources and funding centers, centers of incoming financial flows by type, and so on.

One of the most important conditions for the functioning of an effective budgeting system is its global use in conjunction with the elements and procedures of risk management at all levels of the organizational structure of the enterprise. Involving in the process of budgeting and risk management a sufficient number of employees with clearly defined «limits of responsibility» will solve the following tasks: reduce the complexity of the process of implementation and maintenance of budgeting by its decentralization; increase the number of areas and areas of detection, monitoring and initial identification of risks that affect the activities of the enterprise; increase the responsibility of specific executors, delegating to them the authority and responsibility for the implementation of certain budget indicators; to improve the system of motivation with elements related to the evaluation of the results of the planned indicators.

The main task of budgeting as a management technology is to increase the efficiency of production activities of the enterprise on the basis of target orientation and coordination of all events, as well as increase the flexibility of the enterprise in the transformation of the economic system.

In the West, a «risk-based budgeting» approach was introduced a few years ago. In this approach, any input parameter for the budget is set not by a single digit, but by a range of values. This range can be set by 2-3 values and expert assessment of their probability (for example, pessimistic, optimistic, and realistic scenarios), and can be set more complex in the form of statistical distribution [13].

With the help of simulation, the collected information on uncertainties can be consolidated into a financial model. The output will be a budget in which the final data will be presented not in a single value, but in the form of probability distribution in a certain range. The information provided in this way gives decision-makers an understanding of the full picture of the possible future and allows them to make informed decisions about realistic targets and the necessary reserves.

It should be noted that the formation and use of reserves should take into account the following: contingencies should be included in the budget as a

separate item; reserves should not be used to cover costs incurred as a result of negligent performance by officials, etc.

Due to the fact that budgeting is likely to determine the planned indicators that the company risks not meeting, it is worth using a historical approach to the calculation of key targets. This approach is that in order to calculate the indicators for the planning period it is necessary to analyze the size of similar, which was achieved in previous reporting periods. It should be noted that with such an approach, the more analyzed the previous reporting periods, the more accurate the sample will be. We propose to calculate the planned indicators by using the methods of mathematical statistics and calculating the historical volatility of the total income of the enterprise.

The use of the KPI motivation system allows establishing the levels of responsibility of employees for the implementation of the budget, which will allow for more effective control in the event of significant deviations of the actual indicators from the planned.

Under conditions of risk during budgeting, it is mandatory to reflect in the budget of the total costs of the enterprise a separate item of unforeseen costs, which we propose to submit as follows: probable costs caused by the risk; the cost of measures to eliminate the effects of risk.

To determine the planned indicators of probable unforeseen costs, we propose to use the methods of mathematical statistics on costs, which were carried out in previous reporting periods and are associated with the occurrence of a risk situation. Table 3 shows the risky business transactions that took place in LLC «Kurland» during 2018–2020, with a distribution of the probability of their occurrence.

Using the probability coefficients calculated in Table 3 for each type of probable risk that took place in the company from results in previous years, we determine using a mathematical expectation of random variables the estimated amount of costs that may incur in case of recurrence of risk in economic activity of LLC «Kurland (formulas 1-4):

$$M(Xp) = 849 \times 0{,}25 + 610 \times 0{,}25 = 212{,}25 + 152{,}5 = 364{,}75 \text{ (thousand UAH)} \quad (1)$$

$$M(Xk) = 52 \times 1 = 52 \text{ (thousand UAH)} \quad (2)$$

$$M(Xz) = 0 \text{ (thousand UAH)} \quad (3)$$

$$M(Xb) = 13 \times 1 = 13 \text{ (thousand UAH)} \quad (4)$$

$$M(Xs) = 48 \times 0{,}2 + 148 \times 0{,}2 = 9{,}6 + 29{,}6 = 39{,}2 \text{ (thousand UAH)} \quad (6)$$

Table 3

Calculation of the coefficient of the probability of economic risk in LLC «Kurland»

№	Number of events (s) / Tax risk (*X*)	2018	2019	2020
1	Occurrence of overdue payments by counterparties, thousand UAH, *Xp*	-	849	610
	Pi, coefficient	-	0,25	0,25
2	Erroneous transfer of funds to third party accounts, thousand UAH *Xk*	52	-	-
	Pi, coefficient	1	-	-
3	Violation of tax legislation, thousand UAH, *Xz*	-	-	-
	Pi, coefficient	-	-	-
4	Bankruptcy of counterparties, thousand UAH, *Xb*	-	-	13
	Pi, coefficient	-	-	1
5	Payment of penalties, thousand UAH, *Xs*	-	48	148
	Pi, coefficient	-	0,2	0,2

Source: calculated by the author according to the studied company

According to the calculated indicators, the estimated values of costs that the company may incur in the event of a risk situation are determined.

Having calculated the estimated absolute values of costs that may occur in the forecast period in LLC «Kurland», we calculate the possible deviations from the calculated forecast values (formulas 7-10):

$$\sigma(X_p) = \sqrt{849^2 \times 0,25 + 610^2 \times 0,25 - 364,75^2} = \sqrt{180200,25 + 93025 - 13342,56} = \sqrt{259882,69} = 509,78 \text{thousand UAH} \quad (7)$$

$$\sigma(X_k) = \sqrt{52^2 \times 1 - 52^2} = 0 \text{thousand UAH} \quad (8)$$

$$\sigma(X_b) = \sqrt{13^2 \times 1 - 13^2} = 0 \text{ thousand UAH} \quad (9)$$

$$\sigma(X_s) = \sqrt{48^2 \times 0,2 + 148^2 \times 0,2 - 39,2^2} = \sqrt{460,8 + 4308,8 - 1536,64} = \sqrt{3232,96} = 56,86 \text{thousand UAH} \quad (10)$$

On the basis of the calculations, a possible deviation of costs associated with the recurrence of overdue debt by 509,78 thousand UAH; expenses for payment of penalties – by 56,86 thousand UAH.

Taking into account the calculations and the scenario approach to budgeting, we will build a simplified model of contingency budget LLC «Kurland» (Table 4).

Table 4

Contingency budget of LLC «Kurland» for the forecast period

№	Indexes	Budget scenarios are possible		
		optimal	real	critical
1. Probable costs of risk				
1.1	Erroneous transfer of funds to third party accounts, thousand UAH	100	100	100
1.2	Violation of tax legislation, thousand UAH	-	-	-
1.3	Bankruptcy of counterparties, thousand UAH	13	13	13
1.4	Payment of penalties, thousand UAH	19,4	39,2	58,6
1.n	Other expenses, thousand UAH	-	-	-
	Total costs	132,4	152,2	171,6
2. Expenses for measures to eliminate the consequences of the risk				
2.1	Creating a reserve for doubtful debts, thousand UAH	16,14	364,75	729,5
2.n	Other costs for the creation of events	-	-	-
	Total costs	16,14	364,75	729,5
	The total amount of unforeseen costs	148,54	516,95	901,1

Source: calculated by the author according to the studied company

So, as can be seen from Table 4, the total planned unforeseen costs of LLC «Kurland» in the real budget scenario will be 516,95 thousand UAH, and taking into account the calculated possible deviations, their amount will be 148,54 thousand UAH. and 901,1 thousand UAH. under the optimal and critical scenario, respectively. All estimated contingencies should be included in the total cost budget for the respective scenarios.

We propose to calculate the planned amount of income of the enterprise by using the retrospective degree of variability of total income.

The retrospective degree of variability of total income allows establishing the level of variability of the studied indicator taking into account the studied period of time and is calculated by the formula 11.

$$S = \sqrt{\frac{\sum_{i=1}^{n}(x_i - \bar{x})}{n}} \times \sqrt{t} \times 100\%. \quad (11)$$

where S – retrospective degree of variability,

xi and $\bar{x}$ – growth rate of the indicator,

n – the number of years involved in the calculation,

t – the total number of years studied.

Using the indicator of the retrospective degree of variability of total income allows you to set the level of variability of the total income of the enterprise for several periods of time.

The calculation of the retrospective degree of variability of total income is given in Table 5 and formula 12.

Table 5

Calculation of the forecast income level of LLC «Kurland»

Indexes	2018	2019	2020
The amount of income received, thousand UAH	291 288	362 366	327 233
Income growth rate, %	x	24,4	90,3
Retrospective degree of variability of total income			

Source: calculated by the author according to the studied company

Using the dynamics and growth rates of the total income of LLC «Kurland», we calculate its retrospective degree of variability:

$$S = \sqrt{\frac{\sum_{i=1}^{2}(24,4^2 + 90,3^2)}{2}} \times \sqrt{3} \times 100\% = \sqrt{\frac{595,36 + 8154,09}{2}} \times 1,732 \times 100\% = 66,14 \times 1,732 \times 100\% = 114,55$$

So, the degree of variability in the amount of total income for the last three years is within 114,55%. This degree should be taken into account when determining the forecast values of income in different scenarios.

Analyzing the dynamics of the financial results of LLC «Kurland» for 2018-2020 and using the methods of mathematical statistics, we determine the forecast level of profitability of the company and the degree of deviation of the calculated value (Table 6 and formulas 13-14).

Table 6

Calculation of the forecast level of profitability of LLC «Kurland»

№	Number of events (s) / Tax risk (*X*)	2018	2019	2020
1	The amount of net profit, thousand UAH, *Xpr*	77731	77466	- 8270
	Pi, coefficient	0,2	0,2	0,2

Source: calculated by the author according to the studied company

Using the probability coefficients calculated in Table 4, we determine the estimated amount of profit:

$$M(Xpr) = 77731 \times 0,2 + 77466 \times 0,2 - 8270 \times 0,2 =$$
$$= 15546,2 + 15493,2 - 1654 = 29385,4 \text{ thousand UAH} \quad (13)$$

$$\sigma(X_{pr}) = \sqrt{77731^2 \times 0,2 + 77466^2 \times 0,2 + (-8270)^2 \times 0,2 - 29385,4^2} =$$
$$\sqrt{6042108361 \times 0,2 + 6000981156 \times 0,2 + 68392,9 \times 0,2 - 863501733,16} =$$
$$= \sqrt{1208421672,2 + 1200196231,2 + 13678,58 - 863501733,16} =$$
$$\sqrt{1545129848,82} = 30938,14 \text{ thousand UAH}$$

So, based on the analytical actions, it is established that the projected level of profit will be 29385,4 thousand UAH with a possible fluctuation of 30938,14 thousand UAH.

Using the above calculations and following the concept of Target-Profit System, we will build a generalized three-scenario budget of financial results, which will reflect the total projected income, financial result, and expenses of LLC «Kurland» (Table 7).

Table 7

Generalized budget of financial results of LLC «Kurland» for the forecast period

№	Indexes	Budget scenarios are possible		
		optimal	real	critical
1	Total income, thousand UAH	618107	327 233	275665
2	Financial result, thousand UAH	27041	29385,4	32198
3	Total costs, thousand UAH	359183	196070	123758
	incl. unforeseen costs	148,54	516,95	901,1

Source: calculated by the author according to the studied company

For the real scenario, we propose to take into account the calculated forecast values, and for the optimal and critical-adjusted forecast values for their possible deviations.

It should be noted that this approach to the calculation of forecast values does not take into account all the features of the entity, and therefore the identified indicators need to be studied for their compliance with short-term prospects for development and feasibility. If there is a range of possible deviations from the budget, it is necessary to understand what is the potential cost of such deviations in the form of, for example, additional funds to cover them.

The main indicators of the budget of financial results are net profit and profitability of sales. The first indicator is determined in absolute terms, and the other – in relative terms. It should be noted that these indicators refer to the strategic indicators of the entity, the threshold values of which are set by the owners of the enterprise or senior management.

In addition, thresholds can be set not only for one value for the entire planning year but also for each month separately, taking into account pre-known factors affecting the income and expenses of the entity. This is due to the fact that, depending on the specifics of doing business in some months, economic activity may be unprofitable, and in general for the reporting year – profitable with a sufficient rate of return.

Each business entity, when planning its business activities, determines the target values of strategic indicators, the achievement of which is a kind of strategic goal. For these indicators, it is mandatory to set a period of achievement, which must be at least one calendar year. These indicators must be communicated to all responsible structural units.

Any budget is made in order to keep financial results under control and to be able to correlate costs with revenues. The budget management system is, first of all, a management system that is implemented with the help of budgets.

Setting up a budget management system can lead to additional labor costs. In addition, the introduction of a budget management system can afford stable medium or large companies in which the activity is profitable: products are manufactured, successfully sold, shipped from stock, contractors are solvent and satisfied.

In recent years, to ensure the budget indicators of economic entities, a system of motivation «Key Performance Indicators» (KPI system), which

allows you to monitor the business activity of officials of the company in real-time.

Using the KPI system as a basis for motivation to achieve goals in the budget process can be the best solution to the problem of non-compliance with budget indicators and the ability to involve staff in creating a working budget system.

In addition, based on the KPI system, it is possible to differentiate the responsibility of responsibility centers for financial results and develop a budget model. Note that the KPIs of strategic financial objectives should always set those responsible at the level of the respective budgets.

The main advantage of the KPI motivation system is that the management decision-making process is reduced to the analysis of data that is available at any time and presented in a pre-accessible format.

We believe that the use of a KPI motivation system with an important tool in the management of each business entity, especially in modern conditions of operation in a risky environment. This system allows you to monitor the performance of the most important performance indicators of the entity, and especially indicators that affect the overall financial result.

This model provides the definition of key indicators of income, expenses, and financial results based on the historical experience of the entity, the separation into a separate system of indicators of unforeseen costs that may occur as a result of risk, as well as establishing a system of motivation and responsibility to results of implementation key budget indicators.

3. Economic analysis of forecasting the behavior of financial results under the conditions of risk-oriented management

Modern conditions of operation of domestic enterprises are characterized by a high level of uncertainty and risk, which is due to a lack of information and the ability to predict the probability of future events and their impact on the financial performance of the enterprise. Uncertainty of the situation forms a set of possible options that should be considered by management in the process of forming the economic strategy of the enterprise.

Profit is one of the most important indicators of the enterprise, which, uniting all aspects of its operation, reflects the efficiency and effectiveness of the use of resources in the process of economic activity. Peculiarities of the organization of economic analysis of profit are also the need for

permanent study of the dynamics of this indicator, to ensure the ability to predict and identify promising areas of enterprise development and avoid risky activities, ensuring the possibility of forming and implementing a system of preventive measures.

In order to make managerial decisions, it is necessary to conduct an economic analysis focused on ensuring the implementation of the management function, which is forward-looking and has a high level of uncertainty, examines the economic system on the parameters that determine its future state.

Risk-oriented profit management is traditionally aimed at maximizing it in favorable business conditions, or minimizing the negative consequences in the event of adverse events, and involves management decisions at the stages of formation, distribution, and use of profits [14].

Considering the financial results of LLC «Kurland», it is appropriate to analyze their formation during the 2018–2020 years (Table 8).

As can be seen from Table 8 LLC «Kurland» is developing dynamically, but the financial results of its activities in the reporting period are much worse than in previous periods. The operating activity of the company is especially ineffective, where the growth rate of both direct costs of production (21%) and other operating costs (48,4%) is much higher than the growth rate of income (revenue of sales of products (goods, works), services) (12,3%), operating income (15,2%).

As a part of financial results from investment and financial activity both positive, and negative tendencies are observed: growth of financial expenses to 121540 thousand UAH in 2020 affected the getting loss of 8270 thousand UAH.

Economic analysis of profits in the new environment should be aimed not only at the formation, distribution, and analysis of reserves to increase profits, but also to study internal (business environment, risks, and factors of formation profit) and external factors that will help such economic analysis meet new conditions operation of the enterprise (including in conditions of uncertainty) and the demands of the management process.

In such conditions, a necessary task for the management staff of the enterprise is to adapt to an unstable environment, which requires a flexible formation of the financial mechanism to ensure the profitability of the enterprise.

Table 8

Analysis of the formation, dynamics, and changes in financial results, thousand UAH

№	Indexes	2018	2019	2020	Deviation of the reporting year (+,-)	
					from the base year	from the intermediate year
1	2	3	4	5	6	7
1	Net income (revenue) from sales of products (goods, works, services)	291288	362366	327 233	35945	- 35133
2	Cost of goods sold (goods, works, services)	265608	309984	321 494	55886	11510
3	Gross profit	25680	52 382	5 739	- 19941	- 46643
4	Other operating income	139296	69 521	170 470	31174	100949
5	Administrative expenses	27213	27 266	17 951	- 9262	– 9315
6	Selling expenses	25222	34 581	23 858	- 1364	- 10723
7	Other operating expenses	14289	16 341	21 211	6922	4870
8	Financial results from operating activities	98252	43 715	113 189	14937	69474
9	Gains or losses on financial and investment transactions	- 20521	33751	- 121459	- 100938	- 155210
10	Financial result before tax	77731	77 466	- 8270	- 86001	- 85736
11	Expenses (income) from income tax	-	-	-	-	-
12	Net profit (loss)	77731	77 466	- 8270	- 86001	- 85736

Source: calculated by the author according to the studied company

As noted by O.V. Chernodubova, solving the problem of developing a financial mechanism to ensure the profitability of enterprises on the basis of an adaptive approach has two components:

1) formation of an adaptive financial mechanism focused on the balance of financial relations and adaptation to changing economic conditions;

2) development of tools for the implementation of this mechanism, aimed at ensuring flexible financial policy [15].

This changes the traditional approach to the formation, distribution, and use of profits, which, adapting to changes in the environment, leads to consideration of the financial mechanism for profitability based on an adaptive approach as a set of coordinated methods, tools, levers which provide balance financial relations. For this purpose, the tools of analysis and forecasting of profitability indicators and their adjustment based on changes in the external and internal environment are used.

So, the conceptual foundations of the adaptive financial mechanism to ensure the profitability of the enterprise include the purpose, principles, object and subjects, implementation mechanism, tools, methods of evaluating the effectiveness, and providing systems.

Considering the need to calculate the integrated indicator of profit as a general indicator for further analysis of its components and the choice of direction of the enterprise, L.O. Chorna determines that the adoption of «sound organizational and technical and economic and managerial decisions it is advisable to use systems for monitoring and analysis of profitability and their dependence on external (market, legal, administrative) and internal (logistical, organizational and managerial, strategic, informational, economic, social) factors» [16].

The main indicators of economic analysis of profit include indicators of profitability (total profitability of the enterprise, return on equity, the profitability of means of production), revenue indicators (gross return on sales of products (works, services), the revenue of core, operating, investment and financial activities), factor analysis and integrated valuation (integrated profit margin) [17].

The analysis of revenue, in particular, the analysis of indicators on the indicator of the profitability of the main activity allows to reveal effective and inefficient directions of functioning of the enterprise and to make necessary changes. Similarly, using the financial levers of the adaptive mechanism of profitability provides an assessment of the tax, innovation, investment, credit, and dividend policies of the enterprise.

Let’s analyze the profitability of the studied company in Table 9.

Table 9

Analysis of profitability indicators LLC «Kurland», %

Indexes	2018	2019	2020	Deviation, (+,-)
1. Return on assets	20,09	16,32	- 2,27	- 22,36
2. Return on share capital	- 51,61	- 71,75	8,46	60,07
3. Return on fixed assets	83,54	77,49	- 5,88	- 89,42
4. Profitability of the main activity	26,68	21,38	- 2,57	- 29,25
5. Product profitability	109,67	116,89	1,78	- 107,89
6. Profitability of sales	8,82	14,45	1,75	- 7,07

Source: calculated by the author according to the studied company

As can be seen from the above calculations, the profitability of LLC «Kurland» for the period under review is declining in almost all indicators, except the return on equity, as the amount of equity is negative. The presence of undistributed loss affected the value of return on equity. During the study period, there is a decrease in the efficiency of LLC «Kurland».

Having identified shortcomings in the analysis of profitability, we must actively develop possible ways to improve production, increase the competitiveness of products, which in the future will contribute to the growth of profits and profitability of the enterprise.

So, the economic analysis of profits in terms of risk-oriented management acquires the features of strategic analysis, which, using various applied techniques, ensures the achievement of strategic management goals.

The interconnectedness of the components and the coherence of the main tasks and objectives of economic analysis of profits in risk-oriented management, strategic analysis, and adaptive financial mechanism to ensure the profitability of enterprises are systematized in Figure 2.

So, the main tasks of economic and strategic analysis of profits, an adaptive financial mechanism for profitability need to be considered as a system, interaction in dynamics, as such an approach allows risk-oriented profit management in the enterprise.

A risk-oriented approach to the organization of economic profit analysis allows you to identify both external and internal risks, identify key ones, develop an appropriate management model to neutralize, reduce impact and prevent. An important aspect that will contribute to the goals is the formation of quality information that meets the needs of users.

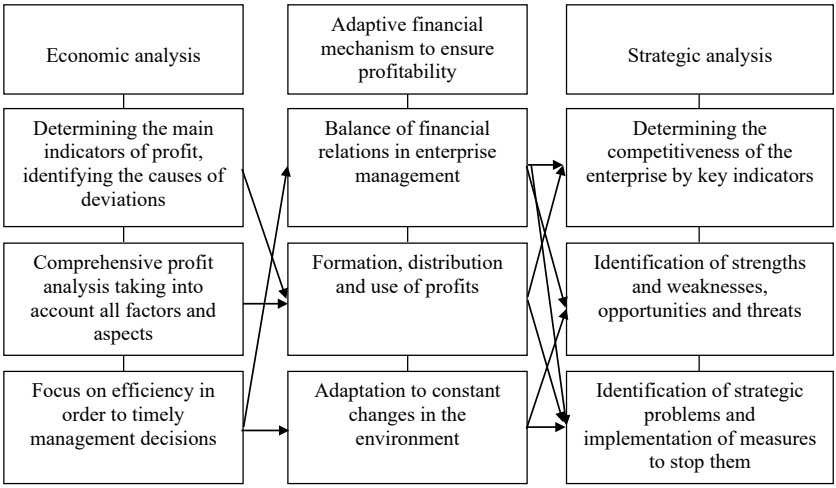

Figure 2. Features of the influence of risk-oriented management system on the method of economic analysis of profit

Source: formed by the author on the basis of [18]

The methods of economic analysis shown in Figure 2 are mainly aimed at retrospective or current analysis of financial results and factors of their formation.

Effective operation of risk-oriented management requires not only retrospective and current but also forecast economic analysis in order to assess the forecast (budget) value of the financial result in the future, taking into account information about the risks of economic activities that affect the formation of financial results.

Strategic analysis is designed to assess the forecast values of strategically important indicators of the enterprise, but it is based mainly on comprehensive assessments of economic activity, forecasting its development, establishing current and forecast competitive advantages, assessing markets, assessing the place of the entity in the market and more.

4. Findings

Today it is common practice to use statistical, mathematical, and expert methods of assessing economic, financial, market risks. Expert

methods have very subjective assessments and their application requires the involvement of highly qualified specialists in risk assessment and their impact on a particular economic indicator.

Statistical and mathematical methods are more accurate and are used on the basis of economic indicators that have occurred in the enterprise as a result of past events over time. And the longer the period of time, the more accurate, they believe, will be the forecast.

In the field of mathematical statistics, there is a correlation and regression analysis of data that allow estimating the predicted values of the studied indicator, taking into account the influence of various factors.

Correlation analysis shows the relationship between performance and factors and determines the influence of the same factors on each other. Regression analysis allows you to build a model of the behavior of the performance indicator taking into account the influence of various factors and, based on the built model, to predict the value of the performance indicator for a certain value of each of the studied factors.

We propose to use correlation-regression analysis to determine the forecast values of financial results, which is now widely used in economics at both the macro and micro levels.

The choice of correlation-regression analysis is related to the requirements of risk-oriented management, which consist of an unseparated study of a particular economic indicator, and in relation to the factors that influence it.

That is why we propose to carry out at the enterprise with the help of correlation-regression analysis to establish the forecast value of the financial result, taking into account various factors of influence, including those that arose due to risk.

The purpose and objectives of correlation-regression analysis of financial results are given in Table 10.

Having considered the essence, purpose, tasks, and information sources of correlation-regression analysis of financial results, we proceed to consider the procedure for such analysis, which is depicted as an algorithm in Figure 3.

Table 10

The purpose and objectives of correlation and regression analysis of financial results

Purpose and objectives	Brief description
The purpose of correlation-regression analysis	It consists in establishing the forecast value of the financial results of the entity, establishing a set of factors that have a significant impact on them, and, on this basis, modeling the behavior of the performance indicator
Tasks of correlation regression analysis	The main tasks of correlation-regression analysis are: – to establish factors of significant influence on financial results of the investigated enterprise; – establish a form of relationship between factors and financial performance; – estimate the unknown parameters of the equation in order to build a model of behavior of financial results under the influence of established factors; – check the reliability of the constructed model; – build a graphical dependence of the financial result on each of the established factors.

Source: suggested by the author

The results of regression analysis are presented in the form of the Report of regression analysis, which contains the following sections: indicators of regression statistics; indicators of analysis of variance, coefficients of correlation-regression analysis.

Regression statistics indicate the tightness of the relationship between the factors selected in the model and the financial result, as well as indicate the share of factors influencing the financial result, which remained unaccounted for in the correlation-regression model of financial results.

The graphical method of constructing both the correlation-regression model of financial results and the graphs of balances play an important role in the analysis.

Graphs of the correlation-regression model are constructed separately for each pair of performance indicators and one of the factors and shows the dependence of the performance factor on each factor separately. The number of graphs constructed will depend on the number of factors presented in the model.

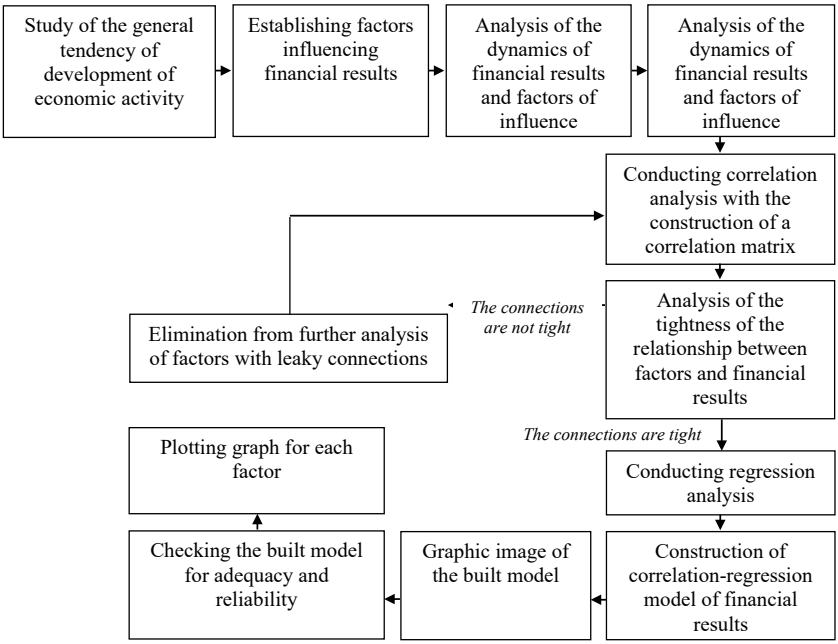

Figure 3. General procedure for correlation and regression analysis of financial results

Source: suggested by the author

Graphs of factor residues show the correctness of calculations and reliability of the model. The model is reliable and accurate if the balances are normally distributed, their values are approaching or are equal to zero and there are no trends in the performance indicator.

Fulfillment of all the above conditions is a confirmation of the construction of a reliable correlation-regression model that can be used to predict financial results.

So, our proposed correlation-regression model of financial results is significant and reliable, and can also be used when budgeting financial results taking into account the predicted values of factors that affect their behavior.

5. Conclusions

An important tool in the analysis of the financial performance of enterprises is analytical evaluation in the form of techniques and methods of analysis. This assessment is used at different stages of the study of the formation, distribution, and use of financial results.

The use of analytical assessment in the formation of the analytical base of financial results should assist the company's management in identifying unusual transactions or events, as well as amounts, indicators, and trends that may indicate atypical circumstances in the formation, distribution, and use of financial results.

Risk-oriented approach to the organization of economic analysis of profits allows you to identify both external and internal risks, identify key ones, develop an appropriate management model to neutralize, reduce impact and prevent.

The study of the peculiarities of the budgeting system in terms of risk-oriented management showed the need to create a single effective coordinated budgeting system in order to achieve competitive advantages in the market, in accordance with the requirements of the modern concept of integrated management.

The KPI model provides for the determination of key indicators of income, expenses, and financial results based on the historical experience of the entity, the separation into a separate system of indicators of unforeseen costs that may occur as a result of risk, as well as establishing a system of motivation and responsibility key budget indicators.

Effective operation of risk-oriented management requires a forecast economic analysis in order to assess the budgetary value of the financial result, taking into account information about the inherent risks of the business entity. It is proposed to use in the budgeting process analytical tools for evaluating financial results, which is based on the use methods of correlation and regression analysis and allows you to build a predictive model of financial results taking into account the factors influencing them (the purpose and tasks of correlation-regression analysis of financial results, sources of information for this analysis are determined). The use of correlation-regression analysis allows you to identify the nature of changes in the value of financial results as a result of the factors of impact, both together and separately with each of the identified factors.

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CHAPTER «ENGINEERING SCIENCES»

PROCESSING AND STORAGE OF DIFFERENT DATA WITH THE HELP OF BI-TECHNOLOGIES

ІНФОРМАЦІЙНА СИСТЕМА ОБРОБКИ І ЗБЕРІГАННЯ РІЗНОТИПОВИХ ДАНИХ ЗА ДОПОМОГОЮ BI-ТЕХНОЛОГІЙ INFORMATION SYSTEM FOR

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Abstract. Conditions for the development of modern information space indicate the need to process large amounts of structured, poorly structured and unstructured data, which are in heterogeneous sources. The study describes the approaches, models, methods and tools for building data warehouses, formulates the purpose and objectives of the study, and the concept of building corporate repositories. This section discusses the input and output data features that the system will process. The information model of OLTP systems and data warehouses is also designed; logical essences and their business needs are described. The input data will be the result of the OLTP system, which simulates the operation of the online store. Then, by various means, different amounts of data will be transferred with specific processing to the data warehouse, from the structure of which it will be possible to obtain the original data for further analysis. This section explores the various tools for implementing the system describes their advantages and disadvantages. SQLServer was chosen as the data processing mechanism and DatabaseEngine / SSIS packages as the tools for forming the integration layer and ETL processes. The necessary software and hardware have been included. The object of the study is the process of migrating data from a database that works directly with a business program (OLTP system) to a

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data warehouse (OLAP system) for further archival storage and analysis. The work aims to create a relational database that will simulate the work of the online store, create an appropriate data warehouse and study the speed of the ETL process of data transfer to the data warehouse in different ways. The main tasks for the realization of the research goal should include construction of a relational database and its filling with suboptimal data; construction of a data warehouse; creation of ETL process with the help of SSIS packages; design of ETL process using T-SQL; comparison of the obtained results and conclusions. We also considered the software implementation, which conducted a study of the speed of data transfer using two selected tools and felt some functionality of the system so that the user interacted correctly with it. To achieve this goal, developing a data warehouse on a hybrid approach is necessary and configuring the ETL process between the relational database and the data warehouse using SSIS packages. To perform experiments, you need to compare data transfer efficiency on tables of different dimensions. As a result of the study, a three-tier system was created, consisting of an OLTP system as a transactional layer, ETL processes using DatabaseEngine and SSIS packages, as an integration layer and a data warehouse built on a hybrid principle as an analytical layer. The implemented system is analogous to the latest self-service system, as it can provide its business needs without third-party funds.

1. Вступ

У наш час компанії часто оперують великими обсягами даних, тому запроваджувати різного роду аналіз, базуючись на даних з баз, які напряму використовуються для бізнес потреб не завжди є оптимальним варіантом. Нормалізована реляційна база даних, яка у більшості випадків використовується для таких потреб, може складатись з десятків або навіть з тисяч таблиць, з різною назвою і гранулярністю, тому виявити дані які будуть необхідні для певного аналізу і отримати її є непросто. Сучасні корпорації можу використовувати не одну бізнес програму, які працюють на багатьох базах даних. І об'єднання архітектурно не пов'язаних систем для проведення певного аналізу може вплинути на якість даних.

Часто, вектор дослідження може бути напрямлений на аналіз історичних даних, а такі системи в основному збирають інформацію, яка

актуальна лише на певному проміжку часу, так як зберігати і підтримувати весь історичний об'єм даних у такого типу системах є ресурсозатратним.

Метою даного дослідження є визначення оптимальних засобів для внутрішнього переміщення різних обсягів даних, які б потенційно використовувались організацією для проведення аналізу з метою покращення діяльності.

Основними засобами переміщення даних, які будуть розглянуті у даній роботі являються:

– переміщення даних за допомогою внутрішніх засобів MSSqlServer та T-SQL;

– переміщення даних за допомогою генерації динамічного BIML скрипта, який буде створювати SSIS пакет для інтеграції даних.

Отож типовим рішенням для таких проблем є створення сховища даних. Сховище даних – це централізоване місце зберігання даних для підприємства, яке містить об'єднані, очищені та історичні дані. У сховищі акумулюється інформація, яка отримана з різних джерел, які визначають бізнес сторону діяльності підприємства. Інформація зберігається у такому вигляді, щоб легко задовольнити практичні потреби користувачів. Схеми даних у таких сховищах спрощені і більш придатні для формування аналітичних звітів, ніж нормалізовані реляційні бази даних.

Метою сховища даних є орієнтація на бізнес: вона покликана сприяти прийняттю рішень, дозволяючи кінцевим користувачам консолідувати та аналізувати інформацію з різних джерел.

2. Опис предметного середовища

При набутті широкого попиту серед систем прийняття рішень, спосіб звертання до баз, які базуються на OLTP-системи виявився не оптимальним у багатьох випадках, тому що саме такий тип системи має постійне велике навантаження і дані часто розподіленні по багатьох таблицях. Тому час отримання даних та їх якість будуть далекі від ідеалу. Отож була запропонована концепція сховища даних, що являє собою інтегровані набори даних, зібрані з різних джерел [1].

Для отримання розуміння чому сховища даних є ефективнішим рішенням для проведення аналітичних досліджень, потрібно зрозуміти

ключові відмінності сховищ даних від бази даних. Основна відмінність полягає в тому, що бази даних – це організовані колекції збережених даних. Сховища даних – це інформаційні системи, побудовані з декількох джерел даних – вони використовуються для аналізу даних [2].

Реляційні бази даних базуються на OLTP-системах. OLTP (онлайн обробка транзакцій) – це термін для системи обробки даних, що фокусується на транзакціях.

Зазвичай такі системи містять інформацію, що використовується бізнесом щодня. Результатом їх функціонування є швидкі, ефективні запити та інформація, яка є актуальною та точною. Бази даних OLTP оптимізовані для швидкої роботи CRUD-операцій (створення, читання, оновлення та видалення). Однак більш складні аналітичні запити можуть швидко знизити їх ефективність. Такі бази даних були розроблені для підтримки тисяч або більше користувачів одночасно, без будь-якого погіршення продуктивності.

В свою чергу сховища даних є частиною OLAP-систем. OLAP (онлайн-аналітична обробка) – це термін для системи обробки даних, що фокусується на аналізі даних та прийнятті рішень, а не на продуктивності та повсякденному використанні. Багато систем OLAP пов'язані з рішеннями бізнес-аналітики (BI), які полегшують отримання необхідної інформації. Такі системи можуть містити в собі вже агреговані дані та велику кількість історичних записів. Сховища даних OLAP можуть підтримувати лише відносно обмежену кількість одночасних користувачів. Оскільки рішення для сховища даних використовує більш складні запити, що циркулюють у багатьох різних сховищах даних, воно обов'язково вимагає більше ресурсів і, отже, не таке масштабоване, як база даних[3].

Отже нижче буде наведена узагальнена таблиця ключових відмінностей між сховищем даних та базою даних (таблиця 1).

Сховище даних є центральним елементом системи BI, побудованої для аналізу даних та звітності. Основна мета створення сховища даних полягає в тому, щоб представити дані, які мають вагу в управлінні бізнесом, у стандартизованій та доступній формі та зробити їх придатними для аналізу та отримання необхідних звітів. Це забезпечується процесом ETL (extract, transform, load) – збирання даних з внутрішніх і зовнішніх джерел, їх обробка, очищення та структуризація.

Таблиця 1

Відмінності між сховищем даних та базою даних

Параметр	База даних	Сховище даних
Використання	Запис даних	Аналіз даних
Методи обробки	OLTP	OLAP
Кількість користувачів	Тисячі	Обмежена кількість
Випадки використання	Невеликі транзакції	Комплексний аналіз
Оптимізація	CRUD-операції	аналіз великих масивів
Тип даних	Деталізовані дані в реальному часі	Структуровані історичні дані

Незважаючи на відмінності в підходах та реалізаціях, усім сховищам даних властиві спільні риси (рис. 1).

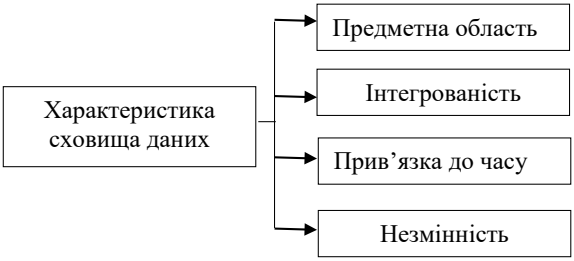


Рис. 1. Спільні характеристики сховища даних

3. Постановка задачі

Міграція неоптимальних для аналізу даних з реляційної бази даних у сховище часто є одним з найскладніших моментів так як цей процес вимагає очищення та структуризації "брудних" даних, для їх подальшого зберігання та аналізу. Метою роботи буде створення реляційної бази даних, яка буде імітувати роботу інтернет-магазину, створення відповідного сховища даних та дослідження швидкодії ETL процесу перенесення даних у сховище даних різними методами.

Дане дослідження можна розділити на декілька підзадач:

– Побудова реляційної бази даних та її наповнення неоптимальними даними;

– Побудова сховища даних;

– Створення ETL процесу за допомогою SSIS пакетів;
– Створення ETL процесу засобами T-SQL;
– Порівняння отриманих результатів та висновки.

4. Аналіз предметної області

Управління даними є дуже важливим моментом, оскільки дані, які створює організація, є дуже цінним ресурсом. Ефективне управління даними набуває все більшої важливості в останні роки, оскільки в сучасних організаціях відбувається значне збільшення обсягу інформації, що зберігається. Чіткий і структурований аналіз цих даних є важливою складовою при здобутті комерційного успіху організації.

У підприємств та організацій є питання та цілі. Щоб відповісти на ці запитання та відстежити результативність цих цілей, вони збирають необхідні дані, аналізують їх та визначають, які дії вжити для досягнення своїх цілей.

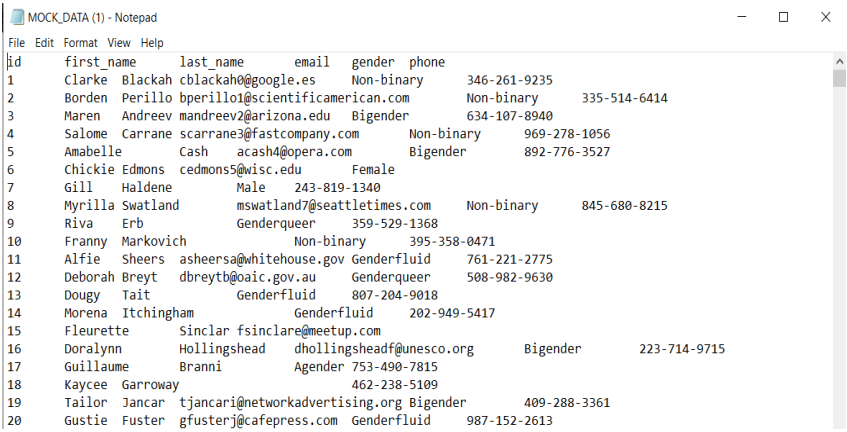
Об'єктом дослідження є процес міграції даних з бази даних яка напряму працює з бізнес-програмою (OLTP система) в сховище даних (OLAP система) для подальшого історичного зберігання та аналізу.

Отже, вхідними даними для дослідження будуть дані з реляційної бази даних, яка буде імітувати роботу онлайн магазину. Так як, дане дослідження буде проводились на тестових даних, набори вхідних даних умовно буде поділено на два типи – статичні і динамічні [4].

До статичних даних будуть відноситись такі дані, які не явно імітують бізнес діяльність організації. До переліку такого типу даних можна віднести інформацію про користувачів, перевізників, магазинів, категорії товарів та послуг, що надаються організацією. Для генерації таких даних буде використано сторонні ресурси з датасетами. Нижче буде наведено приклад вхідного файлу (рис. 2).

Даний тип файлів буде згенеровано для всіх статичних об'єктів та загружено у відповідні об'єкти в реляційну базу даних засобами SQLServerManagementStudio.

До динамічного типу відноситься такі дані/об'єкти, які моделюють бізнес активність організації. Це наприклад дані про продажі або поставки. Даний тип даних буде генеруватись на основі статичних об'єктів за допомогою збережених процедур. Випадковим чином зі статичних таблиць буде відбиратись атрибут, також випадково буде



MOCK_DATA (1) - Notepad

File Edit Format View Help

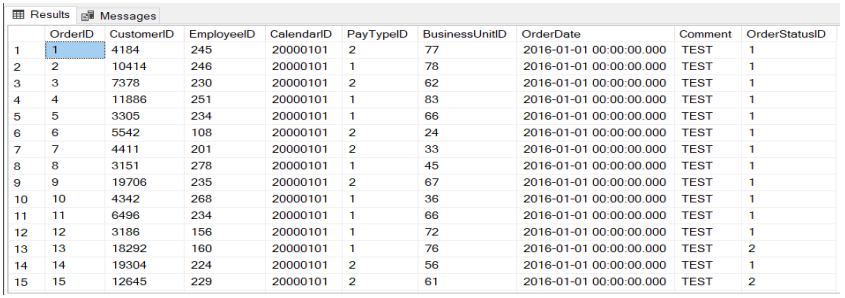
id	first_name	last_name	email	gender	phone
1	Clarke	Blackah	cblackah0@google.es	Non-binary	346-261-9235
2	Borden	Perillo	bperillo1@scientificamerican.com	Non-binary	335-514-6414
3	Maren	Andreev	mandreev2@arizona.edu	Bigender	634-107-8940
4	Salome	Carrane	scarrane3@fastcompany.com	Non-binary	969-278-1056
5	Amabelle	Cash	acash4@opera.com	Bigender	892-776-3527
6	Chickie	Edmons	cedmons5@wisc.edu	Female	
7	Gill	Haldene		Male	243-819-1340
8	Myrilla	Swatland	mswatland7@seattletimes.com	Non-binary	845-680-8215
9	Riva	Erb		Genderqueer	359-529-1368
10	Franny	Markovich		Non-binary	395-358-0471
11	Alfie	Sheers	asheersa@whitehouse.gov	Genderfluid	761-221-2775
12	Deborah	Breyt	dbreytb@oaic.gov.au	Genderqueer	508-982-9630
13	Dougy	Tait		Genderfluid	807-204-9018
14	Morena	Itchingham		Genderfluid	202-949-5417
15	Fleurette	Sinclar	fsinclare@meetup.com		
16	Doralynn	Hollingshead	dhollingsheadf@unesco.org	Bigender	223-714-9715
17	Guillaume	Branni		Agender	753-490-7815
18	Kaycee	Garroway			462-238-5109
19	Tailor	Jancar	tjancari@networkadvertising.org	Bigender	409-288-3361
20	Gustie	Fuster	gfusterj@cafepress.com	Genderfluid	987-152-2613

Рис. 2. Приклад вхідних даних

калькулювати кількість бізнес-дій відповідного типу. Отримані дані будуть напряму вставленні в відповідні об'єкти. Нижче буде наведено приклад динамічних даних (рис. 3).

Оскільки об'єктом дослідження є оптимальний спосіб перенесення різних об'ємів даних з реляційної бази даних в сховище даних, вихідними даними будуть агреговані, структуровані дані подані у вигляді представлень, які будуть базуватись на попередньо з'єднаних та погрупованих таблицях.

Отримані представлення можна використовувати для проведення різного роду аналізу, який допоможе зрозуміти відповідні бізнес контек-



Results Messages

	OrderID	CustomerID	EmployeeID	CalendarID	PayTypeID	BusinessUnitID	OrderDate	Comment	OrderStatusID
1	1	4184	245	20000101	2	77	2016-01-01 00:00:00.000	TEST	1
2	2	10414	246	20000101	1	78	2016-01-01 00:00:00.000	TEST	1
3	3	7378	230	20000101	2	62	2016-01-01 00:00:00.000	TEST	1
4	4	11886	251	20000101	1	83	2016-01-01 00:00:00.000	TEST	1
5	5	3305	234	20000101	1	66	2016-01-01 00:00:00.000	TEST	1
6	6	5542	108	20000101	2	24	2016-01-01 00:00:00.000	TEST	1
7	7	4411	201	20000101	2	33	2016-01-01 00:00:00.000	TEST	1
8	8	3151	278	20000101	1	45	2016-01-01 00:00:00.000	TEST	1
9	9	19706	235	20000101	2	67	2016-01-01 00:00:00.000	TEST	1
10	10	4342	268	20000101	1	36	2016-01-01 00:00:00.000	TEST	1
11	11	6496	234	20000101	1	66	2016-01-01 00:00:00.000	TEST	1
12	12	3186	156	20000101	1	72	2016-01-01 00:00:00.000	TEST	1
13	13	18292	160	20000101	1	76	2016-01-01 00:00:00.000	TEST	2
14	14	19304	224	20000101	2	56	2016-01-01 00:00:00.000	TEST	1
15	15	12645	229	20000101	2	61	2016-01-01 00:00:00.000	TEST	2

Рис. 3. Приклад вхідних даних

OrderKey	OrderID	ProductID	DiscountID	FactPrice	CustomerID	EmployeeID	CalendarID	PayType	BusinessUnitID	OrderDate	OrderStatus
18	10	B003FM4XCG	1	10.71	4342	268	20000101	Card	36	2016-01-01	Done
19	10	B008KT8XOI	1	19.50	4342	268	20000101	Card	36	2016-01-01	Done
20	11	B00374PLQE	1	9.72	6496	234	20000101	Card	66	2016-01-01	Done
21	11	B005JOGO7A	1	74.11	6496	234	20000101	Card	66	2016-01-01	Done
22	11	B0046WO31A	1	30.55	6496	234	20000101	Card	66	2016-01-01	Done
23	12	B00004Z7JH	1	14.79	3186	156	20000101	Card	72	2016-01-01	Done
24	13	B003XH83N8	1	51.97	18292	160	20000101	Card	76	2016-01-01	Decline
25	13	B00CRJUG10	1	229.44	18292	160	20000101	Card	76	2016-01-01	Decline
26	13	B0009K3PFS	1	26.00	18292	160	20000101	Card	76	2016-01-01	Decline
27	14	B008LZZ0W4	1	51.94	19304	224	20000101	Cash	56	2016-01-01	Done
28	14	B003EYVOTK	1	4.54	19304	224	20000101	Cash	56	2016-01-01	Done
29	15	B004IVBCM2	1	28.28	12645	229	20000101	Cash	61	2016-01-01	Decline
30	16	B002V17LHQ	1	3.24	14016	268	20000101	Cash	36	2016-01-01	Done

Рис. 4. Представлення з даними продажі

VendorName	VendorID	Quantity
Skullcandy	SK1083	45
Kodak	KO1087	42
Synergy Digital	SY1099	42
CableWholesale	CA1035	41
Gino	GI1053	41
Asus	AS1018	39
Fenzer	FE1042	38
GE	GE1076	38
C2G	C21011	37
Panasonic	PA1017	37

Рис. 5. Приклад представлення з агрегованими даними

сти організації. Наведемо приклад представлення, яке містить інформацію про загальні, неагреговані дані продажів організації (рис. 4).

Також представлення можна використовувати для швидкого аналізу, роблячи необхідні агрегації даних і використовуючи необхідні формули всередині представлення (рис. 5).

5. Проектування системи

Для проведення досліджень необхідно створити інформаційну модель системи. Насамперед потрібно визначити які логічні сутності будуть представлені у системі, яка буде досліджуватись.

При інтеграції даних в сховище даних потрібно зробити декілька кроків денормалізації для забезпечення швидкодії роботи системи та для забезпечення цілісності даних.

Сутності, які мають однаковий бізнес напрямок будуть об’єднані в одні таблиці – таблиці фактів або вимірів. Дані, які при отриманні вхідних даних і вважалися статичними будуть згруповані і переведені у виміри, динамічні дані будуть переведені в таблиці фактів.

Розглянемо бізнес контекст кожного з об'єктів, які будуть містить в сховищі даних:

– FactOrders: таблиця фактів, яка містити дані про продажі у організації і буде містити два рівня гранулярності – рівень наявності замовлення та його деталізація;

– FactConsigments: таблиця фактів, яка міститьінформацію про поставки в середині мережі. Буде представлено два рівня гранулярності – факт поставки і деталізація;

– FactShipments: таблиця фактів, яка містить дані про поставки, які будуть надходити від зовнішніх постачальників. Буде представлено два рівня гранулярності – факт поставки і його деталізація;

– Dim_Products: таблиця виміру, яка містить інформацію про товари, які наявні в організації та виступає словником і системі для детальної інформації про товари;

– Dim_Discounts: таблиця виміру, яка містить інформацію про знижки, які існували або є діючими та надає детальну інформацію про термін дії, статус та розмір знижки;

– Dim_BusinessUnits: таблиця виміру, яка містить інформацію про точки збуту або склади, які існували або діють в межах організації. Надає інформацію про місце знаходження та статус бізнес одиниці.

– Dim_EmployeeAndRoles: таблиця виміру, яка містить інформацію про працівників та їхні ролі, надає дані про історію переміщень працівників між позиціями та історичні дані працівників.

Враховучи вище наведену структуру і опираючись на бізнес потреби організації формується структура сховища даних.

6. Засоби розробки

Метою даного дослідження є визначення оптимальних засобів для внутрішнього переміщення різних об'ємів даних, які б потенційно використовувались організацією для проведення аналізу з метою покращення діяльності [6].

Основними способами переміщення даних, які будуть розглянуті у даній роботі було вибрано наступні засоби:

– переміщення даних за допомогою внутрішніх засобів MSSqlServer та T-SQL;

– переміщення даних за допомогою генерації динамічного BIML скріпта, який буде створювати SSIS пакет для інтеграції даних;

SQL Server – це механізм обробки даних, запроваджений корпорацією Майкрософт. Він забезпечує середовище, що використовується для створення та управління базами даних. Це забезпечує безпечне та ефективне зберігання. Він надає інші компоненти та послуги, які підтримують платформу бізнес-аналітики для формування звітів та аналізу даних [7].

SQL Server характеризується такими особливостями як:

– Продуктивність: SQL Server працює дуже швидко.

– Надійність і безпека: SQL Server надає шифрування даних.

– Простота: З даною СКБД відносно легко працювати і вести адміністрування.

SQL Server містить ряд компонентів. Кожен компонент надає певні послуги та підтримку клієнтам, підключеним до сервера.

На наступній схемі показані компоненти SQL Server (рис. 6):

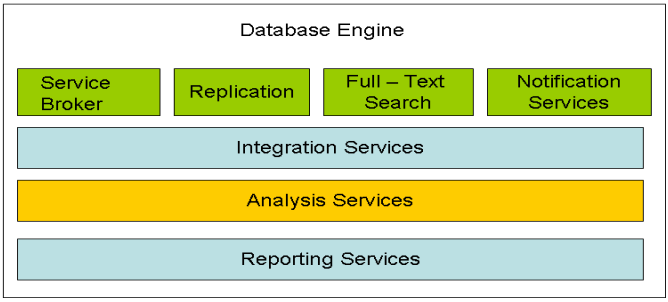


Рис. 6. Компоненти SQLServer

Виходячи з різноманітності технології і засобів, які надаються при використанні SQLServer, можна зробити висновок що даний механізм обробки даних є найоптимальніший і найбільш конкурентно здатний у порівнянні зі своїми конкурентами.

Розглянемо переваги основних засобів, які надаються даним механізмом обробки даних:

– Database Engine:

Компонент забезпечує підтримку зберігання запитів, обробки та захисту даних на сервері. Це дозволяє користувачеві створювати та

керувати об'єктами бази даних. Такі фонові послуги, як реплікація, повнотекстовий пошук, сервіси сповіщень і т.д. надаються даним компонентом

– Сервіси інтеграцій(SSIS):

Даний засіб дозволяє збирати та інтегрувати різноманітні дані у єдиному форматі в сховище даних.

– Сервіси аналізу (SSAS):

Сховища даних призначені для полегшення складання звітності та аналізу. Додатки широко використовують дані засоби в аналітичних цілях. Програми, що використовуються для цієї мети, відомі як програми BI.

– Сервіси звітування (SSRS):

Засоби надають підтримку для створення повних звітів про дані в механізмі баз даних у сховищі даних. Ці послуги надають набір інструментів, які допомагають створювати звіти у різних форматах та керувати ними.

Отже, використання SQLServer у дослідженнях надають нам різноманітність у виборі засобів для роботи з даними. Нижче перелічимо ще декілька переваг даного механізму:

– Масштабованість: це дозволяє розподіляти дані у великих таблицях у різні групи файлів. Сервер може одночасно отримувати доступ до груп файлів;

– Сервісно-орієнтована архітектура: це забезпечує розподілену асинхронну структуру додатків для великомасштабних додатків;

– Високий рівень безпеки: реалізовано високий рівень безпеки шляхом додавання політики для входу та паролів;

– Регулятор ресурсів: використовується для управління робочим навантаженням сервера шляхом розподілу та управління ресурсами.

T-SQL або Transact-SQL – це розширення мови структурованих запитів (SQL) від Microsoft, яке має додаткові транзакційні структури або аспекти з SQL і використовується для роботи з будь-якою з реляційних баз даних на основі сервера SQL [8].

Переваги T-SQL:

– Модульність: великий перехід технологій у бік мікросервісної та модулізованої архітектури. Це впливає на швидкодію роботи системи та допоможе зменшити залежність частин системи один від одного.

– Безпека: дані зберігаються на сервері з власною мірою безпеки як комерційна таємниця. Захист побудований на основі допоміжних знань про реєстрацію та транзакцій у навколишньому середовищі, що сприяє надійності.

– Ефективність: мінімізує трафік на сервері. завдання, що виконуються з даними, обробляються з мінімальними накладними витратами при передачі в програмі. Таким чином, складні нетривіальні завдання можна легко вирішити за допомогою T-SQL.

BIML – це мова, базована на XML, що дозволяє повністю моделювати рішення BI та використовується для автоматизації створення ETL процесів [9].

BIML найкраще працює, якщо вам потрібно створити кілька пакетів SSIS, які всі мають однаковий шаблон. Іншими словами, якщо всі пакети мають приблизно однакову мету та структуру, але, змінюються лише таблиця джерела та призначення, тоді використанням BIML допоможе автоматизувати більшу частину ручної роботи.

7. Опис програмної реалізації

Для створення системи було обрано SQLServer, як один з найоптимальніших механізмів обробки даних. Розробка розпочалась з того, що необхідно створити OLTP систему та сховище даних, зобразити потік даних, та поєднати системи інтеграційним шаром [10].

Для відображення потоку даних було обрано DataFlow діаграму. Даний тип UML-діаграми допоможе зобразити OLTPсистему та сховище даних та візуалізувати інтеграційні зв'язки між цими двома системами. Data Flow діаграма зображена на рис. 7.

Першим компонентом системи є OLTP система. Дана система моделює діяльність інтернет магазину, тобто всі логічні операції будуть відбуватися на стороні реляційної бази даних. Цілісність даних забезпечується ключами та тригерами.

Для генерації даних у системі було створено наступний перелік збережених процедур [11]:

– dbo.STP_GenerateDataForConsignmentDetails
– dbo.STP_GenerateDataForConsignments
– dbo.STP_GenerateDataForDiscounts
– dbo.STP_GenerateDataForShipments

– dbo.STP_GenerateDataForShipmentDetails
– dbo.STP_GenerateDataForOrders
– dbo.STP_GenerateDataForOrderDetails

Вище подані процедури мають схожу логіку генерації даних. Вибираючи випадкове значення з таблиць, які складають логічну сутність таблиці, формується рядок і зберігається у таблиці. Таким чином буде отримано моделювання взаємодії користувачів з системою. Нижче

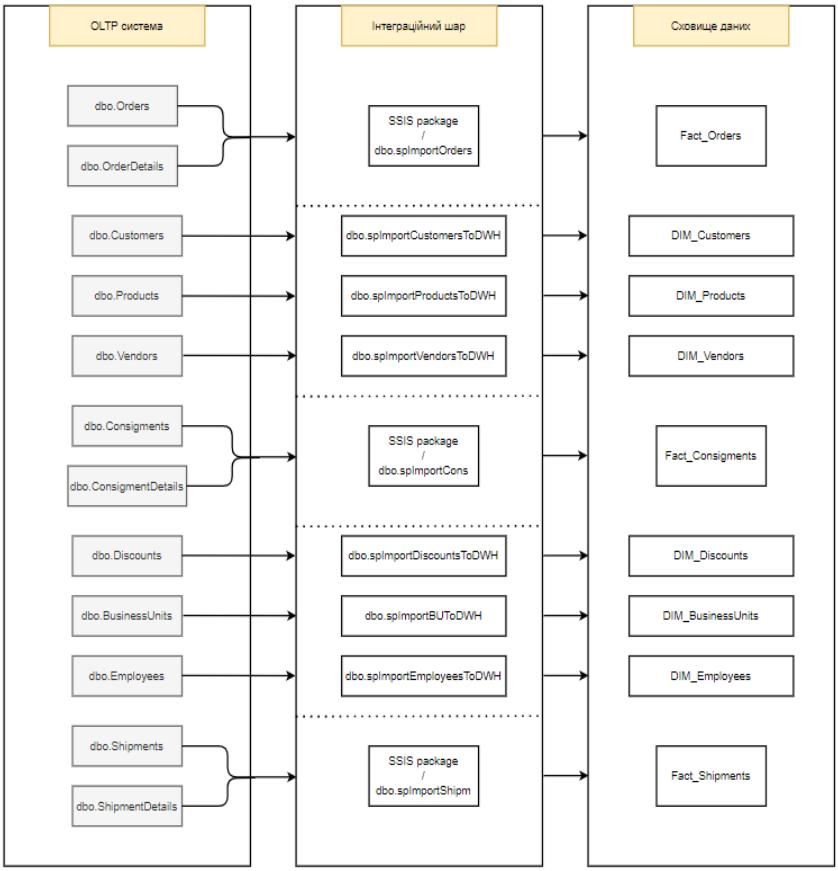


Рис. 7. DataFlow діаграма

буде подано рисунок (рис. 8) на якому буде зображено кількість записів у кожній з таблиць, які будуть використовуватись у подальшому досліджені.

TableName	RowCount
[dbo].[OrderDetails]	1642470
[dbo].[Orders]	821436
[dbo].[Customers]	20538
[dbo].[ConsignmentDetails]	16913
[dbo].[Consignments]	3087
[dbo].[Shipments]	2904
[dbo].[Employees]	323
[dbo].[Discounts]	201
[dbo].[BusinessUnits]	84

Рис. 8. Кількість записів у таблицях

При генерації даних, також було встановлено відсоток невалідних даних. Тобто це так звані пошкодженні рядки, які мають відсутні певні логічні значення. Такі рядки будуть відсіюватись у інтеграційному шарі, так як не несуть ніякої аналітичної цінності.

Отже, на даному етапі реалізації отримано готову OLTP систему, наповнену реалістичними даними. Далі розглянемо побудову сховища даних та його структуру.

Сховище даних є одним з компонентів системи, де будуть зберігатись очищені і структуровані дані. Побудова сховища даних необхідне для подальшого зберігання історичних даних. Також наявність структурованого сховища надає можливість відокремлювати певні вітрини даних та проводити аналіз.

Нижче буде подано діаграму зав'язків, за принципом якої буде реалізована система (рис. 9).

Розглянемо дану структуру в межах реалізованої системи. Сорсовими системами в системі виступає вище описана OLTP система [12].

Інтеграційний шар буде розглянуто далі, так як буде проведено дослідження різних інтеграційних засобів на різних об'ємах даних. Отже, необхідно розглянути як в системі реалізовано аналітичний шар. В реалізованій системі можна виділити три основних бізнес напрямки: Продажі; Поставки; Переміщення.

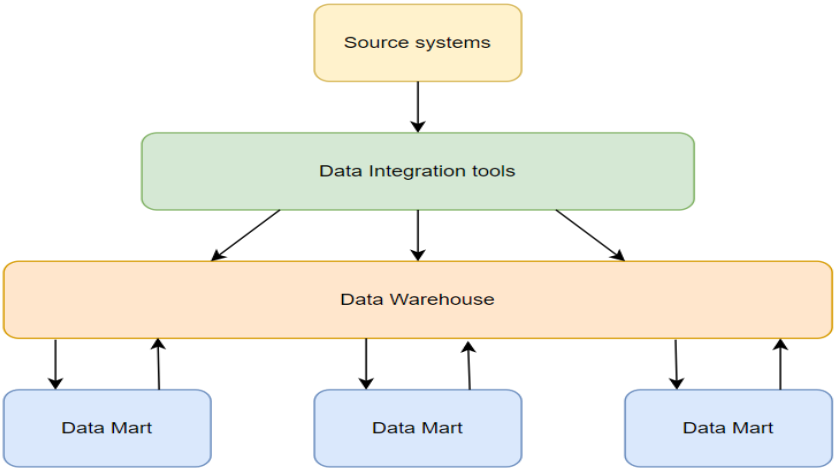


Рис. 9. Діаграма зав'язків системи

На рисунку нижче (рис. 10) буде накладено структуру аналітичного шару системи на рис. 13, що був описаний раніше.

Для побудови повноцінної вітрини даних до визначених основних таблиць було додано таблиці вимірів, які були описані вище (рис. 11).

Також у даному сховищі даних реалізовані певні представлення, які допоможуть швидко отримати певну аналітику.

Найважливішим компонентом у системі буде інтеграційний шар, так як він буде виконувати не тільки роль переміщення даних, але й очищення і структуризації, тобто ETL процес [13].

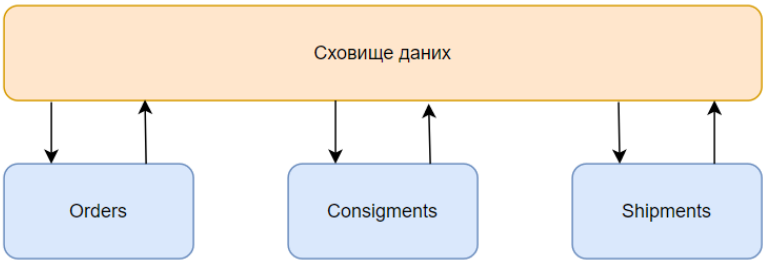


Рис. 10. Реалізація аналітичного шару

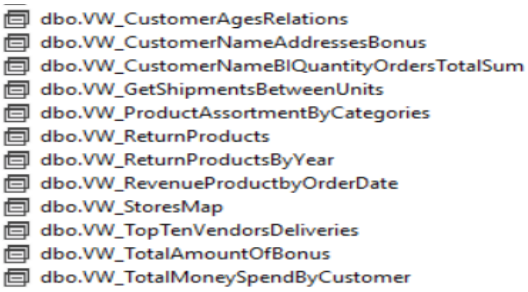


Рис. 11. Аналітичні представлення у сховищі даних

Виконуючи даний процес проведемо порівняння між двома способами переміщення, для визначення найоптимальнішого. Серед розглянутих, будуть наступні способи: SSIS пакети; збережені процедури на T-SQL.

Спершу, необхідно обрати об'єкт бази даних на якому будуть проводитись дослідження. Проаналізувавши об'єкти які були представлені в системі було обрано бізнес напрям замовлень, так як у даних таблицях є не тільки числові, але й текстові поля, що можуть суттєво впливати на час переміщення даних (рис. 12, 13).

Також дані об'єкти дають можливість зробити витяг різної кількості даних так як при повному переміщенні даних об'єктів буде опрацьовано близько 2.5 мільйона записів.

Отже, дослідження швидкодії ETL процесу буде проводитись на наборах даних різної розмірності.

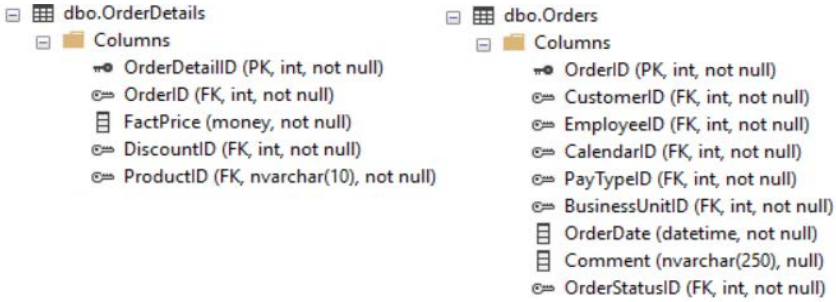


Рис. 12. Структура замовлень в OLTP системі

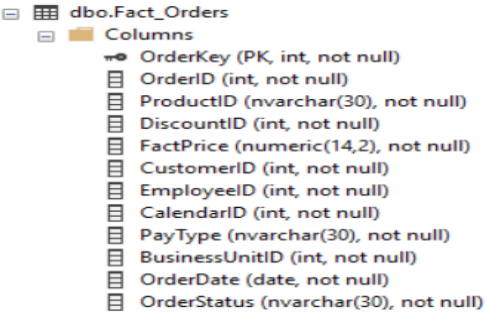


Рис. 13. Структура замовлень в сховищі даних

Спершу проведемо дослідження використовуючи збережені процедури на T-SQL. Для здійснення даного переміщення було створено процедуру, в якій, при переміщені даних, будуть відбуватись певні фільтрації [14].

Проведемо експерименти на обраних об'ємах даних, поступово збільшуючи кількість записів. Результати відобразимо у вигляді таблиці (табл. 2).

Таблиця 2

Час на переміщення даних за допомогою T-SQL

Кількість записів	Час виконання(мс)
1000	176
10000	203
20000	220
50000	356
100000	496
200000	816
500000	2336
1000000	4010
1500000	6203
2000000	7850

Аналізуючи результати, які були отримані під час експериментів та занесені у таблицю 3, видно, що зі збільшенням об'єму інформації що опрацьовується збільшується час роботи.

Рис. 14. Графік залежності часу до об'єму інформації обробленої за допомогою T-SQL

Зобразимо у вигляді лінійного графіка залежність зміни часу переміщення від об'єму даних, що передається (рис. 14).

Тепер проведемо такі ж експерименти, тільки з використанням SSIS пакетів. При використанні SSDT для роботи з даними пропонує на вибір параметр UseFastLoadIfAvailable. Розглянемо два варіанти із застосуванням даного параметру та без нього.

– Fast Load – <UseFastLoadIfAvailable=»false»>

– Plain Load – <UseFastLoadIfAvailable=»true»>

Результати будуть відображені у таблиці нижче (табл. 3).

З отриманих результатів видно, що використання Plain Load починаючи з 10000 записів різко збільшує час виконання і у порівнянні з Fast Load працює довше в середньому у 50 разів довше. Це випливає з того, що при використанні PlainLoad опрацьовується не весь об'єм даних, а дані подаються частково – по 9000 рядків. Тільки після опрацювання однієї порції, наступна перейде у роботу. З опцією FastLoad дані опрацьовуються динамічно, що значно впливає на швидкість роботи.

На рисунках нижче зобразимо відношення часу виконання до об'єму даних, що опрацьовуються для кожного з досліджуваних способів використання SSIS пакетів (рис. 15, 16).

Таблиця 3

Час для переміщення даних двома варіантами використання SSIS

Кількість записів	Час виконання(мс)	
	Fast Load	Plain Load
1000	156	343
10000	160	2266
20000	203	4390
50000	328	13641
100000	516	21515
200000	860	43422
500000	1859	149641
1000000	3547	337109
1500000	5391	533922
2000000	6985	671078

З вище поданих графіків видно, що використання FastLoad не тільки дає значний приріст в часі виконання, але і зростання даного часу у порівнянні з PlainLoad є більш стабільним. З рисунку 17 видно що після різкого збільшення даних час виконання збільшується не

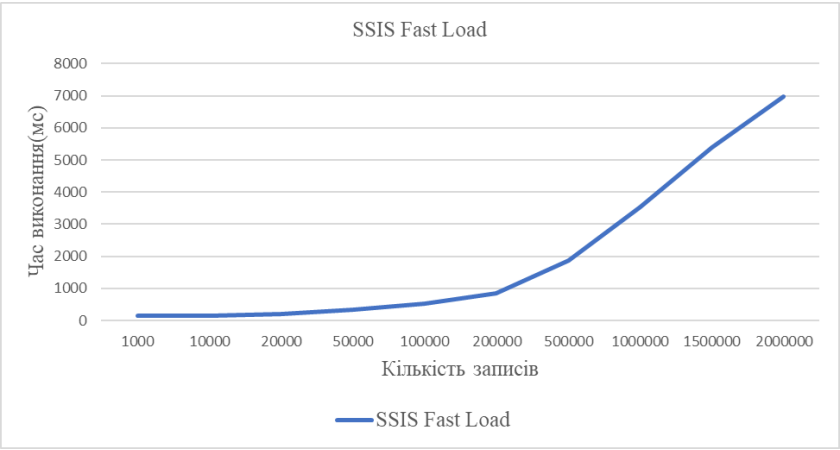


Рис. 15. Графік порівняння швидкості часу завантаження за допомогою SSIS пакетів використовуючи Fast Load

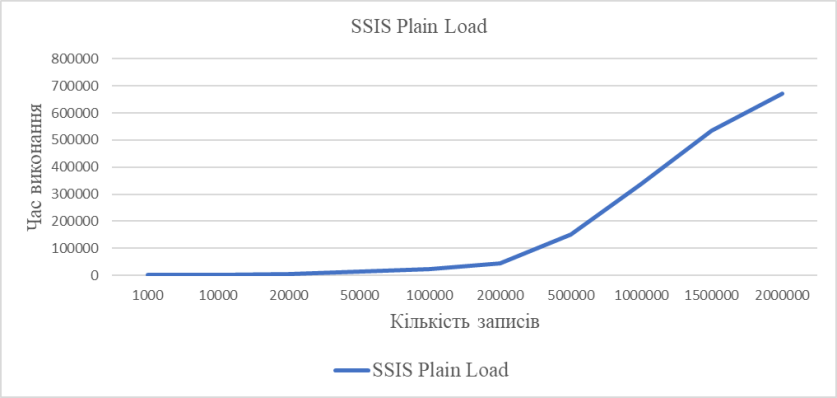


Рис. 16. Графік порівняння швидкості часу завантаження за допомогою SSIS пакетів використовуючи PlainLoad

пропорційно, в той час як використання FastLoad дає лінійний приріст в часі відносно об'єму даних.

Зобразимо на одному рисунку відношення для даних двох операторів, для чіткішого розуміння швидкості приросту часу з використанням PlainLoad (рис. 18). Як і було описано вище, PlainLoad не є

Рис. 17. Графік порівняння швидкості часу завантаження за допомогою SSIS пакетів використовуючи Fastта PlainLoad

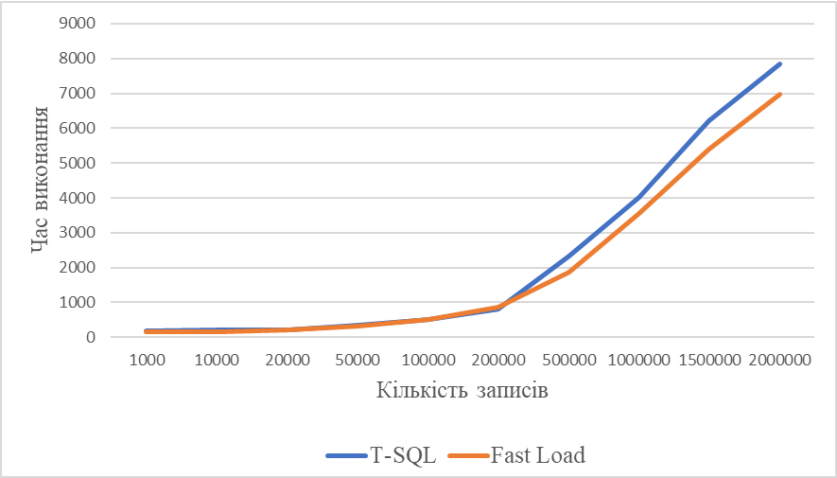


Рис. 18. Графік порівняння швидкості часу завантаження за використанням T-SQLта FastLoad

оптимальним способом для опрацювання і перенесення даних, так як з рисунку вище (рис. 19) видно, стрімке збільшення часу на відносно не великій кількості даних у порівнянні з FastLoad.

Отже, після проведення досліджень було виявлено що створення SSIS пакетів з використанням FastLoad є найбільш оптимальним способом для опрацювання і перенесення даних з використанням даного засобу.

На даному етапі необхідно провести порівняння між T-SQL та FastLoad щоб зрозуміти, який спосіб з усіх розглянутих є найбільш оптимальним.

Зобразимо у вигляді таблиці 4 раніше отриманні значення під час експериментів для способі що порівнюються

З вище поданої таблиці можна зробити висновок, що на будь якому об'ємі даних використання SSIS пакетів з FastLoad є більш швидкодійним аніж використання засобів DatabaseEngine та T-SQL.

Явний приріст по продуктивності починається після 200000 записів де FastLoad є в середньому в 1.25-1.3 рази ефективнішим та швидкодійним у порівнянні з T-SQL.

Таблиця 4

Порівняння часу виконання T-SQL та FastLoad

Кількість записів	T-SQL	FastLoad
	Час виконання(мс)	Час виконання(мс)
1000	176	156
10000	203	160
20000	220	203
50000	356	328
100000	496	516
200000	816	860
500000	2336	1859
1000000	4010	3547
1500000	6203	5391
2000000	7850	6985

На меншій кількості записів різниця не є настільки суттєвою і не перевищує приріст у 1.1 рази.

Зобразимо дане порівняння на графіку для візуального розуміння швидкості приросту часу до об'єму даних (рис. 18).

Отже, з даного графіку видно, що перевагу все ж таки має FastLoad, так як на відносно великих об'ємах даних є приріст по продуктивності, а на об'ємах даних до 200000 приріст не є настільки суттєвим.

Незважаючи на те, що на відносно не великих об'ємах даних FastLoad показав кращі результати, рекомендацією би було використовувати T-SQL, так як розробка цими засобами є більш простішою та не вимагає додаткових засобів, так як це потрібно при розробці SSIS пакетів. Але необхідно враховувати всі фактори і бізнес-потреби для прийняття оптимального рішення [15].

Створена система передбачає своє керування використовуючи засоби SQLServerManagementStudio. Керування даними передбачено як для OLTP системи так і для сховища даних. Було реалізовано ряд об'єктів бази даних для отримання швидкого аналізу даних.

Розглянемо об'єкти, якими є змога керувати користувачу. Для додавання, оновлення або видалення інформації в системі реалізовані процедури які будуть відповідати за дані операції. Також реалізовано декілька об'єктів, які відповідають за бізнес процеси, такі як звільнення працівника і т.д. Нижче буде наведено їх перелік (рис. 19).

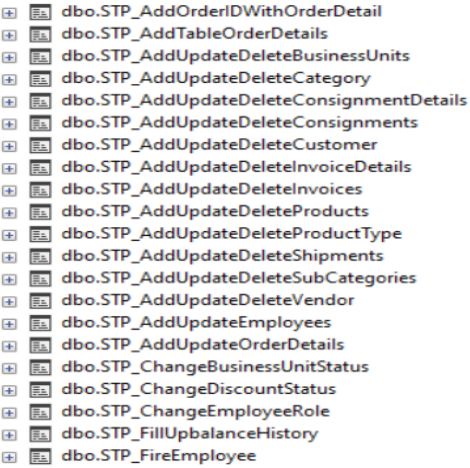


Рис. 19. Процедури для керування даними в системі

У кожній з даних процедур передбачено передавання інформації яку потрібно змінити і на основі отриманих вказівок буде виконана певна дія.

Розглянемо роботу однієї з них на прикладі додавання та видалення нового типу продуктів у систему. Перевіримо які існуючі типи вже є, для цього переглянемо дані у таблиці dbo.Products. Для обмеження кількості записів у вибірку візьмемо лише ті, що починаються на 'W' (рис. 20).

	ProductTypeID	TypeName
1	WAL13174	Wall Plates & Connectors
2	WAL14042	Wall Chargers
3	WAT10056	Water Cooling Systems
4	WEA14900	Weather Radios
5	WIR16584	Wireless Jack Systems
6	WIR18884	Wireless Access Points

Рис. 20. Вибірка типів продуктів

На даний момент у системі представлено 6 типів продуктів які задовольняють умови нашої вибірки. Припустимо з'явилась бізнес-потреба добавити ще один тип. Для цього скористаємось процедурою dbo.STP_AddUpdateDeleteProductType.

При виклику процедури слід вказати необхідну дію та дані, які потрібно добавити та після успішного виконання даної задачі у системі з'явиться необхідний запис (рис. 21).

	ProductTypeID	TypeName
1	WAL13174	Wall Plates & Connectors
2	WAL14042	Wall Chargers
3	WAT10056	Water Cooling Systems
4	WEA14900	Weather Radios
5	WIR16584	Wireless Jack Systems
6	WIR18884	Wireless Access Points
7	WIRTEST	Wireless Charges

Рис. 21. Модифікована вибірка типів продуктів

За допомогою виклику даної процедури, тільки з передачею іншого параметра дії можна взаємодіяти з даними в системі без додаткових засобів і не надаючи користувачам доступ до початкових таблиць.

Вище був розглянутий один з найпростіших варіантів взаємодії з OLTP системою. Натомість взаємодія зі сховищем даних буде відріз-

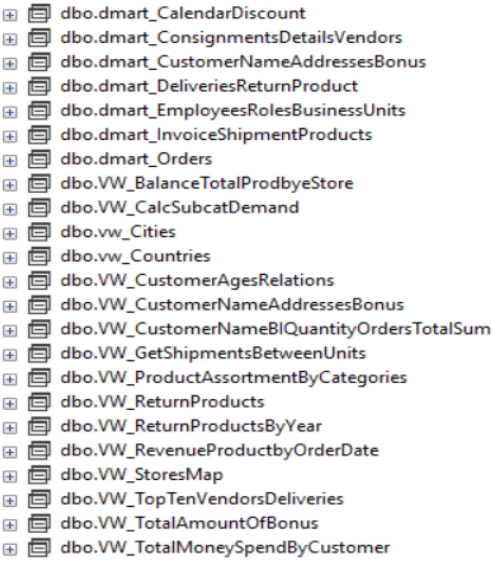


Рис. 22. Аналітичні представлення у сховищі даних

нятись від вище описаної. Так як у сховищі даних зберігаються вже трансформовані, архівні дані.

Користувач не повинен мати доступ на їх модифікацію, але повинен мати можливість отримувати дані для аналізу. Для цього було створено певний перелік представлень, які будуть слугувати вихідними даними системи.

За допомогою даних представлень користувач буде мати можливість або самостійно отримати агреговані або чисті дані для аналізу, або передати інформацію з даних представлень в сторонні програми для створення BI-рішень, такі як PowerBI, для проведення більш глибшого аналізу (рис. 22).

8. Висновки

Отже, в результаті дослідження було створено трьох шарову систему яка складається з OLTP системи, як транзакційного шару, ETL процесів за допомогою засобів DatabaseEngine та SSIS пакетів, як інтеграційного шару та сховища даних побудованого за гібридним принципом, як аналітичного шару. Реалізована система є аналогом новітньої self-service системи, так як може забезпечувати свої бізнес потреби без сторонніх засобів.

Було розглянуто різницю між реляційною базою даних та сховищем даних, наявні підходи до побудови сховищ даних, їх переваги та недоліки. Було проаналізовано предметну область та описано концепцію побудови сховища даних та OLTP системи. Також було виконано усі завдання, які були описані в постановці, тобто реалізовано інформаційну self-service систему.

При проектуванні системи було створено інформаційну модель реляційної бази даних та сховища даних, описано логічні сутності які представлені в системі та сформовано бізнес потреби кожного з об’єктів. Описано структуру вхідних та вихідних даних та запропоновано варіанти їх подальшого використання.

Для коректної роботи програми було сформовано та описано вимоги до програмного та технічного забезпечення, сформована записка з керуванням для користувача з детальним описом основного функціоналу системи.

Розроблену систему можна використовувати як аналог для взаємодії з даними на підприємстві. Використані інтеграційні засоби можна

застосувати для перенесення будь якого типу даних і це допоможе краще аналізувати структуровані дані для визначення основних бізнес потреб системи.

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ADVANTAGES OF APPLYING ELASTIC WAVES THEORY IN SOLVING DYNAMIC PROBLEMS

ПРЕИМУЩЕСТВА ИСПОЛЬЗОВАНИЯ ТЕОРИИ УПРУГИХ ВОЛН ПРИ РЕШЕНИИ ДИНАМИЧЕСКИХ ЗАДАЧ

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Abstract. *The purpose* of the paper is to demonstrate that the application of the theory of elastic waves in solving dynamic problems allows expanding the possibilities of a modeling and diagnosing natural phenomena necessary for productively solving the issues of ensuring the functional safety of objects in the technosphere of the human habitat. The method based on the use of the provisions of the elastic waves' theory provides the analytical modeling of natural processes inside the simulated objects in time. *Methodology*. The paper evaluated the advantages and disadvantages of approaches to modeling dynamic processes. A holistic approach to the modeling of dynamic processes was formed, using the theories of elastic waves, examples demonstrating the advantages of the proposed approach are given. *Results* of the paper showed that applying elastic waves theory allows complementing the description of force impulses, such characteristic as a law of altering the force impulse in time. The possibility of using the time to describe the effect of force impulses on any object allows extending the use of the second law of motion and applying the first law of thermodynamics in time. *Practical implications.* The proposed approach facilitates the detailed operation of operating conditions and takes into account the structural, technical, and technological characteristics of the operation of different facilities. This makes it possible to optimize objects by modifying their construction, the properties of the materials of objects, and the technology of maintenance for specific operating conditions. All this contributes to increasing the competitiveness of the facilities as a whole. *Value/ originality*. Since it is possible to use the law of momentum conservation for

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individual objects as well as for parts of them, using the holistic approach makes it possible to turn to systems previously considered open.

1. Вступление

Технологическое развитие человечества столкнулось с необходимостью обеспечить инженеров и ученых инновационным и эффективным инструментом для продуктивного решения вопросов обеспечения функциональной безопасности объектов техносферы среды обитания человека.

Проблема состоит в том, что оценка рисков функциональной безопасности любых объектов инженерии связана с определением второго граничного состояния [1, с. 13, п. 6.2.3], при котором определяется пригодность объектов выполнять свои функции безопасно (с определенными уровнями риска на всех этапах жизненного цикла) и эффективно (с определенным уровнем издержек) в условиях конкретных параметров эксплуатации. По этому состоянию должны быть оценены характеристики деформативности.

Но современные инструменты, используемые для определения состоя-ния объекта (методы и программные продукты) базируются на принципах, разработанных для определения первого предельного состояния [1, с. 13, п. 6.2.2], определяющего общую пригодность объекта работать в определен-ных условиях. По этому состоянию оценивают показатели прочности и устойчивости, полученные путем численного моделирования, например, методом конечных элементов, для имитации квазидинамических процессов деформации, происходящих внутри элементов под действием внешних воздействий.

При численном моделировании соответствующее решение определяется путём подбора данных, то есть моделируются условия для получения определенного результата. Но для оценки рисков необходимо применять аналитические методы, использующие пространственно-временные зависимости и имитирующие процессы, происходящие внутри как каждого элемента конструкции, так и в конструкции вообще под действием внешних воздействий.

Для машиностроения и оборудования, транспортной инфраструктуры, горнодобывающей, военной, строительной, энергетической и природо-охранной техники с 70-х годов прошлого века основной целью

проектирования является обеспечение условий деформативности. Но специалисты рынков CAD/CAM и мультифизической инженерии, такие как университеты, научные лаборатории, компании, занимающиеся проектированием, обслуживанием и испытанием механических систем, используют численные расчеты, подобные методу конечных элементов, которые используют основы, разработанные для обеспечения условий прочности и устойчивости механических систем, но не деформативности. Поэтому технические расчеты содержат слишком много ненужных приближений и допущений, мешающих моделировать природные явления. Существующие подходы инженерии позволяют решать аналитическими методами только 3% задач, остальные 97% решаются путем подбора индивидуальных решений, основанных на экспериментальных данных, полученных для определенных условий, так как расчетные системы не учитывают такие временные характеристики как:

– изменение импульса во времени;

– изменение деформативности объектов во времени.

Отсутствие параметра времени в расчетах не позволяет установить связь между исходными причинами и симптомами, которые выявляются в результате.

Таким образом, на рынке расчета 3D-моделирования отсутствует инструмент для расчета реальных процессов деформативности в объектах, что приводит к необходимости проведения дополнительных экспериментов для минимизации ошибки.

Решением этой проблемы является, во-первых, формирование подхода к аналитическому решению задач определения параметров деформативности во времени с использованием теории упругих волн. Во-вторых, создание программного обеспечения для решения задач определения параметров деформативности конструкций объектов для оценки рисков их эксплуатации.

Данная работа имеет целью показать, что применение теории упругих волн при решении динамических задач позволяет расширить возможности моделирования и диагностики природных явлений, необходимых для продуктивного решения вопросов обеспечения функциональной безопасности объектов техносферы среды обитания человека.

2. Существующие проблемы моделирования динамических процессов

В настоящее время вся наука физика, все ее понятия и законы группируются вокруг фундаментальных теорий: ньютоновской механики и теории относительности, молекулярно-кинетической теории и принципов термодинамики, теории электромагнитного поля и электронной теории, теории колебаний, квантовой теории [2, с. 12]. Высокий теоретический уровень развития физики приводит к тому, что в ней очень широко используются математические методы и очень многие положения выводятся из основных. Вместе с тем, физика, как часть естествознания, является наукой экспериментальной. Эксперимент служит в ней как исходной базой, поставляющей фактический материал, так и методом проверки, того или иного следствия теории. Условия применение математического аппарата и методики эксперимента зависят от условия поставленной задачи. Как уже указывалось ранее, для обеспечения работоспособности объектов, рассматривались условия потери несущей способности или непригодности к эксплуатации, критериями которых выступают прочность, устойчивость и выносливость. Поэтому методы моделирования и проведения экспериментов соответствовали определению этих критериев. Для таких условий достаточно было рассматривать динамический процесс как квазидинамический, поскольку основными оценочными параметрами выступали величины максимально возможных напряжений или деформаций, появляющиеся в объектах в процессе эксплуатации. Эти же величины напряжений и деформаций, измеряются и в экспериментах.

Таким образом, для изучения квазидинамического воздействия на любой объект необходимо задать исходные данные в виде: геометрических моделей или приведенных масс; типы связей между элементами; жесткостные (упругие) свойства элементов; локацию, направление и значение воздействия. В результате расчета получают данные напряжено-деформированного состояния объекта.

При моделировании силовых квазидинамических процессов используют следующие допущения:

1. Воздействие на объект задается в виде действия квазидинамической силы, значение которой учитывает максимально вероятную совокупность влияния статических и динамических сил. Воздействие

циклической силы описывается законом ее изменения, который характеризуется частотой ее повторения.

2. Перемещение точек объекта обусловлены его деформациями, которые значительно меньше размеров тела. Сила вызывает прямо пропорциональные деформации в направлении силы, обусловленные жесткостью объекта.

3. Считается что сила в объекте вызывает мгновенное изменение его напряженно-деформированного состояния. Таким образом, заложено отсутствие временной зависимости между моментом приложения силы и моментом ее преобразования.

4. Деформативность объекта, как совокупность деформаций и перемещений всех элементов, представлена линией (полем, при использовании методов, подобных методу конечных элементов) влияния. Считается что линия влияния имеет определенную форму при воздействии одиночной силы и их суперпозицию при действии группы сил. Линия влияния передвигается вместе с перемещением силы или группы сил вдоль объекта.

Перечисленные допущения выступают в роли ограничений при изучении вопросов изменений, происходящих в объекте при действии временной нагрузки поскольку:

1. Как правило, не существует изолировано работающего под динамическими нагрузками объекта. Рассматриваемый объект в инженерии чаще состоит из совокупности связанных между собой различных элементов, каждый из которых характеризуется своими физико-механическими и геометрическими характеристиками. Отсутствие временной составляющей не позволяет изучить какие изменения происходят в элементах во времени, как эти изменения влияют на функционально-безопасное состояние каждого элемента и как их совокупность влияет на работу объекта.

2. При любом влиянии нагрузки на объект она имеет время воздействия и закон воздействия, характеризующиеся фактическими условиями эксплуатации. В тоже время любой элемент обладает «своим» временем на восприятие силового воздействия и последующую реакцию на это воздействие, которые формируют жесткостные (упругие) характеристики объекта. Отсутствие временной составляющей не позволяет изучить, как и за счет чего изменяются жесткостные и геометрические параметры объекта и его деформативное состояние во времени.

3. Как правило при функционировании, процесс деформативности объекта происходит под влиянием силовых, электромагнитных и гравитационных полей на фоне протекания процессов изменения температуры и влажности. Среди описанных процессов только протекание процесса силового влияния не описано временной зависимостью. Отсутствие временной составляющей не позволяет изучить взаимосвязь и влияние этих процессов на функционально-безопасное состояние объекта во времени.

Таким образом, появилась необходимость описать фундаментальные положения физики математическими методами, позволяющими изучить протекание динамических процессов, для формирования условий функционально безопасной работы объектов.

3. Описание динамических процессов средствами теории упругости

В зависимости от того, какие величины принимают в качестве основных неизвестных, различают три способа решения задачи теории упругости:

− решение в перемещениях;

− решение в напряжениях;

− смешанное решение.

Решение задачи в перемещениях сводится к интегрированию трех уравнений Ламе при удовлетворении условий на поверхности. По найденным перемещениям из формул Коши находят деформации и, далее из формул закона Гука находят напряжения.

Для решения задачи в напряжениях необходимо проинтегрировать три уравнения Навье вместе с шестью уравнениями Бельтрами-Митчелла при удовлетворении условий на поверхности. После этого по формулам закона Гука получают деформации и, далее, по формулам Коши – перемещения.

Для решения задачи теории упругости во всех случаях должны учитываться условия на поверхности (граничные условия). Для этого должно быть задано уравнение поверхности тела и силы или перемещения ее точек.

Различают два типа граничных условий: кинематические, когда задаются значения перемещений точек поверхности, и статические, если задаются значения напряжений на поверхности.

Возможны также смешанные граничные условия, когда на части поверхности задаются перемещения, а на части – напряжения.

Различают три основных математических метода решения задачи теории упругости:

− прямой метод, который заключается в непосредственном интегрировании основных уравнений при выполнении граничных условий;

− обратный метод, если задаются функциями напряжений или перемещений, удовлетворяющими дифференциальным уравнениям задачи, а затем устанавливают, каким граничным условиям эти функции соответствуют;

− полуобратный метод Сен-Венана, когда задаются частью функций перемещений или напряжений и из уравнений задачи устанавливают, каким условиям должны удовлетворять остальные функции. При этом дифференциальные уравнения существенно упрощаются.

Таким образом, использование теории упругости при решении задач имеет как преимущества, так и недостатки. К преимуществам относятся следующие положения:

1. Внутреннее состояние характеризуется с помощью ряда величин: напряжений, деформаций, температур и т. д.

2. Построение модели материала основывается на понятии материального континуума: представлении реального материала как бесконечной совокупности элементарных материальных частиц, которые в геометрическом смысле можно рассматривать как точки, а в физическом смысле как частицы, наделенные свойствами материала в целом.

3. Материал при деформации рассматривается как совокупность точек, взаимное расположение которых изменяется в результате физических воздействий на материал или тело. Гипотеза сплошности приводит к тому, что соседние материальные частицы, которые были смежными в естественном начальном состоянии остаются смежными и в деформированном состоянии. Это физическая интерпретация того, что изменение материала происходит непрерывно, при этом никакая материальная частица не превращается в объем исчезающе малый или бесконечно большой.

4. При деформировании сплошной среды все материальные частицы могут получать перемещения. В основе классической теории деформаций лежит метод описания кинематики сплошной среды

с помощью вычисления удлинений линейных элементов и изменений углов между линейными элементами, имеющими общую вершину.

К недостаткам теории упругости относятся нижеприведенные положения:

1. Основной проблемой теории упругости является отсутствие временной составляющей. Нет зависимостей, которые во временной шкале связывают продолжительность воздействия силы, деформации или напряжения.

2. В теории напряжений изучаются внутренние силы, возникающие в твердых деформируемых материалах или объектах в следствии физических воздействий на них. При внешнем физическом воздействии изменяются расстояния между внутренними точками материала (материальными частицами), в следствии этого возникают внутренние силы, которые отражают макроскопическое взаимодействие между атомами или молекулами. Для описания внутренних сил в теории напряжений используются метод сечений и аксиома связи. Внутренние силы могут изменяться при переходе от одной частицы к другой, и поэтому напряженное состояние в объекте в общем случае является неоднородным (также, как и деформируемое состояние). Но деформации можно измерить, а напряжения нет, так как для измерения напряжений физически измеряют деформации. Поэтому теория напряжений аксиоматическая, а напряжение является искусственной мерой внутренних сил, возникающих в объекте.

3. В теории деформаций кинематика сплошной среды рассматривается вне зависимости от физических воздействий. В теории напряжений изучаются внутренние силы, возникающие в объекте или в материале, в результате физического воздействия, при этом ни в теории деформаций, ни в теории напряжений не учитывались конкретные свойства материала для описания протекания процесса распространения силовых воздействий внутри объектов. Даже при использовании численных методов моделирования, например метода конечных элементов, разбиение внутренней сетки не зависит от свойств материалов.

4. Поведение конкретных материалов и конструкций объектов, а также связей между ними, под различными воздействиями, придаются изучаемым моделям с помощью определяющих соотношений. Для построения определяющих соотношений проводят эксперименты по

физическому воздействию на образцы объектов. Из обработки данных экспериментов устанавливают конкретный вид зависимостей и значения входящих в эти зависимости констант. Поэтому такие эксперименты называют установочными экспериментами, а константы в выражениях – материальными константами. И эксперименты, и константы применимы только для рассматриваемых условий и отображают реальные физические процессы по отдельным коррелируемым аспектам, физическая природа которых не учитывается.

5. Теория упругости отлично описывает материал объектов используя понятие материального континуума, но полностью исключает возможность изучения поведения внутренних сил. Знание механизмов изменения внутренних сил используется, например, для создания материалов с высоким или низким демпфированием механических колебаний, применяемых в различных областях техники. Даже при изучении внутреннего состояния в упругости анизотропных материалов рассматривается макроскопическое поведение материалов, то есть атомное или молекулярное строение не рассматривается.

Указанные шесть недостатков далее будут использоваться как направления усовершенствования моделирования за счет использования теории упругих волн.

4. Преимущества использования теории упругих волн

Объемные акустические волны в твердом теле нашли широкое применение как в научных исследованиях, так и в промышленной технологии. В последние годы, после открытия надежных способов возбуждения ультразвука, возрос интерес к нему как к средству контроля механических свойств материалов. О механических свойствах материалов можно судить по акустическим характеристикам, поскольку акустические параметры такие, как скорость распространения упругих волн, затухание, дисперсия, связаны с механическими свойствами материалов.

Волны сжатия (*P*-волны, или продольные волны) заставляют частицы материала колебаться, подобно спиральной пружине, вдоль направления распространения волны путем чередования участков сжатия и разрежения. Волны сдвига (*S*-волны, или поперечные волны) заставляют частицы колебаться перпендикулярно направлению рас-

пространения волны, подобно вибрирующей гитарной струне. S-волны распространяются только через материал, обладающий упругостью. Благодаря этому явлению в 1906 г. Английский сейсмолог Олдгем, наблюдая за распространением *S*-волн, сделал вывод о существовании земного ядра, так как *S*-волны не в состоянии проходить через жидкое ядро Земли.

Скорости объемных продольных и поперечных волн зависят от механических свойств материала, в котором они распространяются. Скорость *P*-волн больше скорости *S*-волн.

В литературе наиболее часто рассматриваются плоские объемные волны. Понятие плоской упругой волны, для которой поверхность равных фаз (фронт волны) является плоскостью, отражает бесконечно широкий поток акустической энергии. В действительности же никогда не существует идеально плоских волн. В любом реальном случае при ограниченных поперечных размерах акустического пучка имеет место дифракционная расходимость, которая приводит к искривлению фазового фронта. Лишь в некоторых случаях, когда реальный пучок имеет большое поперечное сечение по сравнению с длиной волны, он может приближенно считаться плоской волной. Объемные волны с неплоскими фронтами представляют в виде так называемого углового спектра, который по существу представляет собой бесконечную сумму плоских элементарных волн.

Весьма ценным свойством объемных волн в упругих изотропных средах является отсутствие дисперсии, т. е. зависимости фазовой скорости от частоты вплоть до оптического диапазона. Это свойство облегчает создание широкополосных акустических и акустооптических устройств обработки сигналов.

В кристаллах можно наблюдать затухание объемных волн. Оно зависит от рода кристалла, от типа волны и от направления распространения. Затухание существенно уменьшается при охлаждении звукопровода и почти исчезает при температуре, близкой к абсолютному нулю. У большинства кристаллов при нормальной температуре затухание возрастает пропорционально квадрату частоты.

Несмотря на широкое применение теории упругих волн в диагностике и понимание что силовые воздействия в объектах передаются с помощью объемных волн, до сих пор не произошло процесса исполь-

зования положений теории упругих волн для аналитического описания распространения динамических процессов в пространстве и времени.

Динамический процесс можно описать в виде двух взаимосвязанных блоков: 1) воздействие, 2) перенос и преобразование воздействия. Далее приведены положения для указанных блоков, на которых базируется предлагаемое в работе моделирование динамических процессов с помощью теории упругих волн.

1. Воздействие. Будем рассматривать импульсы в качестве меры воздействий различных физических величин на объект во времени, при котором происходит обмен энергией во времени. Например, по закону Гука, сила, действующая на объект, вызывает прямо пропорциональные деформации или перемещения. При действии силы на объект последний будет совершать работу, равную произведению силы на перемещение. Действие постоянной в единицу времени силы на объект, не зависимо от времени ее воздействия, характеризуется одинаковым значением количества движения в единицу времени, что служит потенциалом для совершения одинакового количества работы объекта в единицу времени. Значит, передает одинаковое количество энергии во времени за время действия силы. Таким образом, импульсы постоянных сил передают постоянное количество энергии в единицу времени и вынуждают объект либо иметь постоянную деформацию под их воздействием, то есть ведут себя согласно законам статики с момента установления равновесия. Либо, если тело не взаимодействует с другими телами, двигаться прямолинейно и равномерно с установившейся в этой среде скоростью. Если же сила имеет переменное значение во времени, тогда импульсы переменных сил вызывают обмен переменным количеством энергии в единицу времени за время действия силы. Поскольку при воздействии происходит обмен энергией, то одной из его характеристик является закон изменения воздействующей физической величины во времени. Данная величина характеризует интенсивность воздействия импульса силы. При описании воздействий, амплитуда силы характеризует силу удара в механических системах или громкость в музыке. А интенсивность воздействия позволяет описывать такие характеристики воздействия как «legato» и «moderato» и плотность звучания в музыке или «мягкий» и «жесткий/резкий» удар в механических системах.

Как указано выше, при импульсах происходит передача энергии во времени. Таким образом, действие импульса на объект имеет четкие временные характеристики начала и конца действия, то есть продолжительности воздействия. Что позволяет определить еще одну характеристику: время передачи импульса. Таким образом, влияние любых физических величин, при циклических воздействиях в динамическом процессе, характеризуется двумя видами частот [3, с. 30]:

– частотой (или частотами) передачи импульса, действующего на опре-деленную площадку контакта. Она характеризуется продолжительностью воздействия;

– частотой повторения импульса в определенном сечении. Она характеризуется временем, через которое происходит повторение воздействия.

Таким образом, возможность использования времени при описании воздействия импульса на любой объект, позволяет расширить использование основного закона механики от формулировки «сила равна производной импульса по времени» [2, с. 56] до «закон изменения импульса силы во времени, характеризующий интенсивность воздействия в единицу времени, определяет изменение количества движения во времени, характеризующее величину энергии во времени на совершение возможной работы в единицу времени».

2. Перенос и преобразование воздействия. При рассмотрении направлений усовершенствования моделирования было указано, что основной проблемой моделирования является отсутствие временной составляющей. Поэтому для описания процесса переноса импульса в объектах необходимо выбрать такой способ, который, во-первых, имеет место во всех средах, из которых может состоять материал объекта (газообразных, жидких и твердых), а во-вторых, имеет закон распространения во времени в указанных средах. Этим условиям соответствует только теория упругих волн. Поэтому перенос воздействия, то есть импульса, при моделировании, осуществляется с помощью распространения упругих волн. Упругие волны обладают свойствами, которые на основании физико-механических и геометрических характеристик объекта, позволяют описать преобразование физических величин как внутри объектов, так и при переходе из одного в другой при моделировании динамических процессов.

На основе теорий упругости и распространения упругих волн разработан метод определения процессов, приводящих к изменению во времени локальных значений деформаций внутри элементов [3, с. 31]. Основным преимуществом предлагаемого метода моделирования является использование способности упругих волн распространять энергию силовых воздействий (импульсов) в пространстве и во времени.

Свойства материалов определяют наличие и скорость распространения внутри элементов поперечных и продольных волн. Закон изменения силового импульса и его направление, как характеристики механического воздействия, определяют направление и величину движений материальных частиц внутри элемента. На рис. 1 показано направление движения как всех видов волн относительно направления действующей силы, так и материальных частиц под действием продольных волн. На рис. 2 показано направленное движение частиц под действием поперечных волн. На рис. 1 и 2 показаны направления движения материальных частиц для одного из сечений пространственного распределения сферических поперечных и продольных волн.

В направлении действия силы вся энергия силового воздействия перемещает материальные частицы посредством продольных волн.

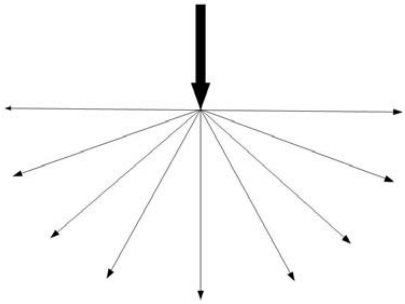

Рис. 1. Направление движения как всех видов волн относительно направления действующей силы, так и материальных частиц под действием продольных волн

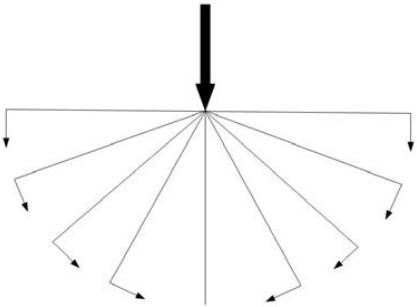

Рис. 2. Направленное движение материальных частиц под действием поперечных волн

В направлении, перпендикулярном направлению действия силы, частицы движутся только за счет поперечных волн. Во всех других направлениях распространения волн частицы приводятся в движения двумя типами волн, в соответствии со скоростью распространения волн, а также временем и амплитудой воздействия на каждую материальную частицу. Процессы отражения и преломления волн зависят как от геометрии объектов и их соединения в конструкции, так и от плотности материала и скорости распространения волн в нем.

Силовой импульс, воздействуя на объект, передает ему определенное количество энергии, которая поглощается и передается внутри объекта силовыми волнами, создающими силовые поля. Последние вызывают движение частиц материала, в результате чего внутри объекта происходят различные физические процессы с изменением во времени:

– локальной плотности материала (изменение расстояния между частицами под действием силовых волн);

– локальной температуры материала (за счет трения при перемещении частиц или неупругого столкновения силовых волн);

– сжимаемости материала (за счет изменения локальной плотности материала, влияющей на изменения движения частиц под действием силовых волн);

– объема объекта (как совокупность описанных выше физических процессов).

Эти физические процессы вызывают: изменение локальной концентрации частиц, изменение локального объема внутри элемента, изменение локальной скорости частиц и, согласно второму закону Ньютона, можно записать в виде:

$$F(t) = R(t) = \frac{d(mu)}{dt} = \frac{d(\rho V \nu)}{dt} = \frac{d(nm_0 V \nu)}{dt} \quad (1)$$

где $F(t)$ – импульс внешней силы, действующей на объект;

$R(t)$ – импульс силового поля, действующего внутри объекта;

m – масса объекта, поглощающего воздействие внешнего импульса за счет импульса силового поля, формируемого на основе суперпозиции силовых волн;

a – ускорение частиц под действием силового поля;

p – плотность материала объекта;

V – объем объекта, поглощающий воздействие внешнего импульса за счет импульса силового поля, формируемого на основе суперпозиции силовых волн;

t – время;

υ – скорость перемещения частиц, находящихся в силовом поле;

m_0 – масса одной молекулы;

n – концентрация, количество молекул в единице объема.

Основой моделирования при использовании теории упругих волн является наличие волновых процессов, вызванных как внешними, так и внутренними колебаниями. Под колебаниями в данном случае имеются ввиду перемещения частиц объекта под действием силовых волн как падающих, отраженных, так и преломленных волновых процессов.

Согласно теории упругих волн, все колебания, возбуждаемые контактированием поверхностей, которые к этому моменту не соприкасались или возобновили свое контактирование из-за разрыва, распространяются сферическими волнами. Они характеризуют основное направление распространения волнового процесса от места нового или обновленного контакта поверхностей и отвечают за контактные и локальные концентрации деформаций.

Все колебания, возбуждаемые контактированием поверхностей, которые к этому моменту касались и имеют контактные связи, распространяются квазисферическими волнами. Они характеризуют основное направление распространения волнового процесса от места контакта поверхностей и отвечают за неоднородность колебания. Но одна сферическая волна падения, несущая продольную и поперечную моды, вызывает четыре квазисферических преломленных волны: две продольные и две поперечные. Каждая из них неоднородна, поскольку имеет четкую зависимость изменения характеристик распространяясь по «своему» направлению с определенной скоростью и несет последствия от распространения соседних преломленных волн, имеющие собственные скорости и направления распространения.

Поскольку в процессе распространения происходит суперпозиция волн во времени, то она характеризует неоднородность всего колебания. Следовательно, в каждой точке конструкции объекта в определенное время действия будут наблюдаться либо однородные

сферические и (или) неоднородные квазисферические волны. Таким образом, колебания, распространяемые волнами во времени, не могут быть прогнозированы на основе аппроксимации, используемой численными методами расчета, поскольку каждая частица объекта будет иметь траекторию колебания, зависящую как от закона изменения силового импульса, так и от геометрии объекта. Существуют промежутки времени, когда частицы объекта непосредственно воспринимают и трансформируют силовые воздействия в соответствии со временем распространения процесса силовых волн в объекте. И время, когда частицы объекта смещаются за счет деформаций и смещений других частиц объекта, расположенных за ними в направлении действия силовых волн. Другими словами, как элементы конструкции, так и частицы объектов могут работать «активно» (преобразовывая силовые воздействия), так и «пассивно» [4, с. 67]. Закон изменения силового импульса характеризует деформации и перемещения, связанные с действием приложенного внешнего силового воздействия, то есть при выполнении «активной» работы. Геометрия объекта характеризует «пассивную» работу. Таким образом, различные частицы объекта имеют различные траектории колебаний во времени, а значит и различные локальные концентрации силовых волн во времени, что позволяет прогнозировать места появления усталостных процессов и дефектов при определенных условиях эксплуатации и характеристиках конструкции и материала объекта.

Современные требования конкурентоспособности объектов предусматривают минимизацию стоимости их безопасного функционирования с учетом фактических эксплуатационных условий. Применение теории упругих волн способствует детализация эксплуатационных условий и учету конструкционных, технических и технологических особенностей работы различных объектов. Это позволяет оптимизировать объекты изменяя их конструкцию, свойства материалов объектов, технологию технического содержания. Что дает возможность рационально распределять материальные ресурсы на его изготовление и обслуживание в период эксплуатации, если таково предусмотрено. И, тем самым, все это будет способствовать повышению конкурентной способности объектов в целом.

Использование теории упругих волн позволяет перейти к рассмотрению систем, которые ранее считались открытыми системами,

поскольку по-является возможность использовать закон сохранения импульса ($p=const$) как для отдельных объектов, так и для их частей.

Пример 1. В механике считается, что в ньютоновской области импульс возрастает только за счет роста скорости, так как изменением массы можно пренебречь. В ультрарелятивистской области скорость объекта практически не меняется и импульс растет только за счет роста массы. В релятивистской области рост импульса происходит за счет возрастания обоих сомножителей – как скорости, так и массы. При этом скорость растет медленнее, чем в ньютоновской области, именно из-за возрастания массы ускоряемого объекта. Теория упругих волн позволяет рассмотрение задач распространения импульса в любой области, так как учет времени при распространении силовых волн в объекте, автоматически учитывает как изменение массы во времени, так и изменения скорости протекания процесса деформативности внутри объекта.

Процесс движения объекта в механике характеризуют два вида энергии: кинетическая и потенциальная. Первая характеризует процесс движения с точки зрения изменения скорости, а вторая с точки зрения изменения координаты. Это искусственное разделение энергии, затрачиваемой на процесс движения, связано с историей развития технических расчетов, приведших к существованию на определенном этапе нескольких систем мер: физической и технической [5, с. 247]. В физической системе мер основной единицей измерения является масса, а сила является производной единицей, размер которой получается путем умножения основной единицы массы на размерность ускорения. В технической системе мер масса является производной единицей, получаемая путем деления основной единицы силы на размерность ускорения. В июле 1978 года постоянной комиссией по стандартизации утвержден Стандарт СЭВ 1052-78 «Метрология. Единицы физических величин», согласно которому единицы Международной системы подлежат обязательному применению во всех отраслях науки, техники, народного хозяйства и учебного процесса. Для Советского Союза постановлением Госстандарта СССР единицы СИ стали обязательными к применению с 1 января 1980 года [2, с. 61] и далее автоматически соблюдаются на территории постсоветского пространства. Но, поскольку любую величину силы, задействованную в экс-

перименте, легче приложить или измерить, чем определить величину масс, задействованных в эксперименте при динамических процессах, то технические расчеты и логика их развития незримо опираются на техническую систему измерения, где используются эквивалентные/приведенные значения масс.

По этой же причине существует разделение понятий удара на «упругий» и «неупругий». Считается что удар называется абсолютно неупругим, если объекты после соударения движутся с одинаковой скоростью, образуя один новый объект. При этом сохраняется только сумма импульсов соударяющихся объектов, но не сохраняется сумма их кинетической энергии. А упругим называется удар, при котором сохраняются как сумма импульсов, так и сумма кинетической энергии соударяющихся объектов.

Давайте оценим процесс перехода и названия энергий при взаимодействии двух шаров, первый из которых двигался в направлении второго, стоящего неподвижно до столкновения. Приложенная сила к первому шару определила импульс, характеризующий скорость движения шара и импульс взаимодействия со вторым шаром. Движение шара характеризуется величиной кинетической энергии. При столкновении со вторым шаром в зависимости от локации соударения и соотношения между акустическим сопротивлением обоих шаров часть энергии первого шара осталась в нем. В зависимости от соотношения между акустическим сопротивлением обоих шаров и амплитуды отраженного силового импульса, характеризующего количество энергии на совершение работы, первый шар способен: 1) остановиться и деформироваться путем сжатия; 2) изменить параметры движения и деформироваться путем сжатия; 3) остановиться и деформироваться путем растяжения; 4) изменить параметры движения и деформироваться путем растяжения. Точно также, второй шар, восприняв силовой импульс, несущий часть энергии от первого шара, характеризующейся амплитудами преломленного процесса, будет способен: 1) остаться стоять на месте и деформироваться путем сжатия; 2) начать двигаться и деформироваться путем сжатия.

Теория упругости при описании процесса взаимодействия шаров при столкновении использовала бы термины импульс, а также кинетическая и внутренняя энергии. При использовании цепочки импульс –

кинетическая энергия первого / второго шара, этот удар считался бы упругим. А при использовании цепочки импульс – внутренняя энергия первого / второго шара, этот удар считался бы неупругим.

Теория упругих волн не требует такого деления и описывает этот процесс как цепочки процессов падения, отражения и преломления силовых импульсов. При этом, появляется возможность рассматривать как процесс внешнего взаимодействия шаров, так и процессы, проходящие внутри шаров.

Пример 2. Применение теории упругих волн позволяет так же рассматривать процессы, возникающие в объектах, воспринимающих динамические воздействия.

Так, например, рассмотрим взаимодействие подвижного состава и железнодорожного пути. Силовыми импульсами во времени для обоих конструкций являются импульсы на контактных площадках взаимодействия рельса и колеса. Существующие подходы для расчета взаимодействия подвижного состава и пути используют численные методы моделирования, при которых используются две независимые друг от друга модели: модель для расчета воздействия пути на подвижной состав и модель для расчета воздействия подвижного состава на путь. Однако при моделировании для каждой модели используются разные характеристики силовых импульсов. Это связано с тем, что в действительности нет четкой зависимости как конструкция каждого объекта влияет на его упруго-диссипативные свойства. Поэтому при моделировании воздействий на подвижной состав используют амплитудно-частотные зависимости, полученные в эксперименте, без привязки к конструкции, плану и профилю железнодорожного пути. А при моделировании воздействий на железнодорожный путь используют квазидинамические силы, без учета их изменения во времени. Кроме того, рассмотрение влияния продольных силовых импульсов от подвижного состава к конструкции железнодорожного пути, при расчете устойчивости конструкции бесстыкового пути, при изменении температурных режимов также отсутствует. Все это приводит к ограниченному использованию этих моделей в рамках задач, определяющих первое предельное состояние.

Поскольку теория упругих волн позволяет рассматривать как происходит процесс распространения внешнего силового импульса внутри

объекта во времени, это дает возможность, с помощью соотношения амплитуд процессов падения, отражения и преломления, охарактеризовать какая часть энергии затрачивается на деформативность внутри объектов (процесс отражения), и какая часть энергии переходит в другой объект как внешний импульс (процесс преломления). Поэтому применение теории упругих волн позволяет рассматривать процесс распространения силового импульса от взаимодействия колеса и рельса одновременно для обоих объектов (конструкции подвижного состава и конструкции пути). Что дает возможность учитывать изменения во времени характеристик колебаний всех элементов как конструкции подвижного состава, так и конструкции железнодорожного пути.

С целью оценки работы элементов конструкции железнодорожного пути в таблице 1 показана взаимосвязь между значениями коэффициентами поведения деформативности элементов и конструкции пути при различных скоростях движения. Для этого были рассчитаны амплитуды колебаний как для всех элементов конструкции пути, так и для самой конструкции пути. По значениям амплитуд и сил, имеющих место для каждого элемента пути за время действия на него силового импульса, были определены значения их деформативной работы (A_V) и интенсивности использования элемента и конструкции (I_V как отношение величины работы ко времени действия силового воздействия). Далее за эталон были приняты показатели для скорости движения 10 км/час и получены коэффициенты поведения деформативности.

По результатам анализа данных, приведенным в табл. 1, при более низких скоростях движения значения амплитуд конструкции пути и времени воздействия силового импульса превышают аналогичные значения при более высоких скоростях движения, но длина пути, воспринимающего нагрузку, меньше. Это приводит к различным соотношениям поведения деформативности при различных скоростях движения. Оценка интенсивности работы конструкции и элементов за время действия силового импульса характеризует интенсивность работы конструкции и элементов при различных скоростях движения. Увеличение скоростей движения приводит к увеличению интенсивности использования рельсовых прокладок и щебня за счет увеличения длины участка конструкции пути, воспринимающей силовой импульс, на фоне общего снижения восприятия силового импульса земляным полотном.

Таблица 1

Коэффициенты поведения деформативности при различных скоростях движения подвижного состава

Скорость, км/час	конструкция	прокладка	шпала	балласт	земляное полотно
$A_V / A_{V=10}$					
10	1	1	1	1	1
30	0,17	0,18	0,09	0,469	0,134
60	0,03	0,08	0,03	0,121	0,044
90	0,02	0,07	0,02	0,055	0,025
120	0,01	0,06	0,01	0,044	0,018
$I_V / I_{V=10}$					
10	1	1	1	1	1
30	0,487	0,513	0,255	1,088	0,391
60	0,159	0,498	0,159	0,679	0,245
90	0,141	0,565	0,129	0,444	0,202
120	0,133	0,655	0,117	0,466	0,184

В таблице 2 показана взаимосвязь между значениями коэффициентов поведения деформативности элементов и конструкции пути при различных значениях силового импульса.

По результатам анализа данных, приведенных в табл. 2, железнодорожный путь под воздействием подвижного состава с силовым импульсом 225 кН, выполняет меньшую работу, чем путь с силовым импульсом 294 кН и 450 кН соответственно в 2,34 и 7,29 раза. Интенсивность использования элементов и конструкции пути с силовым импульсом 225 кН меньше, чем с силовым 294 кН и 450 кН соответственно в 2,23 и 5,15 раза. Это позволяет установить взаимозависимости динамики подвижного состава и интенсивности использования элементов железнодорожного пути.

Основным преимуществом в данном способе описания процессов распространения силовых импульсов является возможность исследовать влияние как геометрии конструкции каждого элемента, так и состояния материала каждого элемента конструкции пути на работу самой конструкции пути.

Таблица 2

Коэффициенты поведения деформативности при различных воздействиях подвижного состава

Объект	Силовой импульс		
	225 кН	294 кН	450 кН
$A_F / A_{F=225}$			
конструкция пути	1	2,34	7,63
прокладка	1	2,25	7,03
шпала	1	2,19	6,83
балласт	1	2,43	8,13
земляное полотно	1	2,48	6,85
$I_F / I_{F=225}$			
конструкция пути	1	2,13	6,02
прокладка	1	2,06	5,57
шпала	1	2,00	5,38
балласт	1	2,73	7,7
земляное полотно	1	2,25	6,63

Пример 3. Еще одно преимущество использования теории упругих волн состоит в том, что описание процесса распространения внутри объектов позволяет использование первого закона термодинамики, согласно которому для любого объема верно:

$$\delta K(t) + \delta U(t) + \delta A(t) = \delta Q(t) \quad (2)$$

где $\delta K(t)$ – изменение кинетической энергии объекта в любой локации его объема во времени;

$\delta U(t)$ – изменение внутренней энергии объекта в любой локации его объема во времени;

$\delta A(t)$ – изменение работы внешних сил;

$\delta Q(t)$ – изменение тепловой энергии в любой локации объекта во времени.

Физико-механические характеристики материала объекта определяют наличие видов волн, так, например, в твердых телах возникают как продольные, так и поперечные волны, а в жидкостях или газах только продольные, естественно если в них нет твердых включений. Например, в рельсах, выполненных из стали и железобетонных шпа-

лах под воздействием силового импульса, возникают как продольные волны, так и поперечные, в то время как в деревянных шпалах распространяются только продольные волны.

Для сравнения работоспособности разных материалов используется понятие энергии абсорбции (энергии разрушения). Но эта энергия зависит от процесса деформативности. Так, например, часть рельса в межшпальном пространстве передает силовой импульс воздуху. Поскольку произведение плотности стали на скорость распространения волн в стали больше по значению чем та же характеристика в воздухе, то процесс отражения вызовет дополнительное растяжение рельса в направлении действия силовых волн процесса отражения, что обеспечит прогиб рельса в межшпальном ящике. Часть рельса, опирающегося на прокладку, так же вызовет прогиб рельса, но меньший, чем в межшпальном пространстве на величину разницы между амплитудами процессов отражения волн в полимерной прокладке и в воздухе. А вот в процессе отражения силовых волн в полимерной прокладке на контакте с железобетонной шпалой, отраженные волны будут сжимающими и противодействовать сжимающим силовым воздействиям преломленного процесса на контакте рельс-прокладка. В данном случае в полимерной прокладке происходит столкновение волн процесса падения и волн процесса отражения, что вызовет концентрацию деформации внутри прокладки на величину суперпозиции амплитуд, действующих во времени процессов падения и отражения, а также выброс количества теплоты на величину «компенсированной» (не реализованной в каждом направлении) деформации.

Волновые процессы внутри объектов способствуют изменению расстояний между частицами материала. И это также позволяет рассматривать процессы непосредственного взаимодействия между частицами материала во времени, что расширит возможности прогнозирования появления усталостных накоплений в материале и появление дефектов.

5. Выводы

Использование теории упругих волн для описания динамических процессов позволяет:

– обеспечить аналитическое моделирование природных процессов внутри моделируемых объектов во времени;

– сформировать целостный подход к моделированию динамических процессов;

– дополнить описание силовых импульсов такой характеристикой, как закон изменения силового импульса во времени;

– расширить использование второго закона движения и применить во времени первый закон термодинамики;

– детализировать условия эксплуатации и учитывать конструктивные, технические и технологические особенности эксплуатации различных объектов;

Поскольку предложенный подход позволяет корректно описывать физические процессы, протекающие внутри элементов во времени, это позволяет управлять функциональной безопасностью объектов техносферы предлагая инновационный подход к созданию комфортного среды обитания людей, путем:

– моделирования пространственно-временных процессов, происходящих как внутри каждого элемента конструкции, так и в конструкции в целом под действием как внешних, так и внутренних воздействий;

– модификации моделей путем изменения геометрических и физико-механических характеристик конструкции для определенных условий эксплуатации;

– оптимизации рисков, связанных с проведением неудачных испытаний;

– контроля параметров деформативности в динамических процессах;

– расширения существующих методов диагностики динамических систем;

– оптимизации затрат на изготовление и эксплуатацию объектов моделирования, а также прогнозирование повреждений при продолжении эксплуатации.

Это позволяет оптимизировать объекты, модифицируя их конструкцию, свойства материалов объектов, технологию обслуживания под конкретные условия эксплуатации. Все это способствует повышению конкурентоспособности объектов в целом. Поскольку можно использовать закон сохранения импульса как для отдельных объектов, так и для их частей, использование целостного подхода позволяет обратиться к системам, ранее считавшимся открытыми.

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A PRIORI RESEARCH RELATED TO THE CALCULATION OF THE REGIONAL ELLIPSOID FOR UKRAINE AND ITS EFFECTIVENESS

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Abstract. Despite the high accuracy of global geodetic reference systems and their widespread use in GPS measurements, regional (local) geodetic systems are becoming more widely used. For example, the World Geodetic System 1984 (WGS84) has 83 such local systems. The emergence of the latter is caused by the emergence of new problems of physical geodesy. These are the so-called regional problems, which make it possible to study in more detail both the geometric and gravimetric (physical) properties of the studied region (territory). For example, the tasks of constructing a high-precision regional geoid (quasi-geoid), regional ellipsoid, determining the regional normal formula of gravity, and others are becoming increasingly important.

That is why at present both national and regional reference ellipsoids are accepted for processing geodetic data on a regional scale (for example, for a specific country), and for global research – a general terrestrial reference ellipsoid GRS80 or, when processing GPS data – a general terrestrial reference ellipsoid WGS84.

In principle, any reference ellipsoid that represents a generalized figure of the Earth with appropriate accuracy can be used to process geodetic information. The deviations of the geoid from such an ellipsoid can determine the corrections that must be made in the results of geodetic measurements to bring the latter to the surface of this ellipsoid.

However, with large deviations of the geoid from the reference ellipsoid, there are large corresponding reductions of geodetic measurements, which are burdened with significant errors due to the linearization of the main problem of geodesy and, consequently, the problem of bringing geodetic measurements to the ellipsoid. Therefore, from a practical point of view, to reduce the impact of these linearization errors and obtain methodologically

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optimal results of geodetic data processing, it is expedient and even necessary to use a reference ellipsoid that best describes the generalized geoid surface in the region of specific geodetic works.

Given the above, the question arose about the national reference coordinate system, as such a system has some advantages over the national system in the process of practical processing of mass geodetic measurements, especially linear. In this regard, the issues of building a national reference system, namely, the definition of a regional ellipsoid, are very *important and relevant*.

Therefore, the scope of our research is the construction of a national reference system based on data on the regional gravitational field of Ukraine.

The *methodology* of such research is that the task of determining the regional ellipsoid is practically reduced to finding some corrections to the known, accepted by us, the general terrestrial ellipsoid GRS80. The regional ellipsoid for the territory of Ukraine should be the one that would best represent the geoid (quasi-geoid) of the region. That is, the heights of the geoid relative to the regional ellipsoid within the territory of Ukraine should be as small as possible.

These questions are reflected in this monograph, the purpose of which is to investigate a priori calculations to determine the parameters of the internal orientation of the regional ellipsoid according to its gravitational field in Ukraine.

Thus, based on the results of the above a priori studies, the following can be noted. Determining all five parameters of a regional ellipsoid leads to a strong functional dependence of the parameters. This dependence (correlation) is quite well demonstrated on the values of root mean square errors, which are proportional to the obtained parameters and even exceed the latter. Taking into account these remarks, we can conclude that the joint calculation of all five parameters by the method of least squares on the territory of Ukraine does not give us the expected good results. This is well seen from a priori calculations based on the heights of the geoid, presented in the form of a spheroidal trapezoid, which describes the territory of Ukraine. In contrast to this solution, studies to determine only the parameters of the internal orientation of the ellipsoid at a given major half-axis and compression of this ellipsoid, make it possible to choose a terrestrial regional ellipsoid that would best represent a geoid (quasi-geoid) built in Ukraine.

1. Introduction

As you know, the results of geodetic measurements carried out on the Earth's surface to determine the relative position of points, ie angles and distances between these points, primarily relate to different level surfaces of the Earth. The same can be said for the results of observations at different points on the Earth's surface, namely: finding their astronomical latitude, longitude and azimuth, which give the direction of the line is difficult as normal to level surfaces at these points. Therefore, these results of geodetic and astronomical determinations must be reduced to one level surface of the Earth, ie to the surface of the geoid [1; 5; 8].

However, this surface of the geoid has a rather complex shape. It is clear that a complex surface cannot serve as a coordinate surface for finding the relative position of geodetic points. The *novelty* of this topic is that in mathematical processing of astronomical and geodetic measurements, the surface of the geoid is usually replaced by a known and simpler surface of relativity, namely: the surface of an ellipsoid that has the appropriate size and position in the Earth's body. Such an ellipsoid of rotation is called a reference ellipsoid. The dimensions of the reference ellipsoid and its position or orientation in the Earth's body must be set so that its surface is more or less close to the surface of the geoid [4].

The dimensions of the reference ellipsoid are characterized, as a rule, by its magnitude and polar compression, and its position in the Earth's body is mainly determined by the components of the deviation of the heavy in the plane of the meridian and the first vertical from the normal to its surface is taken as the starting (initial) point of geodetic measurements. The direction of the line is difficult at the starting point relative to the main coordinate planes (ie the planes of the Earth's equator and the prime meridian) is established by astronomical determinations of its latitude and longitude. By correcting the astronomical latitude and longitude of the starting point for the deviation of the line from normal to the surface of the reference ellipsoid at the same point determine its geodetic latitude and longitude, which together with the height of the geoid at this starting point serve as so-called geodetic reference dates for processing geodetic measurements on the surface of the received reference ellipsoid [1; 3; 4].

Since such orientation of the ellipsoid requires knowledge of astronomical observations, and the elements of orientation depend on the

choice of starting point on the Earth's surface (location, for example, in Ukraine is not yet definitively determined), this paper focuses on finding so-called elements of internal orientation, by means of which, according to the appropriate communication formulas, it is always possible to proceed to the above-described elements of external orientation at the starting point with any coordinates [3; 4].

From the theoretical point of view for processing of geodetic measurements and definition on these data of position of geodetic points it is possible to accept any reference ellipsoid which in one way or another characterizes a figure of the Earth. Knowing the deviation of the geoid from the accepted ellipsoid, it is always possible to determine quite accurately the corrections that must be made in the results of geodetic measurements to bring the latter to the surface of this ellipsoid.

However, if the deviations of the geoid are significant enough, then due to errors in the obtained dimensions and orientation of the received reference ellipsoid, the corresponding reductions in geodetic measurements will also be significant. In this case, the results of geodetic measurements, especially linear elements of triangulation, after bringing them to the surface of the reference ellipsoid will be very different from their values obtained on the surface of the geoid. In addition, from the point of view of their practical use, it is necessary that they do not undergo major changes and distortions. Therefore, for the processing of geodetic measurements it is necessary to use such a reference ellipsoid, which in size and orientation would be closest to the figure of the geoid in a particular region under study [2].

Thus, the main requirement for mathematical elaboration of triangulation networks, as well as for all geodetic measurements performed on the Earth's surface, is the establishment of such a reference ellipsoid, the surface of which best fits or is close to the surface of the geoid, which is relevant to scientific research.

Based on the above, the purpose of our research is to conduct a priori calculations of the parameters of the regional ellipsoid for the territory of Ukraine and to assess the effectiveness of such a reference system in solving some practical and scientific problems of geodesy.

To achieve this goal in this scientific work the following tasks are set and solved:

– Determination of linear elements of orientation of the ellipsoid $\varnothing x$, $\varnothing \eta$, $\varnothing \zeta$.

– Calculation of parameters of the reference ellipsoid $\varnothing x$, $\varnothing \eta$, $\varnothing \zeta$, $\varnothing a$.

– Finding the values of the regional ellipsoid $\varnothing x$, $\varnothing \eta$.

– Calculation of unknown parameters of the reference ellipsoid $\varnothing x$ and $\varnothing a$.

– Finding the values of the regional ellipsoid $\varnothing y$ and $\varnothing a$.

– Determination of ellipsoid parameters $\varnothing z$, $\varnothing \alpha$.

2. Derivation of parametric equations

Consider the results of the measured values, the true values of which are equal to $X_i \left(i = \overline{1,n}\right)$. Assume that their measured values $x_i \left(i = \overline{1,n}\right)$ are obtained with weights $p_i \left(i = \overline{1,n}\right)$, and among them are k necessary and r redundant. Choose k independent parameters (as parameters you can take the required measured or unmeasured values), the true values of which are denoted by $T_j \left(j = \overline{1,k}\right)$. The true values of the measured values X_i $\left(i = \overline{1,n}\right)$ are functionally given through the true values of the parameters $T_j \left(j = \overline{1,k}\right)$ in the form

$$X_i = f_i\left(T_1, T_2, \ldots, T_k\right),\ i = \overline{1,n}.$$

Consider the balanced values $t_j \left(j = \overline{1,k}\right)$ of unknown parameters $T_j \left(j = \overline{1,k}\right)$, the right and left parts of which are written for balanced values $x_i + v_i \left(i = \overline{1,n}\right)$ for both quantities $X_i \left(i = \overline{1,n}\right)$ and balanced values $t_j \left(j = \overline{1,k}\right)$ of parameters $T_j \left(j = \overline{1,k}\right)$

$$x_i + v_i = f_i\left(t_1, t_2, \ldots, t_k\right) \quad \left(i = \overline{1,n}\right),$$

where we get the parametric equations of corrections

$$v_i = f_i\left(t_1, t_2, \ldots, t_k\right) - x_i,\ i = \overline{1,n}.$$

For this case, the condition of least squares is written in the form

$$F = \sum_{i=1}^{n} p_i \left[f_i\left(t_1, t_2, \ldots, t_k\right) - x_i\right]^2 = \left[p \cdot \left(f - x\right)^2\right] = \left[p \cdot v^2\right] \to \min.$$

A function F is a function of parameters $t_j \left(j = \overline{1,k}\right)$, and in order to find the minimum of a function F, it is necessary to have its partial derivatives of the first order by arguments $t_j \left(j = \overline{1,k}\right)$. We differentiate the function F by variables $t_j \left(j = \overline{1,k}\right)$ and equate the obtained relations to zero (a necessary condition for the extremum of the function). As a result, we obtain a system of k equations with k unknowns $t_j \left(j = \overline{1,k}\right)$

$$\frac{\partial F}{\partial t_j} = 2\sum_{i=1}^{n} p_i v_i \frac{\partial v_i}{\partial t_j} = \left[pv \frac{\partial v}{\partial t} \right] = 0, \ j = \overline{1,k}.$$

This system of equations is called a system of normal equations in general. Solving it, we obtain balanced values of the parameters $t_j \left(j = \overline{1,k} \right)$.

However, in the general case, the system of parametric equations of corrections is nonlinear and it is difficult to obtain its solution. Therefore, the above system of nonlinear equations should be linearized. To do this, you need to somehow find the approximate values $t_j^{\circ} \left(j = \overline{1,k} \right)$ of the parameters $t_j \left(j = \overline{1,k} \right)$ and give the balanced values as follows:

$$t_j = t_j^{\circ} + \tau_j \left(j = \overline{1,k} \right),$$

where $\tau_j \left(j = \overline{1,k} \right)$ are corrections to approximate values $t_j^{\circ} \left(j = \overline{1,k} \right)$ of parameters $t_j \left(j = \overline{1,k} \right)$.

The approximate values $t_j^{\circ} \left(j = \overline{1,k} \right)$ are determined as accurately as possible so that the corrections $\tau_j \left(j = \overline{1,k} \right)$ are small enough.

Therefore, we rewrite the system of parametric equations in the form

$$v_i = f_i \left(t_1^{\circ} + \tau_1, t_2^{\circ} + \tau_2, \ldots, t_k^{\circ} + \tau_k, \right) - x_i, \ i = \overline{1,n}.$$

Assume that the functions $f_i \left(i = \overline{1,n} \right)$ are such that they can be decomposed into a Taylor series around a point $\left(t_1^{\circ}, t_2^{\circ}, \ldots, t_k^{\circ} \right)$. Since the amendments $\tau_j \left(j = \overline{1,k} \right)$ are small, we will obtain only the linear members of the schedule

$$v_i = f_i \left(t_1^{\circ}, t_2^{\circ}, \ldots, t_k^{\circ} \right) + \sum_{j=1}^{k} \left(\frac{\partial f_i}{\partial t_j} \right)_0 \cdot \tau_j - x_i \quad \left(i = \overline{1,n} \right).$$

or by entering a notation

$$\left(\frac{\partial f_i}{\partial t_1} \right)_0 = a_i, \ \left(\frac{\partial f_i}{\partial t_2} \right)_0 = b_i, \ldots \ \left(\frac{\partial f_i}{\partial t_k} \right)_0 = u_i, \ f_i \left(t_1^{\circ}, t_2^{\circ}, \ldots, t_k^{\circ} \right) - x_i = l_i, \ (i = \overline{1,n}),$$

we obtain a system of parametric equations in linear form

$$v_i = a_i \tau_1 + b_i \tau_2 + \ldots + u_i \tau_k + l_i, \ i = \overline{1,n}.$$

Corrections v_i to the measured values $x_i \left(i = \overline{1,n} \right)$ and corrections τ_j to the approximate values of the parameters $t_j^{\circ} \left(j = \overline{1,k} \right)$ are unknown in these equations. Therefore, the given system of parametric equations of corrections is uncertain, because the number of unknowns is equal to $n + k$, and the number of equations is equal to n.

To solve the system of parametric equations in linear form, we use the method of least squares. That is

$$\left[pv^2\right] = \sum_{i=1}^{n} p_i \left(a_i\tau_1 + b_i\tau_2 + \ldots + u_i\tau_k + l_i\right)^2 = F\left(\tau_1, \tau_2, \ldots \tau_k\right) \to \min .$$

To find the minimum of the function F, we find its partial derivatives over the variables $\tau_j \left(j = \overline{1,k}\right)$ and equate them to zero. As a result, we obtain a normal system of k linear equations with k unknowns $\tau_j \left(j = \overline{1,k}\right)$

$$\begin{cases} \left[pa^2\right]\tau_1 + \left[pab\right]\tau_2 + \ldots + \left[pau\right]\tau_k + \left[pal\right] = 0 \\ \left[pab\right]\tau_1 + \left[pb^2\right]\tau_2 + \ldots + \left[pbu\right]\tau_k + \left[pbl\right] = 0 \\ \vdots \\ \left[pau\right]\tau_1 + \left[pbu\right]\tau_2 + \ldots + \left[pu^2\right]\tau_k + \left[pul\right] = 0. \end{cases}$$

For isosceles measurements, the normal system of linear algebraic equations is written as follows

$$\begin{cases} \left[a^2\right]\tau_1 + \left[ab\right]\tau_2 + \ldots + \left[au\right]\tau_k + \left[al\right] = 0 \\ \left[ab\right]\tau_1 + \left[b^2\right]\tau_2 + \ldots + \left[bu\right]\tau_k + \left[bl\right] = 0 \\ \vdots \\ \left[au\right]\tau_1 + \left[bu\right]\tau_2 + \ldots + \left[u^2\right]\tau_k + \left[ul\right] = 0. \end{cases}$$

Consider a system of parametric equations of corrections in matrix form. We introduce a matrix A of coefficients of this dimension system $n \times k$

$$A = \begin{pmatrix} a_1 b_1 \ldots u_1 \\ a_2 b_2 \ldots u_2 \\ \vdots \\ a_n b_n \ldots u_n \end{pmatrix},$$

matrix-column τ of the dimension $k \times 1$ of unknown corrections τ_i, called the vector of corrections to the approximate values of the parameters $t_i \left(i = \overline{1,k}\right)$

$$\tau = \begin{pmatrix} \tau_1 \\ \tau_2 \\ \vdots \\ \tau_k \end{pmatrix},$$

matrix-column L of the dimension $n\times 1$ of free members $l_i\left(i=\overline{1,n}\right)$ or vector of free members of the system

$$L=\begin{pmatrix} l_1 \\ l_2 \\ \vdots \\ l_n \end{pmatrix},$$

and a matrix-column V of the dimension $n\times 1$ or vector of corrections $v_i\left(i=\overline{1,n}\right)$ to the measurement results

$$V=\begin{pmatrix} v_1 \\ v_2 \\ \vdots \\ v_n \end{pmatrix}.$$

As a result, the system of parametric equations of corrections in matrix form can be written as follows

$$A\cdot\tau+L=V\,.$$

The condition $\left[pv^2\right]\to\min$ will look like

$$V^TPV\to\min\,.$$

where V^T is transposed matrix-column V of corrections to the measurement results;

$$P=\begin{pmatrix} p_1 & 0 & \cdots & 0 \\ 0 & p_2 & \cdots & 0 \\ \cdots & \cdots & \cdots & \cdots \\ 0 & 0 & \cdots & p_n \end{pmatrix}$$ is diagonal matrix of weights.

The function F will then take the form

$$F=\left(A\tau+L\right)^T\cdot P\cdot\left(A\tau+L\right),$$

and the required minimum condition for the function F is written as follows

$$A^TPV=0\,.$$

As a result, we obtain the matrix normal equation

$$A^TPV=A^TP\cdot(A\tau+L)=A^TPA\tau+A^TPL=0.$$

We show that it is equivalent to the normal system of linear algebraic equations. To do this, we describe the terms that are included in the matrix normal equation

$$A^T PA\tau = \begin{pmatrix} a_1 a_2 \dots a_n \\ b_1 b_2 \dots b_n \\ \vdots \\ u_1 u_2 \dots u_n \end{pmatrix} \cdot \begin{pmatrix} p_1 0 \dots 0 \\ 0\ p_2 \dots 0 \\ \vdots \\ 0\,0 \dots p_n \end{pmatrix} \cdot \begin{pmatrix} a_1 b_1 \dots u_1 \\ a_2 b_2 \dots u_2 \\ \vdots \\ a_n b_n \dots u_n \end{pmatrix} \cdot \begin{pmatrix} \tau_1 \\ \tau_2 \\ \vdots \\ \tau_k \end{pmatrix} =$$

$$= \begin{pmatrix} a_1 p_1\ a_2 p_2 \dots a_n p_n \\ b_1 p_1\ b_2 p_2 \dots b_n p_n \\ \vdots \\ u_1 p_1\ u_2 p_2 \dots u_n p_n \end{pmatrix} \cdot \begin{pmatrix} a_1 b_1 \dots u_1 \\ a_2 b_2 \dots u_2 \\ \vdots \\ a_n b_n \dots u_n \end{pmatrix} \cdot \begin{pmatrix} \tau_1 \\ \tau_2 \\ \vdots \\ \tau_k \end{pmatrix} =$$

$$= \begin{pmatrix} [a^2 p] & [abp] & \dots & [aup] \\ [abp] & [b^2 p] & \dots & [bup] \\ \vdots & & & \\ [aup] & [bup] & \dots & [u^2 p] \end{pmatrix} \cdot \begin{pmatrix} \tau_1 \\ \tau_2 \\ \vdots \\ \tau_k \end{pmatrix} = \begin{pmatrix} [a^2 p]\tau_1 + [abp]\tau_2 + \dots + [aup]\tau_k \\ [abp]\tau_1 + [b^2 p]\tau_2 + \dots + [bup]\tau_k \\ \vdots \\ [aup]\tau_1 + [bup]\tau_2 + \dots + [u^2 p]\tau_k \end{pmatrix}$$

$$A^T PL = \begin{pmatrix} a_1 p_1\ a_2 p_2 \dots a_n p_n \\ b_1 p_1\ b_2 p_2 \dots b_n p_n \\ \vdots \\ u_1 p_1\ u_2 p_2 \dots u_n p_n \end{pmatrix} \begin{pmatrix} l_1 \\ l_2 \\ \vdots \\ l_n \end{pmatrix} = \begin{pmatrix} [apl] \\ [bpl] \\ \vdots \\ [upl] \end{pmatrix};$$

$$A^T PA\tau + A^T PL = \begin{pmatrix} [a^2 p]\tau_1 + [abp]\tau_2 + \dots + [aup]\tau_k + [apl] \\ [abp]\tau_1 + [b^2 p]\tau_2 + \dots + [bup]\tau_k + [bpl] \\ \vdots \\ [aup]\tau_1 + [bup]\tau_2 + \dots + [u^2 p]\tau_k + [upl] \end{pmatrix}.$$

As can be seen from the obtained equality, its right-hand side is equivalent to the normal system of linear algebraic equations.

Now we turn to the problem of determining the parameters of the regional ellipsoid relative to the known accepted total terrestrial ellipsoid

GRS80 on the basis of our formulas of the parametric method of compatible balancing of measured quantities.

Under the definition of a regional ellipsoid here we understand the finding of its parameters: the major semi-axis a, the polar compression α and the rectangular coordinates of its center in the Earth's body: x_0, y_0, z_0. The relationship between these quantities can be represented as an abbreviated formula of the Molodensky transformation for geodetic height [4]

$$\Delta H = \Delta x \cos \bar{B} \cos \bar{L} + \Delta y \cos \bar{B} \sin \bar{L} + \Delta z \sin \bar{B} + \left(\bar{a}\Delta\alpha + \bar{\alpha}\Delta a\right)\sin^2 \bar{B} + \Delta a. \quad (1)$$

Formula (1), as it is easy to see, gives a connection not of the parameters themselves, but of some parameter shifts $\Delta a, \Delta\alpha, \Delta x, \Delta y, \Delta z$, ie corrections, which represent the differences between the parameters of some two ellipsoids. In this formula: $\varnothing H$ is the difference in geodetic heights of a point on the Earth's surface relative to each of the two ellipsoids. In practice, this value can be written as [2]

$$\Delta H = N - \bar{N}, \quad (2)$$

where N and $\bar{N}$ are the height of the geoid (quasi-geoid) relative to each of the ellipsoids.

So, to find the necessary parameters a, α, x_0, y_0, z_0 of some ellipsoid E, you need to have an ellipsoid $\bar{E}$ with known parameters $\bar{a}, \bar{\alpha}, \bar{x}_0, \bar{y}_0, \bar{z}_0$.

Then

$$\left.\begin{aligned} a &= \bar{a} + \Delta a; \\ \alpha &= \bar{\alpha} + \Delta\alpha; \\ x_0 &= \bar{x}_0 + \Delta x; \\ y_0 &= \bar{y}_0 + \Delta y; \\ z_0 &= \bar{z}_0 + \Delta z. \end{aligned}\right\} \quad (3)$$

In principle, you can use any known ellipsoid $\bar{E}\left(\bar{a}, \bar{\alpha}, \bar{x}_0, \bar{y}_0, \bar{z}_0\right)$. But, as we will see below, it is best to adopt a geocentric ellipsoid. Such an ellipsoid may be, for example, the well-known general terrestrial ellipsoid GRS80. Its parameters are as follows [7]

$$\left.\begin{aligned} \bar{a} &= 6378137\ m; \\ \bar{\alpha} &= 1/298.257222101; \\ \bar{x}_0 &= 0\ m; \\ \bar{y}_0 &= 0\ m; \\ \bar{z}_0 &= 0\ m. \end{aligned}\right\} \quad (4)$$

Then formulas (3) can be rewritten as

$$\left.\begin{aligned} a &= \bar{a} + \Delta a\,; \\ \alpha &= \bar{\alpha} + \Delta\alpha\,; \\ x_0 &= \Delta x\,; \\ y_0 &= \Delta y\,; \\ z_0 &= \Delta z\,. \end{aligned}\right\} \qquad (5)$$

It is easy to note that all values in formula (1) with a dash above must be known and assigned to the GRS80 system, and values without a dash will be unknown.

Therefore, the task of determining the regional ellipsoid is practically reduced to finding some corrections $\Delta a, \Delta\alpha, \Delta x, \Delta y, \Delta z$ to the known, accepted by us, the general terrestrial ellipsoid GRS80.

The regional ellipsoid for the territory of Ukraine should be the one that would best represent the geoid (quasi-geoid) of the region. That is, the heights of geoid N relative to the regional ellipsoid within the territory of Ukraine should be as small as possible. Given this basic requirement, we will perform a priori research to determine the regional ellipsoid for Ukraine.

Since we need to identify five unknown amendments $\Delta a, \Delta\alpha, \Delta x, \Delta y, \Delta z$, we need to have at least five points within the territory of Ukraine with known geodetic coordinates $\bar{B}, \bar{L}, \bar{H}$.

For the planned coordinates $\bar{B}$ and $\bar{L}$ take the approximate geodetic coordinates of the vertices of the spheroidal trapezoid *ABCD* and its center *O*, in which (trapezoid) fits the territory of Ukraine.

That is

$$\left.\begin{aligned} A\begin{Bmatrix} B_A = 52.5^0 \\ L_A = 21.6^0 \end{Bmatrix} \qquad & B\begin{Bmatrix} B_B = 52.5^0 \\ L_B = 40.0^0 \end{Bmatrix} \\ O\begin{Bmatrix} B_O = 48.3^0 \\ L_O = 30.8^0 \end{Bmatrix} & \\ D\begin{Bmatrix} B_D = 44.1^0 \\ L_D = 21.6^0 \end{Bmatrix} \qquad & C\begin{Bmatrix} B_C = 44.1^0 \\ L_C = 40.0^0 \end{Bmatrix} \end{aligned}\right\} \qquad (6)$$

Note that although the geodetic coordinates of points *A, B, C, D, O* are given in the system of the Krasovsky reference ellipsoid, they are approximate, so they can be considered as known in the GRS80 system.

The heights of the geoid $\bar{N}$ of the corresponding five points of the geoid can be taken, for example, from the decomposition of the potential of gravity into a number of spherical functions. The known model GEMT1 (with $n = m = 36$) gives us the following values $\bar{N}$ [9]

$$\left.\begin{array}{ll} \bar{N}_A = 30.7\ m & \bar{N}_B = 9.8\ m \\ \bar{N}_O = 25.9\ m & \\ \bar{N}_D = 43.7\ m & \bar{N}_C = 16.5\ m \end{array}\right\} \tag{7}$$

Having the necessary initial data and using Molodensky's formula (1), in which the unknown corrections $\Delta a, \Delta\alpha, \Delta x, \Delta y, \Delta z$ are presented in linear form, we write the following parametric equations for the described five points (*A, B, C, D, O*)

$$\left.\begin{array}{l} a_A\Delta x + b_A\Delta y + c_A\Delta z + d_A\bar{a}\Delta\alpha + e_A\Delta a + l_A = v_A\ ; \\ a_B\Delta x + b_B\Delta y + c_B\Delta z + d_B\bar{a}\Delta\alpha + e_B\Delta a + l_B = v_B\ ; \\ a_C\Delta x + b_C\Delta y + c_C\Delta z + d_C\bar{a}\Delta\alpha + e_C\Delta a + l_C = v_C\ ; \\ a_D\Delta x + b_D\Delta y + c_D\Delta z + d_D\bar{a}\Delta\alpha + e_D\Delta a + l_D = v_D\ ; \\ a_O\Delta x + b_O\Delta y + c_O\Delta z + d_O\bar{a}\Delta\alpha + e_O\Delta a + l_O = v_O\ , \end{array}\right\} \tag{8}$$

where

$$\left.\begin{array}{l} a_A = \cos B_A \cos L_A;\ b_A = \cos B_A \sin L_A;\ c_A = \sin B_A;\ d_A = \sin^2 B_A;\ e_A = 1 - \bar{\alpha}\sin^2 B_A\ ; \\ a_B = \cos B_B \cos L_B;\ b_B = \cos B_B \sin L_B;\ c_B = \sin B_B;\ d_B = \sin^2 B_B;\ e_B = 1 - \bar{\alpha}\sin^2 B_B\ ; \\ a_C = \cos B_C \cos L_C;\ b_C = \cos B_C \sin L_C;\ c_C = \sin B_C;\ d_C = \sin^2 B_C\ ;\ e_C = 1 - \bar{\alpha}\sin^2 B_C\ ; \\ a_D = \cos B_D \cos L_D;\ b_D = \cos B_D \sin L_D;\ c_D = \sin B_D;\ d_D = \sin^2 B_D\ ;\ e_D = 1 - \bar{\alpha}\sin^2 B_D\ ; \\ a_O = \cos B_O \cos L_O;\ b_O = \cos B_O \sin L_O;\ c_O = \sin B_O;\ d_O = \sin^2 B_O\ ;\ e_O = 1 - \bar{\alpha}\sin^2 B_O \end{array}\right\} \tag{9a}$$

and

$$\left.\begin{array}{l} v_A = N_A\ ; \\ v_B = N_B\ ; \\ v_C = N_C\ ; \\ v_D = N_D\ ; \\ v_O = N_O\ . \end{array}\right\} \tag{9b}$$

The right-hand sides of equations (8), as can be seen, will play the role of unknown corrections. Since the system (8) of five equations has ten unknown quantities $(\Delta a, \Delta\alpha, \Delta x, \Delta y, \Delta z, v_A, v_B, v_C, v_D, v_O)$, we impose on it (the system) an additional condition of the least squares method

$$\sum v_i^2 \to \min, \qquad i = A, B, C, D, O, \tag{10}$$

to get a single solution.

Using formulas (9a), we first find the coefficients of the parametric equations of corrections (8). The results are recorded in Table 1.

Table 1

Calculation of coefficients of parametric equations of corrections

Points	Formula	Value	Formula	Value	Coefficient	Value
A	$\cos B_A$	0.608761	$\mathrm{COS}B_A\mathrm{COS}L_A$	0.5660113	aA	-0.5660113
	$\mathrm{COS}L_A$	0.929776	$\cos B_A \sin L_A$	0.2241001	bA	-0.2241001
	$\sin B_A$	0.793353	$\sin^2 B_A$	0.6294089	cA	-0.793353
	$\sin L_A$	0.368125			dA	0.6294089
					eA	-0.9978897
B	$\cos B_B$	0.608761	$\mathrm{COS}B_B\mathrm{COS}L_B$	0.4663377	aB	-0.4663377
	$\cos L_B$	0.766044	$\cos B_B \sin L_B$	0.3913042	bB	-0.3913042
	$\sin B_B$	0.793353	$\sin^2 B_B$	0.6294089	cB	-0.793353
	$\sin L_B$	0.642788			dB	0.6294089
					eB	-0.9978897
C	$\cos B_C$	0.718126	$\cos B_C \cos L_C$	0.5501161	aC	-0.5501161
	$\cos L_C$	0.766044	$\cos B_C \sin L_C$	0.4616027	bC	-0.4616027
	$\sin B_C$	0.695913	$\sin^2 B_C$	0.4842949	cC	-0.695913
	$\sin L_C$	0.642788			dC	0.4842949
					eC	-0.9983762
D	$\cos B_D$	0.718126	$\mathrm{COS}B_D\mathrm{COS}L_D$	0.6676963	aD	-0.6676963
	$\mathrm{COS}L_D$	0.929776	$\cos B_D \sin L_D$	0.2643601	bD	-0.2643601
	$\sin B_D$	0.695913	$\sin^2 B_D$	0.4842949	cD	-0.6959130
	$\sin L_D$	0.368125			dD	0.4842949
					eD	-0.9983762
O	$\cos B_O$	0.665230	$\cos B_O \cos L_O$	0.5714059	aO	-0.5714059
	$\mathrm{COS}L_O$	0.858960	$\cos B_O \sin L_O$	0.3406263	bO	-0.3406263
	$\sin B_O$	0.746638	$\sin^2 B_O$	0,5574683	cO	-0.746638
	$\sin L_O$	0.512043			dO	0.5574683
					eO	-0.9981309

The free terms of the parametric equations of corrections (8) according to formula (1) can then be written

$$\left.\begin{aligned} l_A &= \bar{N}_A ; \\ l_B &= \bar{N}_B ; \\ l_C &= \bar{N}_C ; \\ l_D &= \bar{N}_D ; \\ l_O &= \bar{N}_O . \end{aligned}\right\} \tag{11}$$

Substituting instead of the heights of the geoid $\bar{N}_A, \bar{N}_B, \bar{N}_C, \bar{N}_D, \bar{N}_O$ their values from expression (7), we obtain

$$\left.\begin{aligned} l_A &= 30.7\ m ; \\ l_B &= 9.8\ m ; \\ l_C &= 16.5\ m ; \\ l_D &= 43.7\ m ; \\ l_O &= 25.9\ m . \end{aligned}\right\} \tag{12}$$

Therefore, taking the values of the coefficients from Table 1 and the values of the free terms from expression (12), we solve the system of parametric equations of corrections (8) under the condition of least squares (10). Then we obtain the following required parameters and their root mean square errors

$$\left.\begin{aligned} \Delta x &= -5 \pm 28\ m ; \\ \Delta y &= -136 \pm 17\ m ; \\ \Delta z &= 982 \pm 549\ m ; \\ \bar{a}\Delta\alpha &= 783 \pm 393\ m ; \\ \Delta a &= -222 \pm 170\ m . \end{aligned}\right\} \tag{13}$$

The obtained a priori values of the parameters of the regional ellipsoid and their errors indicate a strong dependence (correlation) between the unknown values. To find out which values are most correlated with each other, you need to perform some additional research to calculate the required parameters. Consider a few partial cases.

3. Determination of parameters $\varnothing x$, $\varnothing y$, $\varnothing z$

Case 1. Assume that the parameters $\varnothing a$ and $\Delta\alpha$ are known. Then we will look for only linear elements of orientation $\varnothing x$, $\varnothing y$, $\varnothing z$ of the regional ellipsoid.

That is, the parametric equations will look like

$$\left.\begin{aligned} a_A\Delta x + b_A\Delta y + c_A\Delta z + l_A^I = v_A\ ;\\ a_B\Delta x + b_B\Delta y + c_B\Delta z + l_B^I = v_B\ ;\\ a_C\Delta x + b_C\Delta y + c_C\Delta z + l_C^I = v_C\ ;\\ a_D\Delta x + b_D\Delta y + c_D\Delta z + l_D^I = v_D\ ;\\ a_O\Delta x + b_O\Delta y + c_O\Delta z + l_O^I = v_O\ , \end{aligned}\right\} \qquad (14)$$

and free members will be recorded as follows

$$\left.\begin{aligned} l_A^I = \left(\bar{a}\Delta\alpha + \bar{\alpha}\Delta a\right)\sin^2 B_A + \Delta a + \bar{N}_A\ ;\\ l_B^I = \left(\bar{a}\Delta\alpha + \bar{\alpha}\Delta a\right)\sin^2 B_B + \Delta a + \bar{N}_B\ ;\\ l_C^I = \left(\bar{a}\Delta\alpha + \bar{\alpha}\Delta a\right)\sin^2 B_C + \Delta a + \bar{N}_C\ ;\\ l_D^I = \left(\bar{a}\Delta\alpha + \bar{\alpha}\Delta a\right)\sin^2 B_D + \Delta a + \bar{N}_D\ ;\\ l_O^I = \left(\bar{a}\Delta\alpha + \bar{\alpha}\Delta a\right)\sin^2 B_O + \Delta a + \bar{N}_O\ . \end{aligned}\right\} \qquad (15)$$

The corresponding coefficients of the system (14) are selected from Table 1. To calculate the free terms (15) you need to enter some numerical values for corrections $\varnothing a$, $\Delta\alpha$.

Regarding the choice of these amendments, the following should be noted. The European Regional Geodetic System European 1950, which is used by 16 countries located in Europe, is well known to all. As Ukraine is a European state, it is quite logical to use the parameters of the European 1950 system. Therefore, the main parameters here and in our future research will be the shift of the parameters of the regional geodetic system European 1950 in the national system GRS80 [7]

$$\left.\begin{aligned} \Delta a = 251\ m\ ;\\ \Delta\alpha = 0.14192702\times10^{-4}\ ;\\ \Delta x = -87\ m\ ;\\ \Delta y = -98\ m\ ;\\ \Delta z = -121\ m\ . \end{aligned}\right\} \qquad (16)$$

Therefore, taking the values $\varnothing a$ and $\Delta\alpha$ from expression (16), we calculate by formula (15) the values of free members. That is

$$\left.\begin{aligned} l_A^I &= -162.8\ m; \\ l_B^I &= -183.7\ m; \\ l_C^I &= -190.3\ m; \\ l_D^I &= -163.1\ m; \\ l_O^I &= -174.2\ m. \end{aligned}\right\} \tag{17}$$

Then, having the corresponding values of the coefficients from Table 1 and the free terms from expression (17), we solve the system of parametric equations (14) under the condition of least squares (10). Unknown values and their root mean square errors will take the following values

$$\left.\begin{aligned} \Delta x &= -58 \pm 9\ m; \\ \Delta y &= -167 \pm 8\ m; \\ \Delta z &= -115 \pm 8\ m. \end{aligned}\right\} \tag{18}$$

Let us now consider the following case.

4. Determination of parameters $\varnothing x$, $\varnothing y$, $\varnothing z$, $\varnothing a$

Case 2. Let us know only the value $\Delta\alpha$. You need to find the parameters $\varnothing x$, $\varnothing y$, $\varnothing z$, $\varnothing a$. Parametric equations in this case will take the form

$$\left.\begin{aligned} a_A\Delta x + b_A\Delta y + c_A\Delta z + e_A\Delta a + l_A^{II} &= v_A; \\ a_B\Delta x + b_B\Delta y + c_B\Delta z + e_B\Delta a + l_B^{II} &= v_B; \\ a_C\Delta x + b_C\Delta y + c_C\Delta z + e_C\Delta a + l_C^{II} &= v_C; \\ a_D\Delta x + b_D\Delta y + c_D\Delta z + e_D\Delta a + l_D^{II} &= v_D; \\ a_O\Delta x + b_O\Delta y + c_O\Delta z + e_O\Delta a + l_O^{II} &= v_O, \end{aligned}\right\} \tag{19}$$

and free members are equal

$$\left.\begin{aligned} l_A^{II} &= \bar{a}\sin^2 B_A\Delta\alpha + \bar{N}_A; \\ l_B^{II} &= \bar{a}\sin^2 B_B\Delta\alpha + \bar{N}_B; \\ l_C^{II} &= \bar{a}\sin^2 B_C\Delta\alpha + \bar{N}_C; \\ l_D^{II} &= \bar{a}\sin^2 B_D\Delta\alpha + \bar{N}_D; \\ l_O^{II} &= \bar{a}\sin^2 B_O\Delta\alpha + \bar{N}_O. \end{aligned}\right\} \tag{20}$$

Then the coefficients of the system (19) can be taken from Table 1. And the free terms (20), if we take the value from expression (16), after simple calculations will have values

$$\left.\begin{aligned} l_A^{II} &= 87.7\ m; \\ l_B^{II} &= 66.8\ m; \\ l_C^{II} &= 60.3\ m; \\ l_D^{II} &= 87.5\ m; \\ l_O^{II} &= 76.4\ m. \end{aligned}\right\} \tag{21}$$

Thus, taking into account the corresponding values from Table 1 and from expression (21), we solve the system of parametric equations (19) under condition (10). Then we will get

$$\left.\begin{aligned} \Delta x &= 110 \pm 89\ m; \\ \Delta y &= -67 \pm 53\ m; \\ \Delta z &= 101 \pm 115\ m; \\ \Delta a &= -39 \pm 154\ m. \end{aligned}\right\} \tag{22}$$

5. Determination of parameters $\varnothing x$, $\varnothing \phi$

Case 3. Let the quantities $\Delta a, \Delta\alpha, \Delta z$ be known. You need to find the values $\varnothing x$, $\varnothing \phi$. Parametric equations of corrections will then be written as

$$\left.\begin{aligned} a_A \Delta x + b_A \Delta y + l_A^{III} &= v_A; \\ a_B \Delta x + b_B \Delta y + l_B^{III} &= v_B; \\ a_C \Delta x + b_C \Delta y + l_C^{III} &= v_C; \\ a_D \Delta x + b_D \Delta y + l_D^{III} &= v_D; \\ a_O \Delta x + b_O \Delta y + l_O^{III} &= v_O. \end{aligned}\right\} \tag{23}$$

The coefficients in equations (23), as in the previous cases, can be selected from Table 1.

Free members of the system (23), as you can see, will take the form

$$\left.\begin{aligned} l_A^{III} &= \sin B_A \Delta z + \left(\bar{a}\Delta\alpha + \bar{\alpha}\Delta a\right)\sin^2 B_A + \Delta a + \bar{N}_A ; \\ l_B^{III} &= \sin B_B \Delta z + \left(\bar{a}\Delta\alpha + \bar{\alpha}\Delta a\right)\sin^2 B_B + \Delta a + \bar{N}_B ; \\ l_C^{III} &= \sin B_C \Delta z + \left(\bar{a}\Delta\alpha + \bar{\alpha}\Delta a\right)\sin^2 B_C + \Delta a + \bar{N}_C ; \\ l_D^{III} &= \sin B_D \Delta z + \left(\bar{a}\Delta\alpha + \bar{\alpha}\Delta a\right)\sin^2 B_D + \Delta a + \bar{N}_D ; \\ l_O^{III} &= \sin B_O \Delta z + \left(\bar{a}\Delta\alpha + \bar{\alpha}\Delta a\right)\sin^2 B_O + \Delta a + \bar{N}_O . \end{aligned}\right\} \quad (24)$$

If we take the values of $\bar{a}$ and $\bar{\alpha}$ from expression (4), and the values $\Delta a, \Delta\alpha, \Delta z$ of expression (16), then the free terms after simple calculations will be equal

$$\left.\begin{aligned} l_A^{III} &= -66.8\ m ; \\ l_B^{III} &= -87.7\ m ; \\ l_C^{III} &= -106.0\ m ; \\ l_D^{III} &= -78.8\ m ; \\ l_O^{III} &= -83.8\ m . \end{aligned}\right\} \quad (25)$$

Then, solving the parametric equations (23) under condition (10), we obtain

$$\left.\begin{aligned} \Delta x &= -52 \pm 4\ m ; \\ \Delta y &= -164 \pm 6\ m . \end{aligned}\right\} \quad (26)$$

6. Determination of parameters $\varnothing x$, $\varnothing a$

Case 4. Let us be given the values of $\varnothing y$, $\varnothing\beta$ and $\Delta\alpha$. It is necessary to find the values of $\varnothing x$ and $\varnothing a$. Then the parametric equations (8) will look like this

$$\left.\begin{aligned} a_A \Delta x + e_A \Delta a + l_A^{IV} &= v_A ; \\ a_B \Delta x + e_B \Delta a + l_B^{IV} &= v_B ; \\ a_C \Delta x + e_C \Delta a + l_C^{IV} &= v_C ; \\ a_D \Delta x + e_D \Delta a + l_D^{IV} &= v_D ; \\ a_O \Delta x + e_O \Delta a + l_O^{IV} &= v_O , \end{aligned}\right\} \quad (27)$$

where

$$\left.\begin{aligned} l_A^{IV} &= \cos B_A \sin L_A \Delta y + \sin B_A \Delta z + \bar{a} \sin^2 B_A \Delta\alpha + \bar{N}_A ; \\ l_B^{IV} &= \cos B_B \sin L_B \Delta y + \sin B_B \Delta z + \bar{a} \sin^2 B_B \Delta\alpha + \bar{N}_B ; \\ l_C^{IV} &= \cos B_C \sin L_C \Delta y + \sin B_C \Delta z + \bar{a} \sin^2 B_C \Delta\alpha + \bar{N}_C ; \\ l_D^{IV} &= \cos B_D \sin L_D \Delta y + \sin B_D \Delta z + \bar{a} \sin^2 B_D \Delta\alpha + \bar{N}_D ; \\ l_O^{IV} &= \cos B_O \sin L_O \Delta y + \sin B_O \Delta z + \bar{a} \sin^2 B_O \Delta\alpha + \bar{N}_O . \end{aligned}\right\} \quad (28)$$

Substituting in formula (28) the values of the corresponding values from expressions (4), (6), (7) and (16), we obtain

$$\left.\begin{aligned} l_A^{IV} &= 205.6\ m ; \\ l_B^{IV} &= 201.1\ m ; \\ l_C^{IV} &= 189.8\ m ; \\ l_D^{IV} &= 197.7\ m ; \\ l_O^{IV} &= 200.1\ m . \end{aligned}\right\} \quad (29)$$

Taking the coefficients from Table 1 and the free terms from expression (29), we solve the system of parametric equations of corrections (27) under the condition of least squares (10). Then we will get

$$\left.\begin{aligned} \Delta x &= -10 \pm 47\ m ; \\ \Delta a &= 205 \pm 27\ m . \end{aligned}\right\} \quad (30)$$

Consider the following case.

7. Determination of parameters $\varnothing y$, $\varnothing a$

Case 5. Suppose we know the values of $\varnothing x$, $\varnothing$ and $\Delta\alpha$. Using the system of equations (8), we find the quantities $\varnothing y$ and $\varnothing a$. In this case, the parametric equations of corrections will take the form

$$\left.\begin{aligned} b_A \Delta y + e_A \Delta a + l_A^V &= v_A ; \\ b_B \Delta y + e_B \Delta a + l_B^V &= v_B ; \\ b_C \Delta y + e_C \Delta a + l_C^V &= v_C ; \\ b_D \Delta y + e_D \Delta a + l_D^V &= v_D ; \\ b_O \Delta y + e_O \Delta a + l_O^V &= v_O , \end{aligned}\right\} \quad (31)$$

and the free members of the system of equations (31) are written as

$$\left.\begin{aligned} l_A^V &= \cos B_A \cos L_A \Delta x + \sin B_A \Delta z + \bar{a} \sin^2 B_A \Delta\alpha + \bar{N}_A ; \\ l_B^V &= \cos B_B \cos L_B \Delta x + \sin B_B \Delta z + \bar{a} \sin^2 B_B \Delta\alpha + \bar{N}_B ; \\ l_C^V &= \cos B_C \cos L_C \Delta x + \sin B_C \Delta z + \bar{a} \sin^2 B_C \Delta\alpha + \bar{N}_C ; \\ l_D^V &= \cos B_D \cos L_D \Delta x + \sin B_D \Delta z + \bar{a} \sin^2 B_D \Delta\alpha + \bar{N}_D ; \\ l_O^V &= \cos B_O \cos L_O \Delta x + \sin B_O \Delta z + \bar{a} \sin^2 B_O \Delta\alpha + \bar{N}_O . \end{aligned}\right\} \quad (32)$$

Taking the values $\varnothing x$, $\varnothing$ and $\Delta\alpha$ from expression (16), we will have

$$\left.\begin{aligned} l_A^V &= 232.9\ m ; \\ l_B^V &= 203.3\ m ; \\ l_C^V &= 192.4\ m ; \\ l_D^V &= 229.8\ m ; \\ l_O^V &= 216.4\ m . \end{aligned}\right\} \quad (33)$$

Taking into account the coefficients from Table 1 and the free terms from expression (33), we solve the system of equations (31) under the condition of least squares (10). Then we will get

$$\left.\begin{aligned} \Delta y &= -179 \pm 12\ m ; \\ \Delta a &= 276 \pm 4\ m . \end{aligned}\right\} \quad (34)$$

Consider the latter case.

8. Determination of parameters $\varnothing z$, $\varnothing a$

Case 6. Let the quantities $\Delta x, \Delta y, \Delta\alpha$ be known. It is necessary to calculate the values $\varnothing z$, $\varnothing a$. Parametric equations of corrections will then be written

$$\left.\begin{aligned} c_A \Delta z + e_A \Delta a + l_A^{VI} &= v_A ; \\ c_B \Delta z + e_B \Delta a + l_B^{VI} &= v_B ; \\ c_C \Delta z + e_C \Delta a + l_C^{VI} &= v_C ; \\ c_D \Delta z + e_D \Delta a + l_D^{VI} &= v_D ; \\ c_O \Delta z + e_O \Delta a + l_O^{VI} &= v_O , \end{aligned}\right\} \quad (35)$$

where

$$\left.\begin{aligned} l_A^{VI} &= \cos B_A \cos L_A \Delta x + \cos B_A \sin L_A \Delta y + \bar{a} \sin^2 B_A \Delta\alpha + \bar{N}_A ; \\ l_B^{VI} &= \cos B_B \cos L_B \Delta x + \cos B_B \sin L_B \Delta y + \bar{a} \sin^2 B_B \Delta\alpha + \bar{N}_B ; \\ l_C^{VI} &= \cos B_C \cos L_C \Delta x + \cos B_C \sin L_C \Delta y + \bar{a} \sin^2 B_C \Delta\alpha + \bar{N}_C ; \\ l_D^{VI} &= \cos B_D \cos L_D \Delta x + \cos B_D \sin L_D \Delta y + \bar{a} \sin^2 B_D \Delta\alpha + \bar{N}_D ; \\ l_O^{VI} &= \cos B_O \cos L_O \Delta x + \cos B_O \sin L_O \Delta y + \bar{a} \sin^2 B_O \Delta\alpha + \bar{N}_O . \end{aligned}\right\} \quad (36)$$

Assuming the values $\varnothing x$, $\varnothing y$ and $\Delta\alpha$ from expression (16), the free terms will accept the following results

$$\left.\begin{aligned} l_A^{VI} &= 158.9\ m ; \\ l_B^{VI} &= 145.7\ m ; \\ l_C^{VI} &= 153.4\ m ; \\ l_D^{VI} &= 171.5\ m ; \\ l_O^{VI} &= 159.5\ m . \end{aligned}\right\} \quad (37)$$

Taking into account the values of the corresponding coefficients from Table 1 and the free terms from expression (37), we solve the system of parametric equations (35) under the least squares method (10). Then we will have

$$\left.\begin{aligned} \Delta z &= -103 \pm 94\ m ; \\ \Delta a &= 235 \pm 70\ m . \end{aligned}\right\} \quad (38)$$

9. Conclusions

Thus, based on the results of the above a priori studies, the following can be noted.

The determination of all five parameters of the regional ellipsoid (or rather, their corrections $\Delta a, \Delta\alpha, \Delta x, \Delta y, \Delta z$), shown in the form of results (13), is due to the strong functional dependence of the parameters. This dependence (correlation) is quite well demonstrated on the values of root mean square errors, which are proportional to the obtained parameters and even exceed the latter. Moreover, according to the results (22), (30), (34) and (38), the greatest correlation occurs between the following values: a) $\varnothing a$ and $\varnothing x$; b) $\varnothing a$ and $\varnothing y$; c) $\varnothing a$ and $\varnothing z$.

Taking into account these remarks, we can conclude that the joint finding of all five parameters by the method of least squares on the territory of

Ukraine does not give us the expected good results. This is clearly seen from the a priori calculations (13) according to the geoid heights, presented in the form of a spheroidal trapezoid, which describes the territory of Ukraine. In contrast to this solution, studies to determine only three parameters $\varnothing x$, $\varnothing y$, $\varnothing$ for the given $\varnothing a$ and $\Delta\alpha$ demonstrated by the results (18), make it possible to choose a regional ellipsoid that would best represent a geoid (quasi-geoid) built on the territory of Ukraine.

Thus, we have two different tasks: a) joint determination of the parameters of the regional ellipsoid $\Delta a, \Delta\alpha, \Delta x, \Delta y, \Delta z$; b) determination of the parameters of the displacement of the regional ellipsoid $\varnothing x$, $\varnothing y$, $\varnothing$, provided that the major half-axis of the ellipsoid $\varnothing a$ and the compression of the ellipsoid $\Delta\alpha$ are given. The solution of these problems showed us very different results, which were obtained according to the same data for the same territory. This leads us to the need for additional research to obtain correct solutions to the so-called unstable or ill-defined problems [6].

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MATHEMATICAL AND COMPUTER MODELING OF INTERPHASE INTERACTION IN HETEROGENEOUS SOLID STRUCTURES

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Abstract. *The aim* of this work was to develop a mathematical model and computer modelling of interphase interaction, mechanical stresses and adhesion mechanisms between mechanically inhomogeneous media (different phases). *Methodology*. For the system "metal – dielectric" we use a macroscopic approach, which corresponds to the ratio of non-equilibrium thermodynamics and physics of solid surfaces. Let's consider the system of equations and boundary conditions for describing the change of energy parameters (σ_h, γ), which characterize the thermodynamic state of the system of contacting bodies. Method for calculating the main energy parameters (interfacial energy – γ_m, interfacial tension – σ_m, work of adhesion – A_{ad} and energy of adhesive bonds – γ_{ad}) in complex solid-state structures containing boundary phases is proposed. Based on the basic equations of nonequilibrium thermodynamics and surface physics a mathematical model of the interphase boundary is designed. A comparative analysis of the features of interphase interaction in the systems "metal-metal", "metal-semiconductor" and "metal-dielectric" on the example of interacting systems "Cu – Zn", "Cu – Si" and "Cu – quartz". It is established that the most sensitive parameter in the analysis of interphase interactions is the interphase energy γ_m.

A model of mechanical stress formation in the "condensate-substrate" system is proposed. In particular, internal stresses in metal condensates are caused by changes in the value of interphase energy parameters (primarily interfacial tension) in the substrate-nanocondensate system and due to

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phase-forming processes accompanied by changes in surface energy in the condensate volume during its formation. The resulting internal stresses in metal condensates are an integral result of the action of statistically distributed on the plane of the film local stresses. Such phenomena are due to the anisotropy of the energy parameters of the interphase interaction in the condensate plane.

Behavior analysis of energy and adhesion parameters can be used to predict the results of interphase interaction in order to select contact pairs to create thermodynamically stable structures with predicted values of energy parameters of interphase interaction, a certain type of chemical bond and a given level of mechanical stresses.

1. Introduction

Modern functional materials are, as a rule, complex heterophasic systems with formed internal boundaries of the contact phase. In such systems, due to the physico-chemical, thermodynamic and mechanical incompatibility of the boundary phases, a complex interphase interaction occurs. Understanding the physical nature of such interaction opens the prospect of effective targeted change in the properties of materials and the creation of unique nanostructures.

These structures are also characterized by the evolution of phase formations in the process of formation, which is accompanied by a change in the surface energy of the system and, as a consequence, a change in its basic structurally sensitive parameters. Typical solid-state structures "semiconductor-metal", "dielectric-metal", "semiconductor (1) – semiconductor (2)" and graphene-based, as well as more complex compositions are used today as basic elements of modern micro- and nanoelectronics. They are characterized by the presence of interfacial boundaries, which are characterized by mechanical stresses, localized charges, linear defects, impurities and other imperfections. All this generally has a negative impact on the performance of such structures and their stability.

The greatest results in the study of interphase phenomena have been achieved for the systems "liquid (melt) – solid" and "liquid (melt) – vapor" [1–9]. However, the problem of interphase interaction in the system "solid body (1) – solid body (2)" (between mechanically inhomogeneous regions (E_1, E_2)) has not been studied today. The situation is complicated by the fact

that modern experimental methods do not allow direct measurements to determine the interphase energy parameters, in particular the energy of the interphase interaction.

Thus, the ability to control surface processes at the interface is an important factor in solving the problem of obtaining materials with predictable physicochemical properties. Understanding the nature of mechanical stresses is also relevant, as their basic concepts were formulated in the in the middle of the last century mainly from a macroscopic standpoint. However, today they are no longer able to explain the peculiarities of their origin and evolution at the interphase boundaries of micro- and nanoobjects. Adhesion processes at the boundary of two media in modern literature are presented only descriptively and are fragmentary. However, the monograph [10] forms the general principles of such interaction for a number of structural materials according to which the main quantitative parameters are the energy of interfacial interaction γ_m and interfacial tension σ_m.

Thus, the outlined problem requires a comprehensive approach in the study of the interaction of two phases using the analysis of physicochemical, thermodynamic and mechanical compatibility of interacting phases.

2. Interfacial energy at the interface of solid media

Despite the significant amount of work devoted to the study of surface and interfacial properties of solids and melts, the theory and practice of these phenomena are still far from complete. It should be noted that the greatest progress in the study of interphase phenomena has been achieved today for the system of melt (liquid) – solid phase. Indicative in this aspect are the classical Jung equation, which is used to describe the interphase interaction in the system " liquid medium – solid phase" for about 200 years and a significant number of works, including monographs [1; 7; 9] on this issue. In particular, Jung showed for the first time that the surface energies of the separation of solid and gas phases σsp, liquid and gas phases σ_{cp} are related by equation [1]:

$$2\,\sigma_{sp} = \sigma_{cp}\,(1+\cos\Phi_z) \qquad (1)$$

where Φ_z is the limiting angle of wetting of single-phase cast material. Therefore, by depositing a drop of liquid with known surface energy on the surface of a solid, it is possible to calculate the surface energy of the solid phase by the value of the critical wetting angle.

However, solving the problem of interphase interaction in the system "sol.st.(1) – sol.st.(2)"currently remains in its infancy. Nevertheless, knowledge of the energy parameters of such interaction is essential for modern nanotechnology and the creation of new structures for components of nano- and microelectronics. The problem is complicated by the fact that the existing modern experimental techniques do not allow direct measurements to determine the interfacial energy. In the literature there are only fragmentary data on the interfacial interaction of solid phases. In particular, in [11] surface phenomena during recrystallization of metals are considered, and interphase phenomena between solid metal phases. The influence of the substrate, thermodynamic supersaturation and stress mismatch between the emerging phase and the substrate are discussed in [12]. Based on the energy distribution of the nearest neighbors in [11] derived a formula and calculated the surface energy at the boundary of polymorphic α – and β – phases of tin, and in the Thomas-Fermi method was used to calculate the surface (in this case actually interfacial) energy at the boundary of two contacting dissimilar metals.

The calculated values in the order of magnitude coincide with the experimental data.

In general, it should be noted that the consistent theory of surface (interfacial) energy at the boundary "solid (1) – solid (2)" does not exist today. A significant breakthrough in this problem was the work [13], which obtained a general thermodynamic formula that allows us to estimate the surface energy at different interfacial boundaries, including at the boundary "solid phase – solid phase".

However, the problem can also be considered from another angle. In particular, the authors [14] propose to solve it within the framework of the thermodynamic theory of the origin of a new phase in a solid. The kinetics of phase transformations in the solid phase is determined by the fluctuation of the centers of the new phase and their subsequent growth. Since the rate of nucleation and growth of the centers depend on the surface energy of the interface between the original and new phases, the volume of the transformed phase is directly related to the surface energy σtk at the solid-crystal nucleus boundary. It has been experimentally established that the formation of a crystalline nucleus on a solid-state substrate is easier than homogeneous nucleation, as follows from the general thermodynamic representations.

The action of the substrate can be associated with a decrease in the value of the interfacial energy of the interface "solid phase – crystalline nucleus" compared to the surface energy of the nucleus at the interface with steam or melt.

For surface energy at the boundary "solid – crystalline nucleus" the equation is obtained:

$$\sigma_{ТК} = \sigma_{РП} \cdot \left[\left(\frac{2 - 3\cos\theta + \cos^3\theta}{4} \right)^{2/3} + \left(\frac{2 - 3\cos\theta + \cos^3\theta}{4} \right)^{1/3} \cos\theta \right], \quad (2)$$

which is true for $0 < \theta > 180$. Here σрп is the surface energy at the liquid-vapor boundary, θ is the edge angle of wetting of a solid with liquid. The results of calculations based on this formula are in good agreement in order of magnitude with the data obtained by other methods [11].

The monograph [1] proposes a simple theoretical estimate of the surface energy of the separation of two solid phases. In particular, for typical metals it is evaluated:

$$\sigma_{\alpha\beta} = 0,268 \cdot \left[\frac{\Delta(H_{Mt})_{\alpha}}{(\alpha V_{Mt})^{2/3}} - \frac{\Delta(H_{Mt})_{\beta}}{(\beta V_{Mt})^{2/3}} \right],$$

where $\Delta(H_{Mt})_{\alpha}$, $\Delta(H_{Mt})_{\beta}$ is the molar heat of fusion of metals α and β, respectively, (αV_{Mt}), (βV_{Mt}) their atomic (molar) specific volumes.

It is established that, other things being equal, the interfacial energy of a solid at the boundary with a crystal is less than the corresponding value of the interfacial energy of the interface "solid phase – melt", which is obviously due to the smaller difference in the binding energy of the solid phases.

3. Thermodynamic description of interphase interactions in composite systems

Research energy parameters (interfacial energy – γ_m, interfacial tension – σm, work of adhesion – A_{ad} and energy of adhesive bonds – γ_{ad}) of the interphase interaction is based on the considerations of the macroscopic approach, culminating in the model relations of nonequilibrium thermodynamics and solid state surface physics [2–4].

For the system "metal – dielectric" we use a macroscopic approach, which corresponds to the ratio of non-equilibrium thermodynamics and

physics of solid surfaces. Let's consider the system of equations and boundary conditions for describing the change of energy parameters (σ_h, γ), which characterize the thermodynamic state of the system of contacting bodies [10; 15].

Relations for the thermodynamic model of the surface layer of metal (x > 0) (quasistatic situation) can be represented in Cartesian coordinates x, y, z (where x is perpendicular to the interface) in the form:

$$Div\,\hat{\sigma} + \rho \cdot \omega \cdot \vec{E} = 0, \quad \Delta\phi = \rho \cdot C_\phi \cdot \phi / \varepsilon_0 , \tag{3}$$

$$\phi = -\Phi_0; \quad \phi + \psi = const; \quad \sigma_x = -\frac{\varepsilon_0}{2} \cdot \left(\frac{\partial \Psi}{\partial x} \right)^2 \text{ if x = 0}, \tag{4}$$

$$\sigma_{ij} = \left(\left(K - \frac{2}{3} G \right) e - \alpha_t K \cdot \Delta T - K(\beta\phi + \beta_c c) \right) \delta_{ij} + 2Ge_{ij} , \tag{5}$$

$$\omega_V = \rho\omega = \rho C_\phi (\phi - \gamma_t \cdot \Delta T) + \beta K e - \rho \eta_c c, \tag{6}$$

$$\mu_c = d_c c + d_t \cdot \Delta T + \beta_c K \frac{e}{\rho} - \eta_c \phi, \quad \Delta T = T - T_0, \tag{7}$$

$$\sigma_h = \int_0^h \sigma_y dx, \quad \sigma_y = \sigma_z, \quad \gamma = \gamma_e + \xi\gamma_d, \tag{8}$$

$$\frac{\partial \gamma}{\partial k} = \frac{\partial(\gamma_e + \xi\gamma_d)}{\partial k} = 0, \quad k = \sqrt{\frac{\rho \cdot C_\phi}{\varepsilon_0}} , \tag{9}$$

$$\sigma_y + p = 0 \text{ (for } x = h) \tag{10}$$

Here γ, σ_h – surface energy (SE) and the surface tension in the case of contact of the metal with inert gas atmosphere (air) with the pressure p = 100 kPa; $\gamma_e = \int_0^h w_e dx$ – electric component of γ; $w_e = \frac{\varepsilon_0}{2}\left(\frac{\partial \Psi}{\partial x} \right)^2$ and $w_d = \frac{\sigma_x(\sigma_x - 4\nu\sigma_y)}{2E} + \frac{(1-\nu)\sigma_y^2}{E}$ – densities of the electrical and mechanical components of the SE; $\gamma_d = \int_0^h w_d dx$ – mechanical component of SE; h – effective thickness of the surface layer; σ_{ij}, e_{ij} – tensors of mechanical stress and strain (i, j = 1,2,3); $\sigma_{11} = \sigma_{xx} \equiv \sigma_x$; $\sigma 22 = \sigma_{yy} \equiv \sigma_y$;

μ_c, c – chemical potential and the concentration of impurities; δ_{ij} – Kronecker symbols; e – the first invariant of the strain tensor; ρ – density of the material; ω_v, ω – volumetric and mass charge density, respectively; $\varphi = \Phi - \Phi_0$ – deviation of the modified chemical potential Φ of the electrical charges from its equilibrium value Φ_0 in the volume of the body at a distance x > 30 nm from the surface ($\Phi = M_e/z_e$, M_e – chemical potential of the conduction electron of the metal; ze – electric charge per unit mass of the conduction electrons ($[M_e]$ = J/kg, $[z_e]$ = C/kg, $[\Phi]$ = C)); Ψ – the potential of the electric field ($[\Psi]$ = V); $\psi = \Psi - \Psi_0$ – deviation of the potential Ψ from its equilibrium value Ψ_0; $\vec{E} = \nabla\Psi = grad\Psi$ – the amplitude of the electrical field; $\varepsilon_0 = 8{,}85 \cdot 10^{-12}$ F/m – electric constant; $\Delta T = T - T_0$ – temperature change; K, G – the bulk modulus and shear modulus; E, ν – Young's modulus and Poisson's ratio; $C\varphi$– capacitance; k – the inverse value of the distance, at which the volume charge in the surface layer varies by a factor e; β – electrostrictive coefficient of thermal expansion; ξ – coefficient (dimensionless) that characterizes the change in γ when changing the mechanical component γd, for condition when the electric component γe remains unchanged $\left(\frac{\partial\gamma}{\partial\gamma_d}\Big|_{\gamma_e=const} = \xi\right)$; α_t, β_c, γ_t, η_c, d_c, d_t – physical characteristics of the material (metal) which are included in the equation of state (4), (5) and (6) [10]. For more adequate fit of the model given by eq. (3–10) to the modern physical notions, it is necessary to take into account the offset Z_b of the electron double layer with respect to the boundary of the solid (metal). For this purpose we use a well-known formula [10]:

$$Z_b = \frac{3}{4k_F}\left(\frac{\pi}{2} + \left(\frac{5E_V}{3E_F} - 1\right)\arcsin\sqrt{\frac{3E_F}{3E_F + 5E_V}} - \sqrt{\frac{5E_V}{3E_F}}\right), \qquad (11)$$

where E_F – Fermi energy, E_V – the work function of the conduction electron and k_F – Fermi wave vector. By setting the values of γ and σ_h (SE and tension) in eq. (8) – (10) (taking into account eq. (3) – (7), (11)), we obtain a system of 4 equations. In this case we can determine the values of ξ, k, β and geometrical characteristics h of the surface layer for the metal, which is in contact with an inert gas atmosphere (air) at a pressure p = 100 kPa. Using the value of k, we can find $C\varphi$ and Φ_0 with the help of the eq. (9) and (11):

$$C_{\phi} = \frac{\varepsilon_0 \cdot k^2}{\rho}, \ \Phi_0 = \frac{q_0 W_e}{2\varepsilon_0 k^2} \cdot \left(2 - \exp\left(-kZ_b\right)\right), \tag{12}$$

where W_e – the bulk density of the conduction electrons of the metal away from the surface (at a distance of more than 30 nm, $[W_e] = 1/m^3$).

For most of metals values of the surface tension σ_h are determined experimentally [11]. The surface energies γ of the metals are determined both experimentally and theoretically. Among the theoretical studies one should note partial results obtained for a number of metals using the method of density functional [16; 17]. According to the authors, the empirical formula for γ in steel [18] has good consistency with the experimental data. Hence it has been applied for a number of other metals:

$$\gamma = a_R \cdot \frac{E_V}{R^2} - a_C, \tag{13}$$

where R – atomic radius, a_R, a_C – empirical constants ($a_R = 7128$; $a_C = 110$ J/m^2).

Surface tension σh and surface energy γ are connected by Hering's relation [19]:

$$\sigma_h = K_R \left(\gamma + \Xi \left(\frac{\partial \gamma}{\partial \Xi} \right)_T \right), \tag{14}$$

where K_R – factor for matching dimensions ($\left[K_R\right] = \frac{N \cdot m^2}{m \cdot J}$), since $\left[\sigma_h\right] = \frac{N}{m}$; $\left[\gamma\right] = \frac{J}{m^2}$; Ξ – surface area and $\left(\frac{\partial \gamma}{\partial \Xi} \right)_T$ represents the change of the surface energy during surface layer deformation at a constant temperature.

Based on the model, wherein the interfacial layer consists of two parts, the interfacial energy γm and interfacial tension σm at the interface between the substrate (semiconductor or insulator) – metal are defined by the following relations:

$$\sigma_m = \int_{-H}^{H} \sigma_y dx, \quad \sigma_y = \sigma_z, \tag{15}$$

$$\gamma_m = \gamma_e + \xi_m \gamma_d, \ \gamma_e = \int_{-H}^{H} w_e dx, \ \gamma_d = \int_{-H}^{H} w_d dx. \tag{16}$$

Here ξ_m-physical characteristics of the interfacial layer (dimensionless)

$\left(\frac{\partial \gamma_m}{\partial \gamma_d}|_{\gamma_e=const} = \xi_m\right)$; $2H$ – its effective thickness; γ_e, γ_d – electrical and mechanical components of the interfacial energy γ_m respectively, as in eq. (8).

Finally, by the analogy to the equilibrium condition of the surface layer we can write the equilibrium condition for the interfacial layer as in [15]:

$$\frac{\partial \gamma_m}{\partial k} = \frac{\partial(\gamma_e + \xi_m \gamma_d)}{\partial k} = 0. \quad (17)$$

Boundary conditions. Let us formulate boundary conditions for metal – insulator (or semiconductor) interface (at x = 0) which corresponds to the electrical double layer. This interface is formed by conduction electrons from the side of metal and by bounded electrical charges from the side of dielectric [10]:

$$\phi_+ = -\Phi_0; \quad z_- = -Z_e; \quad j_x^+ = j_{xe}^-; \quad \sigma_y^+ = \sigma_y^-; \qquad \sigma_x^+ = \sigma_x^-;$$
$$\Psi^+ = \Psi^-; \quad \vec{u}^+ = \vec{u}^-; \quad E_\tau^+ = E_\tau^-; \quad D_x^+ - D_x^- = \Omega, \quad (18)$$

where $\sigma_x^\pm$, $\sigma_y^\pm = \sigma_z^\pm$ – mechanical stresses along directions which are perpendicular to the interface between two media respectively; $\vec{u}^\pm$ displacement; $E_\tau^\pm$ – tangential component of the electrical field; $D_x^\pm, P_x^\pm$ – components of the electrical field induction and polarization vectors respectively are directed along the normal (axis x) towards the plane of interface (x = 0); Ω – density of the surface (excess, uncompensated) charges (created by free electrons). If the metal surface is not charged from the outside, then Ω = 0.

The work of adhesion A_{ad} and adhesive bonds energy γ_{ad} are defined based on the known relations [15]:

$$A_{ad} = \sigma_h + \sigma_{ph} - \sigma_m, \quad \gamma_{ad} = \gamma + \gamma_p - \gamma_m, \quad (19)$$

where σ_{ph} and γ_p – surface tension and energy of a dielectric which contacts with an inert gas medium (air) in which the pressure is 100 kPa.

4. Peculiarities of interphase interaction in the systems "copper – metal (Zn)", "copper – semiconductor (Si)" and "copper – dielectric (quartz)"

As an example of the application of the above thermodynamic description and quantitative comparison, we analyze the interphase interaction in "alternative" and at the same time typical systems: "copper – metal (Zn)",

"copper – semiconductor (Si)" and "copper – dielectric (quartz)". have an excellent nature of the near-surface layers (bound charges – metal and dipole complexes – dielectric, semiconductor). This comparison will allow to analyze the features of the interfacial layers between solids with significantly different surface charge and different mechanical parameters without using complex information about the specifics of the band surface structure of each of the contacting solids.

In the calculations we use the following numerical values of physical constants for copper (indices (+)), zinc (indices (-)), silicon (-), quartz (-):

$$E + = 118 \text{ GPa}; \nu_+ = 0.372; \omega_+ = 8.45 \cdot 1028 \text{ 1/m}^3;$$
$$\sigma h_+ = 2.125 \text{ N/m}, \gamma_+ = 1.623 \text{ J/m}^2 \text{ (Cu)};$$

$$E– = 81 \text{ GPa}; \nu_- = 0.25; \omega_- = 13.1 \cdot 1028 \text{ 1/m}^3;$$
$$\sigma_{h-} = 0.9 \text{ N/m}, \gamma_- = 1.01 \text{ J/m}^2 \text{ (Zn)};$$

$$E– = 70 \text{ GPa}; \nu_- = 0.25; \omega_- = 7.92 \cdot 1028 \text{ 1/m}^3;$$
$$\sigma_{h-} = 1 \text{ N/m}, \gamma_- = 0.737 \text{ J/m}^2 \text{ (quartz)}.$$

Here, the values of surface energies γ_+, γ_- were obtained using the method of atomic interactions and relations (16).

According to calculations using the method of decomposition by a small parameter (small parameter for metal – $b_м = b\Phi_0$; for semiconductor or dielectric – $b_{мс} = b_c \cdot Z_c$) within the system of equations (3–11) due to the solution of contact and contact-boundary value problems for room temperature values of energy and adhesion characteristics of the material of the interfacial layer:

a) "Cu – Zn" system – $\gamma_m = 0.089$ J/m^2; $\sigma_m = 0.112$ N/m; $A_{ad} = 3.023$ N/m;

$z_a = A_{ad} / \sigma_m = 27.0$; $W_{ad} = 2.434$ J/m^2; $z_{ad} = W_{ad} / W_m = 27.3$; $z_e = \gamma_3 / W_m = 0{,}0376$. (2.12)

b) "Cu – quartz" system – $\gamma_m = 0.307$ J/m^2; $\sigma_m = = 0.44$ N/m; $A_{ad} = 2.685$ N/m;

$z_a = A_{ad} / \sigma_m = 6.1$; $W_{ad} = 2.053$ J/m^2; $z_{ad} = W_{ad} / W_m = 6.68$; ze = $\gamma_3 / W_m = 0.133$. (2.13)

The electrical components of the interphase energy in the contact metals "Cu – Zn" ($z_{ea} = 0.0376$) and in the systems "Cu – Si" (zeb = 0.111), "Cu – quartz" ($z_{ec} = 0.133$) differ significantly, respectively, by 2.95 and 3.54 times ($z_{eb}/z_{ea} = 0.111 / 0.0376 = 2.95$; $z_{ec}/z_{ea} = 0.133 / 0.0376 = 3.54$).

It was found that the energy of γad adhesion bonds in the systems "Cu – Zn", "Cu – Si", "Cu – quartz" does not differ much in absolute value (W_{ada} = 2.43 J/m^2, W_{adb} = 2, 55 J/m^2, W_{adc} = 2.05 J/m^2). However, the ratio $z_{ada} = W_{ada}/W_m$ for the system of two metals (z_{ada} = 27.3) is several times greater than that in the system "metal – nonmetal" ($z_{adb} = W_{adb}/W_m$ = 9,9; $z_{adc} = W_{adc}/W_m$ = 6,68),), ie z_{ada}/z_{adb} = 2,76; z_{ada}/z_{adc} = 4,09.

For the systems "Cu – Zn", "Cu – Si", "Cu – quartz" specific numerical values of interphase tension σ_m, interphase energy W_m, adhesion work Aad and new energy characteristic of the interfacial layer – energy of adhesion bonds W_{ad}, which exceeds the interfacial energy W_m. Approximately the same number of times the work of adhesion A_{ad} is greater than the interfacial tension σ_m. In particular, for systems: "Cu – Zn" – $z_{ada} = W_{ada}/W_m$ = 27,3, $z_{aa} = A_{ada}/\sigma_m$ = 27,0; "Cu – Si" – $z_{adb} = W_{adb}/W_m$ = 9,9, $z_{ab} = A_{adb}/\sigma_m$ = 8,87; "Cu – quartz" – $z_{adc} = W_{adc}/W_m$ = 6,68, $z_{ac} = A_{adc}/\sigma_m$ = 6,10).

In order to compare with $z_e = \gamma_3/W_m$ (z_{ea} = 0,0376, z_{eb} = 0,111, z_{eb} = 0,133) we write the data of the ratio $z1 = \gamma_1/\gamma$, obtained on the basis of (3– 9) $z_1 = \gamma_1/\gamma$ = 0,221 (Cu), z_1 = 0,209 (Zn), z_1 = 0,241 (Si), z_1 = 0,242 (quartz). (20)

We can conclude that the contact of the two media causes both absolute and relative reduction of the power of the electric double layer near the interface, which follows from the differences between the relative components of energy characteristics z_e and z_1.

Of practical interest for real systems are the temperature dependences of interphase energy γm, interphase tension σ_m and interphase electric charge Q. For example, for the system "Cu – Zn" such dependences are calculated within the temperature range [0; 1 000oC], presented in Figure 1.

We emphasize that the experimental dependences of the surface tension σ_h on the temperature in the range [0; 1 000°C] for copper, zinc, quartz, silicon are linear. They are test for estimating temperature changes of energy values γ_+, γ_- using the method of atomic interactions and taking into account the centrally symmetric potential of the central forces of Born-Mayer [10]:

$$u_{\alpha\beta} = \frac{q^2}{R_{\alpha\beta}} - \frac{c_{\alpha\beta}}{R^6_{\alpha\beta}} - \frac{d_{\alpha\beta}}{R^8_{\alpha\beta}} + b_{\alpha\beta} \cdot \exp\left(\frac{R_{\alpha\beta}}{\rho_q}\right), \qquad (21)$$

where q is the electric charge of the particles; $R_{\alpha\beta}$ is the distance between the particles α and β; cαβ, $c_{\alpha\beta}$, $d_{\alpha\beta}$, $b_{\alpha\beta}$ – constants (for materials); ρ_q is the "stiffness" parameter.

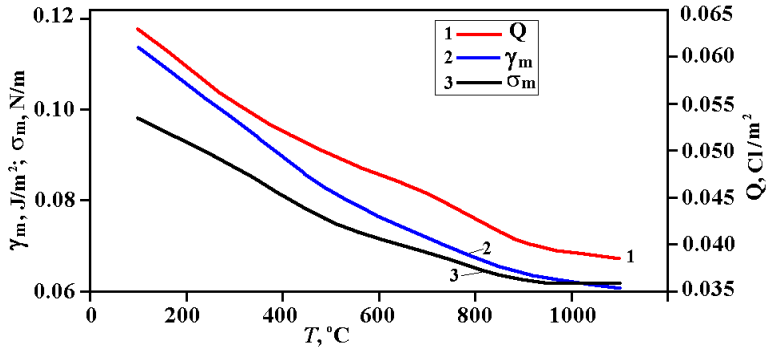

Figure 1. Temperature dependences of interphase energy γ_m, = f_1 (T), interphase tension σ_m = f_2 (T) and interphase electric charge Q = f_3 (T) for the system "Cu – Zn"

From the calculations it is established that the energy values γ_+, γ_- for copper and zinc are in the range [0; 1 000°C] have a temperature dependence close to linear.

Dependences of interphase energy γm, interphase tension σm, interphase electric charge Q on temperature in the range T = [0; 1 000°C] for "copper-quartz" and "copper-silicon" systems are similar to those for "Cu – Zn" and differ only quantitatively.

As we can see from the corresponding graphs (Figure 1), the dependences of the interphase physical quantities $\gamma_m = f_1(T)$, $\sigma_m = f_2(T)$, $Q = f_3(T)$ are nonlinear and their relative changes in the range [0; 1 000°C] can be quantified using the ratios:

$$\Delta w = 2(W_{m0} - W_{m1000}))/(W_{m0} + W_{m1000}) = 0{,}457;$$
$$\Delta\sigma = 2(\sigma_{m0} - \sigma_{m1000})/(\sigma_{m0} + \sigma_{m1000}) = 0{,}657;$$
$$\Delta Q = 2(Q_0 - Q_{1000})/(Q_0 + Q_{1000}) = 0{,}484. \qquad (22)$$

Here the indices (0), (1000) correspond to the limit temperatures $T = 0$°C and $T = 1\ 000$°C.

According to (22) it can be stated that of the analyzed parameters W_m, σ_m, Q undergoes the most significant temperature changes.

Similar dependences are shown in Figure 2, in particular: adhesion energy $W_{ad} = f_4(T)$, adhesion work $A_{ad} = f_5(T)$, the ratio of the electrostatic

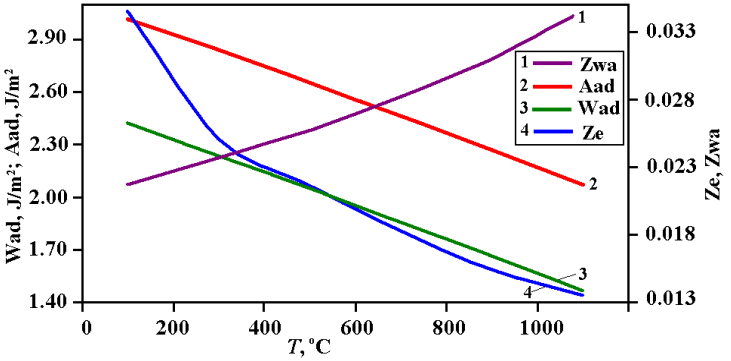

Figure 2. Temperature dependences of the energy of adhesive bonds $W_{ad} = f_4(T)$, adhesion work $A_{ad} = f_5(T)$, the ratio of the electrostatic component to the total interfacial energy $z_e = Z_e = f_6(T)$ ($z_e = \gamma_3/W_m$), as well as the ratio Z_{wa} = 0,12 $(A_{ad} - W_{ad})/(A_{ad} + W_{ad})$ in the temperature range T = [0; 1 000°C] for the "Cu – Zn" system

component to the total interfacial energy $z_e = Z_e = f_6(T)$ ($ze = \gamma_3/W_m$), and also the ratio $z_{wa} = Z_{wa} = 0{,}1 \cdot 2 \cdot (A_{ad} - W_{ad})/(A_{ad} + W_{ad})$ in the temperature range [0; 1000°C] for the "Cu – Zn" system.

Relative changes in physical quantities $W_{ad} = f_4(T)$, $A_{ad} = f_5(T)$, $z_e = f_6(T)$, $z_{wa} = f_7$(T) для T = [0; 1000°C] can be estimated using the relations of type (22):

$$\Delta W_{ad} = 0{,}495;\ \Delta A_{ad} = 0{,}370;\ \Delta z_e = 0{,}875;$$
$$\Delta z_{wa} = 0{,}458\ (z_{wa} = [0{,}217;\ 0{,}346]). \qquad (23)$$

Based on (23) we can conclude that among W_{ad}, A_{ad}, z_e, z_{wa} the most significant temperature changes belong to the parameter z_e ($\Delta_{ze} = 0{,}875$) and exceed the corresponding changes in the parameter σ_m ($\Delta\sigma = 0{,}657$).

5. Modeling of metal condensate growth processes taking into account interphase interaction

Let us analyze the growth of a copper film on a silicon substrate taking into account changes in surface and interfacial energies in the process of its condensation.

When describing the kinetics of metal film formation on the substrate, we will be based on the fact that the formation of condensate in the deposition

process is not correct to describe a simple model with successive layers that structurally repeat each other and differ only in the set of corresponding modules $E_1 \ldots E_n$. The most expedient is the model of chaotically placed microregions, arranged in deformation relative to the substrate (at the stage of nanocondensate) or subsequent layers of condensate unfolded, respectively, relative to each other during deposition.

In particular, the kinetics of the deposition process assumes that each subsequent layer due to condensation is formed on a pre-directed deformed sublayer, which includes chaotically placed microdeformations in the grain volumes carried out in light sliding directions characteristic of this crystal structure of the film.

For the initial stage of condensation, taking into account the orientation dependence of the Young's modulus on the angle θ between the directions of pre-deformation and the resulting stresses, the system "silicon – copper condensate" demonstrates a significant orientation dependence of energy parameters of interphase interaction. In particular, the interphase energy within the disorientation angle (0–90°) has a "bell-shaped" appearance, reaching a maximum value at an angle of 45° (Figure 3).

The energy of the adhesive bonds changes antisymmetrically, reaching a minimum at θ = 45°.The behavior of other energy parameters – σ_m, A_{ad} is also characterized by the described laws [11].

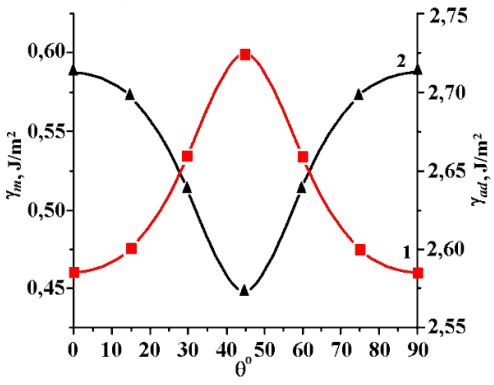

Figure 3. Anisotropy of interphase energy (1) and the energy of adhesive bonds (2) in copper-silicon condensates

To quantitatively describe the mechanical stresses in a thin film from the standpoint of interphase interaction, we formulate a mathematical model of the system "film – substrate". To do this, we use the equilibrium equation for the element of a continuous medium [20; 21] and the well-known equation of electrostatics, which connects the electric potential $\Psi = \psi + \Psi_0$ with the electric

charge ω, (follows from Maxwell's equations). Thus, the main balance relations and equations of the model will look like:

$$Div\ \hat{\sigma} + \rho \cdot \omega \cdot \vec{E} = 0, \tag{24}$$

$$\varepsilon_0 \Delta\Psi = \varepsilon_0 \Delta\phi = -\rho\omega = -\omega_V\ , \tag{25}$$

Here $\hat{\sigma}$ the tensor of mechanical stresses with components σij; $\vec{E} = -grad\psi = -grad\Psi$; $\rho \cdot \omega \cdot \vec{E}$ – ponderomotor force; ρ – specific density of the material.

The system of equations (24–25) is supplemented by linear equations of state for the components of the tensor of mechanical stresses σ_{ij} and the density of electric charge ω, in which the temperature T is taken into account as a parameter:

$$\sigma_{ij} = \left(\left(K - \frac{2}{3}G\right)e - \alpha_t K \cdot \Delta T - Kb\phi\right)\delta_{ij} + 2Ge_{ij}\,, \tag{26}$$

$$\omega_V = \rho\omega = \rho C_\phi(\phi - \gamma_t \cdot \Delta T) + bKe\,. \tag{27}$$

Here δ_{ij} are Kronecker symbols; $e = e_{ii}/3$ – the first invariant of the strain tensor; $\Delta T = T - T_0$ – temperature change; K, G – coefficients of comprehensive compression and shear; C_φ – specific capacitance; b – electrostriction coefficient of volume expansion; α_t – is the temperature coefficient of volumetric expansion; γ_t – is the temperature coefficient of change of the modified chemical potential of conduction electrons Φ.

To complete the picture, we add the equation of the mechanics of a deformed solid, which connects the strain tensor $\hat{e}$ with the displacement vector $\vec{u}$:

$$\hat{e} = Def\,\vec{u}\,. \tag{28}$$

Thus, equations (24, 25) can be solved in displacements.

Using the relationship $E_x = -\partial\psi / \partial x = \partial\phi / \partial x$ (since the change in the electrochemical potential of electrons ($\psi + \varphi$) = const in contact media) and substituting the value of $\rho\omega$ from (27) to (24) on the boundary x=0, we obtain the boundary condition for the component of mechanical stresses (that is perpendicular to the boundary):

$$\sigma_x \equiv \sigma_{xx} = -\frac{\varepsilon_0}{2} \cdot \left(\frac{\partial\psi}{\partial x}\right)^2 = \frac{\varepsilon_0}{2} \cdot \left(\frac{\partial\phi}{\partial x}\right)^2 \tag{29}$$

The second boundary condition is obtained from the continuity of electrochemical potentials at the boundary of the media

$\Psi + \Phi = \psi + \Psi_0 + \varphi + \Phi_0 = \text{const}$. Here $\Psi = \psi + \Psi_0$, $\Phi = \varphi + \Phi_0$. At the boundary metal – non-conductive gaseous medium (or vacuum) $\Psi + \Phi = \text{const} = 0$ and get $\varphi = -\Phi_0$, $\psi = -\Psi_0$. Therefore, the second boundary condition on the boundary x=0:

$$\varphi = -\Phi_0 \tag{30}$$

Solve the one-dimensional problem (24), (25) for the potential $\varphi$and the displacement components u_x. To do this, there are two equations and the two required values of φ, u_x. Mechanical stresses and components of the electric field of the type $E_x = -\partial\psi / \partial x = \partial\phi / \partial x$ in the near-surface layer are fed through φ, u_x.

Since (24) has a ponderomotor force, problem (24) and (25) are nonlinear. To solve it, we use the method of decomposition by a small parameter $b_* = b \times \Phi_0$ [23]. The boundary of the media is considered homogeneous along the y and z axes (no defects on the surface); x is perpendicular to the boundary.

As a result of solving this one-dimensional problem for the metal region, the relations for calculating the potential φ(x) and two relations for σ_x and σy are obtained:

$$\phi(x,k,\Phi_0) = -\Phi_0 \cdot \exp(-kx); \qquad k = \sqrt{\frac{\rho C_\phi}{\varepsilon_0}};$$

$$\sigma_x(x,b,k,\Phi_0) \approx -\frac{1}{2}\varepsilon_0 \cdot k^2 \cdot \Phi_o^2 \cdot e^{-2kx} - \frac{1}{2} b \cdot \Phi_0 \cdot K \cdot \Phi_* \cdot e^{-3kx} -$$

$$-(b \cdot \Phi_0)^4 \cdot \frac{9K^4}{8(3K+4G)^3} e^{-4kx}\left(1 + \frac{1}{10}\Phi_* e^{-2kx}\right) + C_x, \tag{31}$$

$\sigma_y(x,b,k,\Phi_0)$ expressed similarly σ_x,

where $\Phi_0 = \frac{q_0 W_e}{2\varepsilon_0 k^2} \cdot (2 - \exp(-kZ_b))$; $\Phi_* = \frac{\varepsilon_0 \cdot k^2 \cdot \Phi_o^2}{3K + 4G}$;

$$Z_b = \frac{3}{4k_F}\left(\frac{\pi}{2} + \left(\frac{5E_V}{3E_F} - 1\right)\arcsin\sqrt{\frac{3E_F}{3E_F + 5E_V}} - \sqrt{\frac{5E_V}{3E_F}}\right);$$

$$C_x = \frac{b}{2} K \cdot \Phi_0 \cdot \Phi_* + (b \cdot \Phi_0)^2 \frac{3K^2}{2(3K+4G)}\left(1 + \frac{\Phi_*}{4}\right) +$$

$$+ (b \cdot \Phi_0)^3 \frac{9K^3}{2(3K+4G)^2}\left(\frac{1}{3} + \frac{\Phi_*}{20}\right) + (b \cdot \Phi_0)^4 \cdot \frac{9K^4}{8(3K+4G)^3}\left(1 + \frac{1}{10}\Phi_*\right);$$

E_F and k_F – Fermi energy and wave vector; E_V – the work of the electron out of the metal; W_e [1/м^3] – bulk density of electrons of conductivity of metal far from the surface (approximately at a distance greater than 30 nm); q_0 – electron charge; Z_b is the displacement of the electric double layer relative to the body boundary.

Using relations (31) and numerical values of constants for silicon and copper (Young's modulus E, Poisson's ratio ν, surface tension σ_h and energy γ, concentration of free electrons in the metal or particles of bound charges q: E_-= 154 GPa; ν_- = 0.34; q_-= 8.38 · 1028 1/m^3; σ_{h-}= 2.16 N/m, γ_-= 1.85 J/m^2 (Cu); E_- = 138 GPa; ν_- = 0,27; q_-= 5,0 · 1028 1/m^3; σ_{h-}= 1,829 N/m, γ_- = 1,623 J/m^2 (Si), calculated normal parallel limits of stress σyy and strain εy the first boundary layer of copper:

$$\sigma_{yy} = 5.8 \text{ GPa}; \varepsilon_y = \sigma_{yy}/E_1 = 0.05. \quad (32)$$

After spraying the next layer, the previous layer becomes internal. Under these conditions, the σ_{yy} tension relaxes. Deformations to εy = 0,05 decrease, respectively. In the second layer, the concentration of vacancies begins to grow and goes to the ultimate possible value – 5%. However, the concentration of vacancies will not reach the limit, because in the process of stress relaxation vacancies are annealed and migrate parallel to the interface.

Therefore, depending on the spray rate, a certain type of substructure with the appropriate grain size is set. The corresponding grain sizes and film thicknesses correspond to a certain level of internal stresses and, according to the Hall-Patch ratios, also determined values of σ_{n1}.

It was found experimentally that the most interesting in terms of changes in physical and mechanical properties is the range of spray rates:

$$w_n = [w_{n1}; v_{n2}] = [0.2 \text{ nm/s}; 0.5 \text{ nm/s}], \quad (33)$$

which corresponds to the following parameters of the copper film:

$$D_n = [D_{n1}; D_{n2}] = [400 \text{ nm}; 1600 \text{ nm}]; \sigma_{yn} = [\sigma_{yn1}; \sigma_{yn2}] = [17 \text{ MPa}; 51 \text{ M Pa}];$$

$$h_n = [h_{n1}; h_{n2}] = = [56 \text{ nm}; 110 \text{ nm}]. \quad (34)$$

Here D_n is the grain size, σ_{yn} is the maximum normal tensile stresses in the film (acting parallel to the boundary and inside the thickness), which correspond to the film thickness [h_{n1}; h_{n2}]. Analysis of changes in mechanical stresses σ_{yn} in the film revealed that the numerical values decrease from values slightly smaller than σ_{yy} = 5.8 GPa to σ_{yn1}, σ_{yn2} continuously without

maxima. However, the method based on the Stone formula does not allow such stresses to be recorded. There is a transition period during which the stresses in the film decrease to a certain value (for example, to σ_{yn1}, σ_{yn2}), and the displacements of the console δ, increase to some maximum values (they correspond to σ_{yn1}, σ_{yn2}). Therefore, stresses of type σyn (in particular, σ_{yn1}, σ_{yn2}) correspond to the end of the transition period of increasing console displacements δ, and also determine the stresses from which their values in the film can be monitored using a capacitive recorder.

We emphasize that at velocities $w_n < w_{n1}$ and $w_n < w_{n2}$ the maximum stresses σ_{yn} decrease with increasing velocity. In the range (33) the opposite pattern is observed: σ_{yn} = [17 MPa; 51 MPa], which obviously corresponds to changes in mechanical modules and grain size.

According to the applied experimental method for the range (33) it was found out:

$E = [E_1; E_2] = [118 \text{ GPa}; 128 \text{ GPa}]$; $w = [w_1; w_2] = = [0.372; 0.347]$. (35)

The experimentally obtained values of the yield strength σ_m for films, depending on the grain size D, are smaller, compared to polycrystalline copper, from 5 to 20%.

$D_a = 200$ nm – $\sigma_{ma} = 450$ MPa; $D_b = 400$ nm – $\sigma_{mb} = 370$ MPa;

$D_c = 600$ nm – $\sigma_{mc} = 310$ MPa; $D_d = 800$ nm – $\sigma_{md} = 270$ MPa. (36)

Let us estimate the change in the interfacial energy of the boundary "copper film – silicon substrate" with respect to silicon PE, using the method [15; 24]. Calculations, in particular, show that the relative change in interfacial energy during the deposition of the first layer of copper film with a grain size of 200 nm is 58%. During the deposition of the next layer with a grain diameter of 800 nm, the change in interfacial energy is 35%. Thus, the internal dimensional effect is accompanied by a change in the energy parameters of the interphase interaction between the interacting grains of the film.

Conclusion

1. A mathematical model of interphase interaction and adhesion mechanisms in heterophase systems is developed, taking into account the basic relations of surface physics and nonequilibrium thermodynamics. On the proposed model, a method for quantifying the relationship between electrical and mechanical components of the interphase energy of the

interacting phases (solid (1) – solid (2)) has been developed. 2. Based on the equations of nonequilibrium thermodynamics and surface physics, a mathematical model was developed that describes the physical and mechanical processes in the surface layers. The definition of surface energy, interphase energy, interphase tension is introduced and a new method for estimating changes in these physical quantities is proposed, which takes into account the distribution of electric charges in the surface layers. The division of surface energy into electrostatic and mechanical (elastic) components is proposed. Due to this, a method for determining changes in surface tension and energy in nonequilibrium conditions (eg external mechanical load) has been developed.

3. For systems "Cu – Zn", "Cu – Si" and "Cu – quartz" shows: a) electrical components of interphase energy in contact "Cu – Zn" metals and "Cu – Si" and "Cu – quartz" systems are significantly different (2.95 and 3.54 times, respectively), which indicates a much lower value of the power of the electric double layer near the interface two "Cu – Zn" metals in relation to the "Cu – Si" semiconductor or "Cu – quartz" dielectric metal; b) the energies of W_{ad} adhesion bonds in the systems "Cu – Zn", "Cu – Si", "Cu – quartz" differ slightly in absolute value, but the value of the ratio $z_{ad} = W_{ad} / W_m$ for the system of two metals is several times higher, than similar in the system "metal – non-metal"($z_{ada}/z_{adb} = 2{,}76$; $z_{ada}/z_{adc} = 4{,}09$.

4. On the basis of thermodynamic principles, taking into account changes in surface and interfacial energies, the process of copper film formation is analyzed. In the system "silicon-condensate of copper" the orientation dependence of energy parameters of interphase interaction (γ_m, γ_{ad}, σ_m, A_{ad}). is established. Quantitative estimates of mechanical stresses for the layered film growth model were performed. The resulting internal stresses in copper condensates recorded during cantilever deposition are an integral result of the action of statistically distributed local stresses in the film plane due to the anisotropy of the energy parameters of the interphase interaction in the condensate plane. The range of deposition rates ($0.2 \div 0.5$ nm $\cdot$ s^{-1}) of copper condensates on single-crystal Si substrates is characterized by anomalous changes in mechanical stresses due to changes in mechanical modules and grain sizes of copper condensate.

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