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PROBLEMS AND PROSPECTS OF DEVELOPMENT OF THE ROAD TRANSPORT COMPLEX: FINANCING, MANAGEMENT, INNOVATION, QUALITY, SAFETY – INTEGRATED APPROACH

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ABSTRACT

The monograph focuses on the problems and prospects of development of the road transport complex on the basis of the integrated approach. In Ukraine, the road transport system is one of the priority ones. However, its priority status is reflected only in numerous regulations. In such conditions the necessity of realization of scientific achievements and practical recommendations of development of the road transport system as a whole is actualized. The integrated approach to financing, management, innovation, quality and security has been applied.

In order to eliminate the regional imbalance in the development of the state, as an urgent measure, methodological principles of support for weak regions have been substantiated and developed, which envisages its implementation in the short term. It is proposed to determine the rating of the best educational institutions in the region on the basis of mathematical modeling. Relevant clusters of educational institutions of the region have been established and systematized, taking into account their sectoral significance, form of ownership, efficiency of state funding and the amount of own revenues. Methodological support for quality management of transport and logistics services has been developed, which includes a certain procedure and a set of appropriate methods for implementing this activity based on the application of the scenario approach and algorithmization of procedures for obtaining possible states of operation of modern transport and logistics sector objects. A set of functional subsystems of an enterprise by analogy with the systems of a living organism, the activity of which is interdependent, which ensures the stability of the «living organism» of the enterprise to the influence of external conditions has been formed. The process of determining and assessing the competencies of employees on the basis of the modern assessment technology «Assessment Center» has been formed. The program of development of corporate social responsibility at internal and external levels of implementation taking into account features of various groups of stakeholders is offered. The combined safety management system «behavior + transport status + infrastructure + permanent monitoring + post-accident services» is offered.

The proposed theoretical, methodological and applied aspects of the development of the road transport system are of theoretical and practical interest to scientists, entrepreneurs and government agencies.

KEYWORDS

Road transport system, state protectionism, road transport, road construction, regional imbalance, educational institutions, transport and logistics services, employee competencies, corporate social responsibility, transport system safety.

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CIRCLE OF READERS AND SCOPE OF APPLICATION

The monograph is practically useful for public authorities and grantors in the distribution of funds on the vector of selective funding, heads of public and private enterprises from the standpoint of implementing innovation in the management of the road transport sector, and theoretically – researchers, dealing with financial security, innovation management, quality and safety, as well as public administration. The outlined problems and prospects of development of the road transport system are of theoretical and practical interest for scientists, entrepreneurs and public administration bodies.

The scientific value of the monograph is methodological developments and practical recommendations in the field of economics, management and administration both at the level of individual enterprise and at the national level: developed methodological principles for supporting weak regions and ranking quality management of transport and logistics services, proposed a program for the development of corporate social responsibility at the internal and external levels of implementation, proposed a list of measures to ensure the quality and safety of the road transport complex.

Due to the universal approach to achievements of the vector of ensuring the development of the road transport system and the urgency of the problem among a number of countries, the results are methodologically useful and practically applicable both in Ukraine and in other countries.

DOI: 10.15587/978-617-7319-45-9.INTRODUCTION

INTRODUCTION

Ia. Levchenko, I. Dmytriiev

The road transport complex is strategic for each country. The development of the road transport system is in rather difficult conditions. This problem became especially acute during the period of intensification of external and internal challenges, which were provoked by the list of crises. Scientific discussions on the development of an action plan to restore and stabilize the development of the road transport system have been going on for quite a long time and are still relevant today. Transport and its infrastructure (including road) is an important factor in determining the development and security of each country. Its stable, uninterrupted and efficient functioning is the key to successful cooperation of all sectors of the economy, improving the welfare of the population, as well as ensuring the defense capabilities of the state and its interests.

The Eastern Partnership Transport Panel, the main purpose of which is to assist in improving transport links between the EU and its immediate neighbors, is to intensify activities and ensure the development of the road transport system. Transport networks and services play a key role in improving the quality of life of the country's citizens and in increasing opportunities for industrial development. Therefore, the road transport sector is one of the key areas of EU-Ukraine cooperation, and according to Article 368 of the EU-Ukraine Association Agreement, the main purpose of such cooperation is to promote the restructuring and renewal of Ukraine's road transport sector and the gradual harmonization of existing standards and policies with existing in the EU.

However, the road transport sector is underdeveloped. This is the main obstacle to the development of Ukraine's economic activity in the direction of sustainable growth. Therefore, the study of the current state and the elaboration of development trends are important tasks of scientific discussion.

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1 METHODOLOGICAL FUNDAMENTALS OF SUPPORT OF SCIENTIFIC AND EDUCATIONAL INSTITUTIONS THROUGH TARGETED CAPITAL INVESTMENTS

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ABSTRACT

It all starts with learning. From the very beginning of its existence, a person learns to talk, walk… Education is a titan, on which the existence of an intelligent person is based. The decline in the quality of education leads to its collapse, which in turn leads to the collapse of the nation. Therefore, the task of ensuring the quality of education is a priority for every state. The combination of education and innovation is the undisputed driving force behind the vector of development in the era of ephemerality. This section discusses the problem of supporting research and educational institutions. The method of selective financing of scientific and educational institutions, which create innovative technologies taking into account their investments in innovative developments, is offered. On the basis of statistical data on indicators of an estimation of activity of scientific and educational institutions and an indicator of innovative potential of a scientific and educational institution from implementation of innovations, a calculation of their rating has been carried out. In order to stimulate scientific and educational institutions to create innovative technologies, the introduction of targeted investment is proposed.

The problem of quantitative assessment of the rate of targeted investment on the basis of the comprehensive approach to the indicators of innovation potential from innovation and the rating of research and educational institutions has been solved. The approbation of the offered technique by an experimental method has been carried out, the targeted capital investments on the basis of the complex approach have been defined.

KEYWORDS

Scientific and educational institution, allowance, innovative technologies, selective financing, targeted investments, rating.

1.1 FINANCING OF SCIENTIFIC AND EDUCATIONAL INSTITUTIONS: PROBLEMS AND SOLUTIONS

A modern world-class educational institution provides for a real and tangible stay of a correspondent research, production and educational institution in the global space. Therefore, successful internationalization is a necessary prerequisite for joining the elite club of leaders of modern education and science. Until recently, the level of internationalization was measured by the percentage of foreign teachers and students. Currently, a system of international university rankings is emerging and being actively formed, which simultaneously plays the role of both a judge and

a mediator. Indeed, the instrumental mission of rankings is to compare the teaching and research potential of educational institutions and thus identify ways to reform and further develop them. More importantly, in the process of this comparison, the ratings state the substantive field of the «ideal type» of a modern educational institution as an educational, research and innovation center of the knowledge society [1]. The issue of internationalization is also actualized by the innovation vector. According to [2], the elimination of regional imbalances in the state is possible only with the provision of innovative development. All sectors of the economy need new ideas and the introduction of new technologies, where the carriers of ideas for the implementation of the latter and the development of startups are research and educational institutions [3, 4]. Startups or innovation and technological solutions in this case solve a number of problematic issues of all sectors of the economy. However, financial resources are needed to implement such ideas.

Some researchers see the solution to the problem of funding only through government intervention, emphasizing the need for significant capital investment [5]. The COVID crisis has revealed a huge number of research and educational institutions capable of creating technology and innovation. All countries, the UN, donors, founders are ready to finance such institutions and subsidize them through incentive allowances. Each stakeholder should invest (finance, support, subsidize) in educational institutions [6]. In support of this [7, 8]. This raises some scientific questions: how and to whom to allocate financial resources to ensure the implementation of research and educational institutions startup projects? The state administration of investment processes of scientific and educational institutions aims to obtain new solutions and startup projects for the country's enterprises as a result. Those that have the potential to implement and aim to increase competitiveness through the introduction of high-tech quality products are the need of the XXI century.

In turn, the latest techniques should indicate the need for funding and provide additional motivation for research and educational institutions through targeted investments in the development of innovative technologies. Summing up, on the one hand we have the need to ensure innovative development, on the other – research and educational institutions, which in providing a vector of innovation, need to provide new forms of funding [9], and the latest author's methods to provide additional motivation for funding – the need for research today.

1.2 INTRODUCTION OF METHODS OF SELECTIVE FINANCING OF SCIENTIFIC AND EDUCATIONAL INSTITUTIONS THROUGH TARGETED INVESTMENTS IN THE DEVELOPMENT OF INNOVATIVE TECHNOLOGIES

Ensuring an innovative vector of development is a driving factor for industry productivity and its competitiveness [10]. In an era of turbulence, only the development of innovation is the key to economic growth [11]. Innovation is a tool for transforming not only the past but also the present to the highest level. Innovative investments in a broad sense are long-term and, very often,

one-time infusions in order to stimulate the generation, support the development and ensure the implementation of innovations for their practical application. How to generate, manage and finance innovations more effectively is an issue that is still relevant. It is also extremely important when it comes to education and science, because investing in them to ensure innovative development is a powerful engine for the growth of all mankind [12]. It is here that the question of the key role of scientific and educational institutions in the development of the economy of individual regions and the state as a whole becomes relevant [13]. Based on its research, Oxford University creates innovative products every 2 months [14]. The creation of such new products provides university research with finances, contributes to local economic development and the creation of many new jobs in the region. The benefits are obvious to all participants. However, such a system of financing is acceptable in the conditions of a well-established process in the chain «educational institution – state – stakeholder». At present, it is hardly acceptable to talk about nationwide funding of the innovation vector of scientific and educational institutions in the conditions of turbulence. In the context of economy, integrated in technological innovation [15], selective and equitable financing is within the power of each state. Therefore, there is a need to develop a comprehensive methodology for selective financing of research and educational institutions through targeted investments in the development of innovative technologies.

Modern methods do not provide a specific answer to the question of how to conduct a ranking from the standpoint of the innovation component and identify research and educational institutions for funding.

In the study [16], the authors conducted a sample analysis of modern financing methods. The conclusions of the study emphasized that the financing of large projects (including innovative ones) should be carried out not only by the state, but also by the regions. However, this study does not say what underlies selective financing (indicators, ratings, or anything else) and how to conduct such a sample.

In part, the answer to this question is provided in the study [17], which proposed a rating method based on the indicator of investment attractiveness, which is identified as key. The methodology has a practical value due to the comprehensive approach to assessing investment attractiveness. Based on the rating, the authors of the study [17] proposed to conduct funding. This technique is theoretical in nature and can be adapted to assess the investment attractiveness of research and educational institutions. However, it does not offer selective financing of the studied objects through targeted investments and does not solve the problem of quantifying the allowance rate.

The study [18] is devoted to the development of a methodology that proposes the structure and mechanisms of financial flows. However, the study has the specificity – the focus on financing in the housing stock. At the same time, the influence of such a component as innovation and, accordingly, its influence on decision-making regarding funding are also completely ignored.

All of the above studies are unanimous that funding should be based on a preliminary assessment. Researchers also supported selective financing based on the rating [19]. They proved the need for

the comprehensive approach to such an assessment. The agreement with this vector of innovation financing can be traced in the study [20], which deals with the comprehensive approach to the financing of innovation in the state of Poland. It is also emphasized the need to support a branched vector of innovation support, instead of narrowly focused. This approach to complexity is inherent and of practical interest to countries in Europe and around the world.

The above methods are based on an integrated indicator (as a complex), which certifies the quality of the object under study. Such an integral indicator in the assessment of scientific and educational institutions is the indicator of their rating.

The annual ranking of universities «Top 200 Ukraine» is presented by the Center for International Projects «Euroeducation» and the international group of experts IREG Observatory on Academic Ranking and Excellence [21]. The compilers of the rating take into account the comprehensiveness and versatility of universities. The rating is calculated according to ten indicators: six indicators are international, four – national. It should also be noted, that the weights of international performance indicators of universities (results in world rankings, participation of universities in Erasmus+ programs of the European Union) are set higher than the weights of national indicators. However, it should be noted, that this rating does not say anything about innovation and scientific investment.

The most famous in the circle of educational institutions is the world ranking of universities QS [22]. It uses an extremely consistent methodological framework, compiled using a methodology based on six simple indicators [23]:

1. Academic reputation.
2. Reputation of an employer.
3. Ratio of teachers/students.
4. Quotes for a faculty.
5. International coefficient of a faculty.
6. International student ratio.

Each of these six indicators has its own weight. However, it is also worth noting the lack of innovation and scientific investment.

Academic Ranking of World Universities (ARWU) [24] is recognized as the forerunner of the world ranking of universities and the most reliable. ARWU annually represents the top 1,000 research universities based on a transparent methodology and objective third-party data. It is more complex and multicomponent in terms of ranking, as it is an integrated model, which is based on a large number of indicators [25], which are grouped into 4 groups. However, among such a variety of indicators, the innovation and science component is absent.

Another method of global ranking of educational institutions is worth noting – Global Ranking of Academic Subjects (GRAS). GRAS rankings use a number of objective academic indicators and external data to measure the performance of world universities in relevant subjects [26]. However, such a rating is interesting from the standpoint of assessing the quality of education, and not from the standpoint of the innovative vector of scientific and educational institutions.

However, what exactly are the indicators to be used in determining the priority institution in the investment project to obtain financing? The conducted analysis gives grounds to assert that the problem of support of scientific and educational institutions taking into account the innovative component has not been considered by other researchers. There is also a lack of a unified methodological approach in this direction, which indicates the need for appropriate research. This stimulates the need to develop a comprehensive methodology for selective financing of research and educational institutions through targeted investments in the development of innovative technologies.

1.3 THE RESULTS OF THE ELABORATION OF METHODS FOR SELECTIVE FINANCING OF SCIENTIFIC AND EDUCATIONAL INSTITUTIONS THROUGH TARGETED INVESTMENTS IN THE DEVELOPMENT OF INNOVATIVE TECHNOLOGIES

The object of the research is scientific and educational institutions, and the subject is the existing methods of their financing. In order to solve the problem of selective financing of scientific and educational institutions through targeted investments in the development of innovative technologies, the use of modern computer technology using mathematical models is proposed [27].

The whole set of statistical information should contain a small number of indicators that are informative about the state of an educational institution [1].

To determine the additional funding of higher education institutions, two most important indicators will be needed, namely:

1. Index of rating of a scientific and educational institution.

2. Indicator of innovative potential of a scientific and educational institution from innovation.

1. The index of rating of a scientific and educational institution

The rating of scientific and educational institutions in the «Top 200 Ukraine» is taken as a basis – it is an annual open access rating. The method of calculating this indicator is presented in [21].

The compilers of the rating take into account the indicators of comprehensive activity and versatility of universities. The rating is calculated according to ten indicators: six international and four local (**Table 1.1**) [21].

The rating of Ukrainian universities was conducted in accordance with the methodology, presented in [21].

External independent organizations determined the ratings of N scientific and educational institutions on the indicator (nomination) K ($K=1,\ldots, 10$). If the rating of an institution was not carried out on some indicator, it was assigned a conditional place in the rating table ($N+1$).

The next step was to calculate the weighted average value of the Index of the institution by the group of nominations.

All values are presented in conventional units.

Table 1.1 The indicators for evaluating the activities of scientific and educational institutions in 2019

No.	Indicator	Indicator weight
1	QS World University Rankings	0.135
2	Scopus	0.135
3	Webometrics	0.135
4	Participation in Erasmus+ of the European Union	0.135
5	Google Scholar Citations	0.135
6	UniRank	0.10
7	Results of All-Ukrainian student Olympiads and competitions of scientific works (by the sum of points)	0.065
8	Scholarships of the President of Ukraine and the Cabinet of Ministers of Ukraine for young scientists	0.065
9	Average weighted value for HEI ratings by the number of applications submitted by entrants and the average competitive score	0.03

2. The indicator of innovative potential of a scientific and educational institution from innovation

Next, the calculation of the indicator of the innovative potential of a research and educational institution from the implementation of innovations based on the classification of educational institutions by level of efficiency and amount of property, to assess the implementation of innovation potential was conducted [28].

The classification is based on the method [28], which states that for each research and educational institution n innovation potential of the research and educational institution from innovation PN_n is determined based on the revenue of the special fund Dsf_n and expenditures of the budget institution V_n. Formula for calculation:

$$PN_n = Dsf_n / V_n. \quad (1.1)$$

According to the proposed methodology, scientific and educational institutions are further grouped into categories according to the efficiency of financing, ownership and clustered on the basis of the obtained data [28].

The basis for the analysis was the statistical data of scientific and educational institutions of Ukraine. Taking into account confidential information for scientific and educational institutions, 20 educational institutions of Ukraine were selected and given symbols, the parameters of which are presented in **Table 1.2**.

In order to abstract from the specifics to simplify the judgments, the names of scientific and educational institutions (adopted by the letters A–T) and the meaning of their fixed assets and budget allocations are accepted conditionally.

Table 1.2 The main indicators of twenty selected scientific and educational institutions

Conventional name of the scientific and educational institution	Main funds, mln USD	Budget allocations, mln USD	Indicator of the innovative potential of the scientific and educational institution from the implementation of innovations
A	47,910	57,598	0.26
B	37,884	48,371	0.36
C	28,390	80,595	0.02
D	24,800	10,261	0.22
E	3,880	47,762	0.22
F	24,000	16,537	0.23
G	1,174	29,602	0.33
H	10,041	28,127	0.68
I	26,338	22,140	0.06
J	2,164	3,110	0
K	2,007	42,504	0.83
L	7,780	5,729	0
M	4,534	1,396	0.24
N	3,700	13,590	0.42
O	42,860	8,661	0.02
P	2,944	4,329	0.37
Q	41,805	19,368	0
R	1,859	9,667	0.05
S	6,052	1,852	0.11
T	8,000	1,539	0.02

The method of selective financing of scientific and educational institutions by targeted investments in the development of innovative technologies is proposed, which is based on the obtained indicators of the rating of scientific and educational institutions and the indicator of innovative potential of scientific and educational institutions from innovation.

1.4 PROPOSALS FOR THE INTRODUCTION OF THE CONCEPT OF TARGETED INVESTMENT IN ORDER TO STIMULATE SCIENTIFIC AND EDUCATIONAL INSTITUTIONS TO CREATE INNOVATIVE TECHNOLOGIES

In order to stimulate scientific and educational institutions to create innovative technologies, it is proposed to introduce targeted investment.

Targeted investment, according to the author's definition, is a certain part of financial resources that is directed to the recipient in order to stimulate scientific and educational institutions to

create innovative technologies based on the comprehensive approach to innovation potential and ranking of the latter.

We hypothesize that the program of development of scientific and educational institutions consists of n number of scientific and educational institutions that require targeted investment. The index of a scientific and educational institution, involved in the funding process, will be marked $i = \overline{1,n}$. Let the return on investment of the scientific and educational institution per unit of financial resources spent be a_i (a_i cannot be <1).

A formalized description of the model of effective cooperation between a scientific and educational institution and an investor (state, financial donor, etc.) is proposed, which can be presented as follows:

$$Z_i(S_i,x_i) = \varphi_i(S_i) - y_i = \varphi_i(S_i) - (S_i - x_i),\ i = \overline{1,n}, \tag{1.2}$$

where S_i – total amount of funding for the creation of innovative technologies; $\varphi_i(S_i)$ – income of the i-th scientific and educational institution from the implementation of innovative technologies; x_i – financial resources of the scientific and educational institution for the creation of innovative technologies – borrowed funds; y_i – own financial resources of the scientific and educational institution for the creation of innovative technologies; z_i – investments (state, financial donor, etc.), which take into account the amount of targeted funding; Z_i – net profit of the institution as part of the institution's own funds (as part of y_i).

Under conditions $\varphi_i(S_i) > x_i + y_i + z_i$ or $\varphi_i(S_i)/(x_i + y_i + z_i) > 1$ the model of cooperation between scientific and educational institutions and an investor (state, financial donor, etc.) is considered effective. The use of targeted investment optimizes the financing process, helps to increase efficiency.

Also for calculations according to the offered author's technique, the synthetic (artificial) indicator q_i, which is calculated by formula (1.3), will be required:

$$(1 - a_i)/l_i = q_i, \tag{1.3}$$

where a_i – efficiency, which is assessed by the return from a scientific and educational institution per unit of financial resources spent; l_i – priority.

Substituting for formula (1.3) the indicator of innovation potential of the scientific and educational institution from innovation – r instead of the efficiency indicator, and the rating of the scientific and educational institution – R instead of the priority indicator, the calculation of artificial (synthetic) q_i is carried out according to formula (1.4):

$$(1 - r_i)/R_i = q_i, \tag{1.4}$$

where r_i – indicator of innovation potential from innovation of the i-th scientific and educational institution, con.un; R_i – indicator of the rating of the i-th scientific and educational institution, con.un.

To determine the number of scientific and educational institutions that can claim the allowance, the maximum value of n is determined, which would satisfy the following inequality:

$$q_i < Q_n/(n-1), \quad (1.5)$$

where Q_n – sum of synthetic indicators q_i of the corresponding scientific and educational institutions n.

When condition (1.5) is not met, the calculation ends and the following scientific and educational institutions are excluded from the list of candidates for the allowance.

1.5 DETERMINATION OF TARGETED INVESTMENT BASED ON THE INTEGRATED APPROACH TO INDICATORS OF INNOVATION POTENTIAL AND RATING OF SCIENTIFIC AND EDUCATIONAL INSTITUTIONS

On the basis of statistical data on indicators of the estimation of activity of scientific and educational institutions, presented in **Table 1.2**, the rating of scientific and educational institutions was calculated. Taking into account confidential information for scientific and educational institutions, symbols are provided, the parameters of which are presented in **Table 1.3**.

Table 1.3 The rating

Rating of the scientific and educational institution	Conventional name of the scientific and educational institution	Sum of indexes of the scientific and educational institution, *R*
1	A	0.9625
2	B	0.9619
3	C	0.9211
4	D	0.9200
5	E	0.8554
6	F	0.8486
7	G	0.8443
8	H	0.8360
9	I	0.8293
10	J	0.8282
11	K	0.8216
12	L	0.8078
13	M	0.8052
14	N	0.7986
15	O	0.7925
16	P	0.7874
17	Q	0.7760
18	R	0.7750
19	S	0.7678
20	T	0.7675

Next, the calculation of the indicator of the innovation potential of scientific and educational institutions from the implementation of innovations on the basis of their classification according to (1.1) is carried out.

In **Table 1.4** the calculation information is presented.

Table 1.4 The indicator of the innovation potential of the scientific and educational institution from innovation

Rating of the scientific and educational institution	Conventional name of the scientific and educational institution	Indicator of the innovation potential of the scientific and educational institution from innovation, *r*
1	A	0.26
2	B	0.36
3	C	0.02
4	D	0.22
5	E	0.22
6	F	0.23
7	G	0.33
8	H	0.68
9	I	0.06
10	J	0
11	K	0.83
12	L	0
13	M	0.24
14	N	0.42
15	O	0.02
16	P	0.37
17	Q	0
18	R	0.05
19	S	0.11
20	T	0.02

Calculated and formed by the author based on data [21]

The calculations, presented in **Table 1.4**, indicate the following: the indicator of the innovation potential of a scientific and educational institution from the implementation of innovations does not depend on the previous rating of the scientific and educational institutions or vice versa. This is the basis for determining targeted investments based on the integrated approach.

1.6 FORMULATION AND SOLUTION OF THE PROBLEM OF QUANTITATIVE ASSESSMENT OF THE RATE OF TARGETED INVESTMENT

To determine the rate of targeted investment, the calculation procedure of which is represented by formulas (1.2)–(1.5), it is necessary to calculate the synthetic indicator q_i. The initial data for the calculation are presented in **Tables 1.3, 1.4**.

The calculation of q_i is performed by formula (1.4). When determining the share of additional funding for scientific and educational institutions, in accordance with the proposed methodology, it is necessary to sort the latter from the smallest to the largest value q_i. The results of the calculations in ascending order are presented in **Table 1.5**.

Table 1.5 The value of q_i in ascending order

Rating of the scientific and educational institution	Conventional name of the scientific and educational institution	Sum of indexes of the scientific and educational institution, *R*	Indicator of the innovation potential of the scientific and educational institution from innovation, *r*	Value q_i
11	K	0.8216	0.83	0.2069
8	H	0.836	0.68	0.3828
2	B	0.9619	0.36	0.6653
14	N	0.7986	0.42	0.7263
1	A	0.9625	0.26	0.7688
7	G	0.8443	0.33	0.7936
16	P	0.7874	0.37	0.8001
4	D	0.92	0.22	0.8478
6	F	0.8486	0.23	0.9074
5	E	0.8554	0.22	0.9119
13	M	0.8052	0.24	0.9439
3	C	0.9211	0.02	1.0639
9	I	0.8293	0.06	1.1335
19	S	0.7678	0.11	1.1592
10	J	0.8282	0	1.2074
18	R	0.775	0.05	1.2258
15	O	0.7925	0.02	1.2366
12	L	0.8078	0	1.2379
20	T	0.7675	0.02	1.2769
17	Q	0.776	0	1.2887

The whole algorithm of the procedure for determining the number of scientific and educational institutions – candidates for the allowance, can be represented by the inequality (1.5).

Let us check the fulfillment of the given condition for the set of obtained values of q_i. The test must be performed as long as condition (1.5) is met. If the condition is not met, the calculations should be terminated, and subsequent scientific and educational institutions are excluded from the list of applicants for the allowance.

The results of the calculations are presented in **Table 1.6**.

Since condition (1.5) is not satisfied at $n=3$, the calculations are complete. Scientific and educational institutions were identified to receive targeted investments. Such are the institution *K* and *H* with the values of the preliminary rating of 11 and 8 places, respectively. This proves the significant influence of the innovation component on the determination of targeted investment.

Next, the calculated values of the shares of targeted investment, with allocated funds equal to 1, in proportion to the obtained $Q_n/(n-1)$ and the results are presented in **Table 1.7**.

● **Table 1.6** Checking the fulfillment of condition (1.5)

Number of scientific and educational institutions, n	q_i	$\sum q_i$ corresponding to n, Q_n	$Q_n/(n-1)$	Checking the fulfillment of condition (1.5)
2	0.3828	0.5897	0.5897	$0.5897>q_2$
3	0.6653	1.2550	0.6275	$0.6275<q_3$

● **Table 1.7** Allowance of the scientific and educational institution with the allocated funds ($S=1$)

Scientific and educational institution	Targeted investment at $S=1$
K	0.5623
H	0.4376

According to the calculations, 2 scientific and educational institutions (namely: *K* and *H*) will receive targeted investment. Institution *K* will receive a higher allowance, and institution *H* will receive a smaller allowance, the value of which will be 56.23 % and 43.76 %, respectively, from 100 % *S*. It should also be noted, that the final rating of educational institutions differs significantly from the initial rating [21], because it is adjusted to the indicator of the potential of the scientific and educational institution from carrying out innovations.

1.7 DISCUSSION OF THE RESULTS OF DETERMINING THE TARGETED INVESTMENT ON THE BASIS OF THE INTEGRATED APPROACH TO THE INDICATORS OF INNOVATION POTENTIAL FROM INNOVATION AND THE RATING OF SCIENTIFIC AND EDUCATIONAL INSTITUTIONS

A large number of methods of financing innovative vectors of scientific and educational institutions were proposed by modern researchers [16–26]. All of them are integral and complex:

some contain more indicators, others – less. In contrast, the proposed author's definition of targeted investment based on the integrated approach to the indicators of innovation potential and rating of scientific and educational institutions, which is also comprehensive, contains a crucial component – targeted investment. The proposed methodology allows to determine the best scientific and educational institutions on the basis of the integrated approach.

In contrast to the existing methods, the author's is aimed at supporting the most important component – innovative development [29] of both the region and the state as a whole. It is determined that scientific and educational institutions that effectively use the innovation and scientific potential receive targeted investment. The presence of a mathematical justification for targeted investment is also an excellent and latest characteristic of the proposed method from a number of existing ones.

Targeted investment, according to the author's definition, is a certain part of financial resources that is directed to the recipient in order to stimulate scientific and educational institutions to create innovative technologies based on the comprehensive approach to innovation potential and ranking of the latter. In order to stimulate scientific and educational institutions to create innovative technologies, it is proposed to introduce targeted investment, the entire calculation procedure of which is represented by formulas (1.2)–(1.5), and the calculation has been carried out.

The problem of quantitative assessment of the rate of targeted investment on the basis of the comprehensive approach to the indicators of innovation potential from innovation and the rating of scientific and educational institutions for 2 institutions has been solved, the results of which are presented in **Table 1.7**. The main provisions of the section are covered in [30].

The main limitation of this section is the lack of a clear methodology for determining the rating of educational institutions. The next section will be devoted just to filling this gap.

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2 RATING OF EDUCATIONAL INSTITUTIONS USING MATHEMATICAL INSTRUMENTS TAKING INTO ACCOUNT INNOVATIVE AND SCIENTIFIC CAPITAL INVESTMENT

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ABSTRACT

As the analysis of the methods of determining the rating of educational institutions, conducted in Section 1 of this study, showed, there is currently no single and universal approach. It is the lack of such a technique that has been identified as a major drawback at the present stage. This section solves this problem, and with the help of a mathematical model it is proposed to determine the rating of the best educational institutions in the region. Relevant clusters of educational institutions of the region have been established and systematized, taking into account their sectoral significance, form of ownership, efficiency of state funding and the amount of own revenues. It has been determined, that educational institutions that effectively use their innovative and scientific potential receive planned allocations and a bonus for the appropriate rating, taking into account innovative and scientific investments. Educational institutions that do not meet the requirements of the task in the model are doomed to liquidation.

KEYWORDS

Educational institutions, mathematical model, rating, general and special funds, budget allocations, fixed assets.

2.1 RATING – A PREREQUISITE FOR EDUCATIONAL INSTITUTIONS AND THEIR FURTHER DEVELOPMENT

A modern educational institution in world-class higher education provides for a real and tangible stay of a correspondent research, production and educational institution in the global space. Therefore, successful internationalization is a necessary prerequisite for joining the elite club of leaders of modern education and science. And if until recently the level of internationalization was measured by the percentage of foreign teachers and students, then over the last decade a new mode of internationalization, a system of international university rankings that simultaneously act as a «judge and mediator», has emerged and been actively formed. Indeed, the instrumental mission of rankings is to compare the teaching and research potential of educational institutions and thus identify ways to reform and further develop them. More importantly, in the process of this comparison, the ratings state the substantive field of the «ideal type» of a modern educational institution as an educational, research and innovation center of the knowledge society [1, 2].

2.2 THE RATING METHODOLOGY OF EDUCATIONAL INSTITUTIONS WITH THE HELP OF MATHEMATICAL TOOLS TAKING INTO ACCOUNT INNOVATION AND RESEARCH INVESTMENTS AND ITS SOLUTIONS

Ukraine has not yet reached the required level of quality and accessibility of education in the system of higher education institutions. To solve the problems of ratings of educational institutions in a particular area of the region, we propose to use modern computer technology and the existing mathematical tools of applied mathematics, which is based on the use of mathematical models [3].

Let's move on to the monitoring of indicators that should be included in the mathematical model of analysis to improve the formation of financial resources in the rating system of educational institutions.

The effectiveness of the institution's use of its budgetary resources can be assessed by relative indicators. The process of building a mathematical model for improving the rating system of a budget educational institution should begin with the analysis of statistical information. This statistical information should include a small number of general indicators that inform about the state of funding of the budgetary educational institution, etc. [4, 5]. In particular, it is necessary to establish the amount of fixed assets, the total expenditures and revenues of the general and special funds of the budgetary institution. Knowing the amount of budget allocations and the factors, influencing their planning, you can determine the amount of expenditures of the general fund of the budgetary institution.

In the future, for each budgetary *educational* institution «*p*» of the region, its planned (unscheduled) accumulation RP_p can be defined as the ratio of revenues PP_p of the special fund to the amount of expenditures of the budgetary institution PA_p:

$$PN_p = \frac{Dsf_p}{V_p}. \tag{2.1}$$

Based on the indicators of planned (unscheduled) accumulation, we will group educational institutions in the region into *E* categories of funding efficiency, each of which will be characterized by its average level of funding efficiency SE_e:

$$SE_e = \frac{\sum\limits_{p \in GE(e)} RP_p}{\left|GE(e)\right|}, \tag{2.2}$$

where $GE(e)$ – set of educational institutions in the region that belong to the category of funding efficiency *e*.

It is clear, that the efficiency of financing an educational budgetary institution is also influenced by the peculiarity of the relevant state, communal, or private property. Therefore, we will conduct an appropriate classification of educational institutions by appropriate status and ownership. Let the *g*-th property include educational institutions *p*, which form the set $G(g)$. By means of expert assessments we assign to the *g*-th property the corresponding categories of planned (unscheduled) accumulation KRG_g.

Assignment of categories of efficiency of the *g*-th property is carried out in such a way that the values of these categories increase with the growth of the favorableness of the respective property in relation to the efficiency of providing educational services. Educational budget institutions with the lowest average efficiency of providing educational services and budget financing are assigned category 1. Thus, educational institutions of the region can be grouped by categories of financing efficiency and *g*-th property (municipal, public, private). For each of these groups, we will differentiate educational institutions according to their property class.

This grouping is carried out by analyzing statistical information in the region, highlighting the property categories of small, medium and large educational budget institutions ($m = 1,2,3$). Let the *m*-th category in relation to property be formed by educational institutions *p*, which form the set $M(m)$. The power of this finite set $|M(m)|$ is determined by the number of its elements. That is, the number of educational institutions in the region, classified by the anount of property to category *m*, is determined by the mentioned capacity. Let's set the average amount of property of educational institutions of category *m*:

$$SM_m = \frac{\sum_{p \in M(m)} PA_p}{|M(m)|}, \tag{2.3}$$

where PA_p – amount of property of a particular educational institution *p*.

We will cluster educational institutions in the region. One cluster $CR(e,g,m)$ includes those educational institutions that have a category of financing efficiency *e*, their ownership and subordination belongs to category *g*, and property status – to class *m*.

We use the conducted clustering to build proposals for reforming budget policy in the field of education in the region. The purpose of such changes is to reduce (sequestration) and optimize budget expenditures, a fairer redistribution of budget allocations (budget expenditures) of the general fund of a budget institution, which does not lead to a significant increase in social tension.

In order to stimulate the subjects of educational budget institutions that provide educational services, we propose to introduce a surcharge for the rating of an educational institution. The *rating surcharge* should be applied, depending on the category of *g*-th property, to which the institution belongs, taking into account scientific and innovative investment projects in fixed assets of the institution for the current period. Because scientific and innovative investment projects (the amount of innovative acquired property) in the fixed assets of this institution for the current period is much easier to assess than the amount of intellectual property of the subject. However, there is a threat of liquidation of inefficient educational budget institutions, whose own revenues will not cover the surcharge for the rating of an educational budget institution.

Elimination of inefficient educational budget institutions is a necessary attribute of an efficient market economy and hopelessly inefficient educational budget institutions must experience it. However, there are numerous material and moral losses for society. In case of underfunding by the state and self-sufficiency of an educational budget institution, its rating decreases, and, con-

sequently, the base of the rating allowance decreases, or the corresponding allowance is canceled altogether. In addition, the number of unemployed, spending on social programs and social tensions are growing. With the reduction of research and innovation efficiency and investment, inefficient educational budget institutions are faced with the need to increase efficiency and many of them can take this opportunity. To manage the process of scientific and innovative efficiency and investment of educational institutions in the region, it is proposed to choose rating allowances, which are calculated and implemented using the following optimization model.

We will adhere to the condition that the budget request is provided with the necessary funds for both general and special funds of an educational budget institution. In addition, it is necessary to minimize the expected losses from the reduction of investment income due to the elimination of inefficient educational budget institutions.

Consider the assessment of the expected funding of an educational budgetary institution. Assume that the rating allowance SPM_g is determined by the category of planned (unscheduled) accumulation of property category g, which includes the educational budgetary institution p:

$$SPM_g = \alpha + (KRG_g - 1) \cdot \Delta\alpha, \tag{2.4}$$

where α – base rating allowance rate; $\Delta\alpha$ – additional accumulation of a property category; KRG_g – category of property accumulation.

Let's set the expected income OP for an institution from the cluster $CR(e,g,m)$. According to the accepted calculations, the average amount of allowances of an institution of this cluster is SM_m. Multiplying the amount of property of the institution by the average efficiency of the cluster institution SE_e, by analogy with formula (2.1), (2.2), we obtain an estimate of the income of the educational budgetary institution:

$$OP_{e,g,m} = SM_m \cdot SE_e. \tag{2.5}$$

Let the planned accumulation of an institution have a value β. Then the expected amount of revenue SP for an institution from the cluster $CR(e,g,m)$ is:

$$SP_{e,g,m} = SM_m \cdot (\alpha + (KRG_g - 1) \cdot \Delta\alpha) + SM_m \cdot SE_e \cdot \beta. \tag{2.6}$$

If the amount of allowances and accumulations for an institution exceeds the amount of its income, the educational budgetary institution faces the threat of liquidation:

$$SM_m \cdot (\alpha + (KRG_g - 1) \cdot \Delta\alpha) + SM_m \cdot SE_e \cdot \beta \geq SM_m \cdot SE_e. \tag{2.7}$$

Given that $SM_m > 0$, we can reduce this ratio by SM_m, resulting in:

$$(\alpha + (KRG_g - 1) \cdot \Delta\alpha) + SE_e \cdot \beta \geq SE_e. \tag{2.8}$$

Since there is an inefficient use of budget allocations of an educational budget institution, if condition (2.8) is met, liquidation does not occur. In this case, the institution will be forced to spend part of its own revenues of the special fund of the budgetary institution to pay the rating allowance. Let us introduce for consideration the liquidation coefficient *KL*, which is equal to the ratio of budget allocations of the general fund to the own revenues of a budgetary institution:

$$KL = \frac{BA - VN}{VN} = \frac{BA}{VN} - 1, \tag{2.9}$$

where *BA* – budget allocations; *VN* – own revenues, declared by an educational budgetary institution.

It is natural to assume, that an educational budget institution with high efficiency, established according to official statistics, effectively redistributes the income of the special fund of the budget institution, and, consequently, have a lower liquidation rate. This dependence can be represented by the relation:

$$KL_e = MKL \cdot \left(1 - \frac{SE_e}{MRP}\right), \tag{2.10}$$

where *MKL* – maximum liquidation coefficient; SE_e – average efficiency of an institution, which belongs to the *e*-th category of efficiency; $MRP = \max\limits_p \{RP_p\}$ – maximum of the recorded planned accumulations of the region.

Estimating the average liquidation coefficient, we can predict the actual own revenues of a budgetary institution:

$$PF_{e,g,m} = (1 + KL_e) \cdot OP_{e,g,m}. \tag{2.11}$$

Given the amount of actual income of the special fund of a budgetary institution, adjust the condition of liquidation of the institution (2.12):

$$\alpha + SE_e \cdot \beta \geq (1 + KL_e) \cdot SE_e - (KRG_g - 1) \cdot \Delta\alpha. \tag{2.12}$$

Fulfillment of condition (2.12) means the full use of the projected actual own revenues of a budgetary institution and is estimated by us as a condition of real liquidation.

Next, we take into account the factor of transfer of fixed assets at the liquidation of an institution using the renewal coefficient *KZ*:

$$KZ = \frac{PK - ZL}{DK}, \tag{2.13}$$

where *DK* – amount of fixed assets of a liquidated institution; *PK* – amount of the same fixed assets after its transfer to other owners, or return to the owner; *ZL* – costs of liquidation of an educational budgetary institution.

Determining the average value of the liquidation ratio for the region, we can estimate the revenue losses from the liquidation of an educational budget institution of the cluster $CR(e,g,m)$:

$$VL_{e,g,m}(\alpha,\beta) = (1 - KL) \cdot (SM_m \cdot (\alpha + (KRG_g - 1) \cdot \Delta\alpha) + SM_m \cdot SE_e \cdot \beta). \quad (2.14)$$

We will divide clusters of educational budgetary institutions of the region into two sets. The first set of effective educational institutions of *EP* includes those educational institutions of the region, for which liquidation condition (2.12) is not fulfilled. The second set of inefficient educational institutions *NEP* includes such educational budgetary institutions, for which condition (2.12) is fulfilled, ie, which fall into the category of liquidated, even taking into account the effect of subsidies from the state fund.

Based on the conducted estimates, we can derive a formula for calculating the total revenues of *SD* to the special fund of a budgetary institution, taking into account the depreciation of the capital of inefficient educational institutions:

$$SD(\alpha,\beta) = \sum_{(e,g,m)\in EP} (SM_m \cdot (\alpha + (KRG_g - 1) \cdot \Delta\alpha) + SM_m \cdot SE_e \cdot \beta) +$$
$$+ KZ \cdot \sum_{(e,g,m)\in NEP} (SM_m \cdot (\alpha + (KRG_g - 1) \cdot \Delta\alpha) + SM_m \cdot SE_e \cdot \beta). \quad (2.15)$$

To implement a fair redistribution of revenues (budget allocations, subventions) between efficient and inefficient educational budgetary institutions, we will also introduce to consider the coefficient of the expected load *NM* on the fixed assets of a budgetary educational institution:

$$NM_{e,g,m}(\alpha,\beta) = \frac{SM_m \cdot (\alpha + (KRG_g - 1) \cdot \Delta\alpha) + SM_m \cdot SE_e \cdot \beta}{SM_m}, \quad (2.16)$$

which is a share of the division of the total own revenues of the educational budget institution by its property (fixed assets).

Now we will form an optimization problem to estimate the base rate of the rating allowance α and planned (unscheduled) accumulation β. The criterion of optimality can be chosen as the amount of minimum total losses from the liquidation of educational budget institutions. However, this criterion leads to many solutions to many important problems. Therefore, another value was chosen as the criterion of optimality, which also gives positive social consequences. Namely, it is the minimization of the maximum coefficient of *MNM* allowances and load on the clusters of the model:

$$MNM(\alpha,\beta) = \max_{e,g,m} \left\{ NM_{e,g,m}(\alpha,\beta) \right\}. \quad (2.17)$$

In addition, we make it a condition that the specified coefficients for each educational institution take values not less than some minimum base value *BNM*:

$$NM_{e,g,m}(\alpha,\beta) \geq BNM. \quad (2.18)$$

The value BNM can be established on the basis of the analysis of current values of coefficients of load on property in the region. In the future, one of the possible methods for selecting the specified value will be shown.

We will also impose constraints on the planned accumulation of a budgetary institution. We will assume that it must be greater than the allowance for the rating by an amount not less than $\Delta\beta$.

Given the introduced notation, the optimization model of our problem can be written in the form:

$$MNM(\alpha,\beta) \to \min, \tag{2.19}$$

$$SD(\alpha,\beta) \geq NOD, \tag{2.20}$$

$$NM_{e,g,m}(\alpha,\beta) \geq BNM, \tag{2.21}$$

$$\beta \geq \alpha + \Delta\beta, \tag{2.22}$$

$$0 \leq \alpha \leq 1, \quad 0 \leq \beta \leq 1, \tag{2.23}$$

where NOD indicate the necessary revenues to the special fund of an educational budgetary institution.

The solution to this optimization problem will be the parameters of education and budget policy in the region.

Let us analyze the formulation of the optimization problem (2.19)–(2.23). First of all, let us simplify the representation of the objective function. To do this, in formula (2.16) we reduce the numerator and denominator by the common factor PA_m. As a result, we get:

$$NM_{e,g,m}(\alpha,\beta) = \alpha + SE_e \cdot \beta + (KRG_g - 1) \cdot \Delta\alpha. \tag{2.24}$$

Based on the obtained ratio, the representation of the maximum coefficient of planned accumulation of an educational institution is simplified.

$$MNM = \max_{e,g,m}\{NM_{e,g,m}(\alpha,\beta)\} = \alpha + \max_{e,g}\{SE_e \cdot \beta + (KRG_g - 1) \cdot \Delta\alpha\}. \tag{2.25}$$

It is natural to assume, that in important cases the problem model contains a cluster of institutions, which are characterized by maximum gradations in efficiency E and in the planned accumulation of industry G. In this case, the previous formula is simplified to the next:

$$MNM = \alpha + SE_E \cdot \beta + (KRG_G - 1) \cdot \Delta\alpha. \tag{2.26}$$

To simplify constraint (2.20) for each cluster of educational institutions, we introduce our own coefficient of conditional depreciation of fixed assets of an institution:

$$UKZ_{e,g} = \begin{cases} KZ & \text{at } \alpha + SE_e \cdot \beta > (1 + KT_e) \cdot SM_m \cdot SE_e - (KRG_g - 1) \cdot \Delta\alpha; \\ 1 & \text{at } \alpha + SE_e \cdot \beta \leq (1 + KT_e) \cdot SM_m \cdot SE_e - (KRG_g - 1) \cdot \Delta\alpha, \end{cases} \tag{2.27}$$

which is equal to the usual depreciation coefficient when liquidation condition (2.12) is met and equal to one in the opposite case. Using the introduced coefficient and formula (2.15), we present constraint (2.20):

$$\sum_{(e,g,m)} UKZ_{e,g} \cdot (SM_m \cdot (\alpha + (KRG_g - 1) \cdot \Delta\alpha) + SM_m \cdot SE_e \cdot \beta) \geq NOD. \quad (2.28)$$

After simple transformations we get:

$$\alpha \cdot \sum_{(e,g,m)} UKZ_{e,g} \cdot SM_m + \beta \cdot \sum_{(e,g,m)} UKZ_{e,g} \cdot SM_m \cdot SE_e \geq$$

$$\geq NOD - \sum_{(e,r,g)} UKZ_{e,g} \cdot SM_m \cdot (KRG_g - 1) \cdot \Delta\alpha. \quad (2.29)$$

Now analyze constraint (2.21). Given relation (2.24), it can be written as follows:

$$\alpha + SE_e \cdot \beta \geq BNM - (KRG_g - 1) \cdot \Delta\alpha. \quad (2.30)$$

It is clear from the inequality record, that when it is performed for clusters of educational budget institutions with efficiency «*e*» and the lowest category of planned accumulation ($KRG_g = 1$), it is performed for other clusters of the same efficiency and higher categories of planned accumulation ($KRG_g > 1$). Therefore, this inequality can be simplified to the form:

$$\alpha + SE_e \cdot \beta \geq BNM. \quad (2.31)$$

Since all the values on the left side of the inequality are non-negative, when it is performed for clusters with minimal efficiency e_0, it will also be performed for more efficient clusters. Thus, we come to the following constraint on the minimum efficiency of clusters:

$$\alpha + SE_{e_0} \cdot \beta \geq BNM. \quad (2.32)$$

Summarizing the transformations and eliminating the term in the objective function, which does not depend on the optimized parameters α and β, we can write the following simplified formulation of the optimization problem:

$$\alpha + SE_E \cdot \beta \rightarrow \min, \quad (2.33)$$

$$\alpha \cdot \sum_{(e,g,m)} UKZ_{e,g} \cdot SM_m + \beta \cdot \sum_{(e,g,m)} UKZ_{e,g} \cdot SM_m \cdot SE_e \geq$$

$$\geq NOD - \sum_{(e,r,g)} UKZ_{e,g} \cdot SM_m \cdot (KRG_g - 1) \cdot \Delta\alpha, \quad (2.34)$$

$$\alpha + SE_{e_0} \cdot \beta \geq BNM, \tag{2.35}$$

$$\beta - \alpha \geq \Delta\beta, \tag{2.36}$$

$$0 \leq \alpha \leq 1,\ 0 \leq \beta \leq 1. \tag{2.37}$$

We perform numerical implementation of the proposed model using the Excel application package.

Given the above and simplified formulation of the optimization problem, it is possible to make a numerical implementation of the proposed model using econometric tools. All this made it possible to analyze the results of the model on specific statistics of the region, to assess the methods of use and effectiveness of the proposed methodology. Thanks to the mathematical model, it is possible to determine the ranking of the best higher education institutions in the region that effectively use the innovation and research potential. The main provisions of the section are covered in [6].

If the problem of ranking educational institutions in this section is solved, then the problem of determining the region or regions in terms of funding remains open. This can be interpreted as a major constraint under Section 2. Therefore, a study on the vector for identifying regions to ensure their funding will be conducted in Section 3.

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3 STATE FINANCIAL SUPPORT FOR BRIDGE CONSTRUCTION OF TERRITORIAL UNITS

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ABSTRACT

Financial security has always been, is and will be the most painful topic for those who do not have their own funds. This applies to absolutely all sectors of the economy, all industries, all countries. When it comes to large-scale projects, including bridge construction, for Ukrainian realities it becomes a real test. In the context of the COVID-19 pandemic challenges, the problem of financial security is particularly acute, especially when it comes to poor regions that are unable to self-finance themselves and survive only on state financial support. Therefore, this section considers the problem of distribution of state financial support on the basis of the integrated approach. The answer to the research question is given: «What components should be included in the methodology for determining state financial support.» The comprehensive method for determining the share of public funds, which takes into account the investment attractiveness of the region and its risk, is proposed. Since the problem of financing the construction and reconstruction of bridges is relevant for a number of countries, this technique was tested on the example of bridge construction. According to the results obtained, the state financial support includes territorial units that are not leaders in priority for an investor and have a high level of risk in investing funds. The integrated approach allowed to identify 10 territorial centers for funding, with the areas with the worst priority indicators receiving the largest share of financial state support.

KEYWORDS

State financing, financial support, state support, financing model, bridge construction.

3.1 THE IMPORTANCE OF STATE FINANCIAL SUPPORT IN BRIDGE CONSTRUCTION

Research to address the problem of financing the reconstruction and construction of bridges is relevant for a number of countries [1]. For example, inspections of bridges in Italy have shown disappointing findings: 300 bridges in the country are in disrepair and could collapse at any moment. The traffic on these bridges is partially blocked, and the reason for that is structural damage in their supports. Most bridges and roads in Italy were built between 1950 and 1960 and are in poor condition. The shelf life of the concrete, from which they are made, is the same 50 or 60 years [2]. Seismic activity and climatic collapses only aggravate the situation [3]. The results of research [4] showed a long lack of funding and maintenance of existing structures, which often led to partial or complete closure of a bridge part and the destruction of the material.

The situation is similar in France. Every tenth bridge is in poor condition. Of the 12,000 French bridges, a third needs cosmetic repairs to eliminate structural changes. In 7 % of cases, the damage is quite serious, and some of them are at potential risk of collapse [2], which indicates the presence of the same problems as in Italy.

The results of studies of the condition of German bridges are as follows: 12.4 % of bridges are in very poor condition, and only 12.5 % are in good condition. Many structures were built between the 1960s and 1970s and are not designed for the very busy movement of today. In general, the condition of bridges in eastern Germany has been improved thanks to the state Program to support disappearing cities [6, 7]. In the western part of the country the situation is much worse – on a number of bridges the movement of heavy trucks is already prohibited [2].

According to the Information portal of the Russian community in Latvia [8], almost half of the 969 Latvian state-run bridges are in poor or very poor technical condition. The technical condition of 34.9 % of bridges is assessed as poor, 12.1 % – as very poor. And this indicates insufficient state financing.

For Latin American countries, in particular Brazil, the problem of poor bridges and roads is also relevant [9]. This fact is also recorded in [10], where the emphasis is on the age of bridges. The authors of the study [11] acknowledge the problem and propose to take a set of measures to prevent rapid destruction. At the same time, [12] noted that Brazilian researchers focus on solving «narrow problems». They are engaged in technical developments, related to the construction of new roads, bridges and hydraulic systems, which are considered as a priority on the path to innovative development of the country. At the same time, we are talking not only about buildings in large cities, but also about small ones, in which people also live and which must also follow the path of innovative development [12]. But this requires the maximum «elimination of regional imbalances in the state» and the financing of the most problematic regions and districts [13, 14].

Taking into account the complexity of the situation, the study [5] proposed to carry out the reconstruction, extending the service life of bridges through strengthening measures. Some researchers see the solution to the problem through government intervention, focusing on the need for significant capital expenditures [6, 7]. Financing bridge construction is a difficult task [15]. These questions were raised in the first half of the XX century [16] and are relevant in the XXI century [9, 17–20]. To sum up, on the one hand we have catastrophic wear of bridges, on the other – backward regions, which are not capable to cope with the problem of wear of bridges. This is what provokes the development of new forms of financing the latter [21], which provide for the solution of both problems at once.

3.2 WAYS TO DETERMINE THE STATE FINANCIAL SUPPORT OF NON-PRIORITY TERRITORIAL UNITS ON THE EXAMPLE OF BRIDGE CONSTRUCTION

Heads of Europe's world leaders are looking for ways and calling on other countries to help businesses that are global investors and suffering during the 2020–2021 crisis by implementing

government support measures. The road industry in general and bridge construction in particular especially need state support, as it is a guarantee of the country's defense capabilities [22–24]. A clear example is the data [25], where it is recorded, that only about 3 % of bridges do not provide the state's defense capabilities. It is hardly acceptable to talk about the full financing of bridge construction in the conditions of the crisis, but selective and fair regional financing is within the power of each state. Therefore, there is a need to develop a comprehensive methodology for the distribution of public finances and determine their share. It should solve the problem of catastrophic wear of bridges and «eliminate regional imbalances in the state» (support backward regions that are unable to cope with the problem of bridge wear) on the way to innovative development [13, 14].

To solve this problem, it is necessary to answer the research question: «What components need to be taken into account when determining state financial support.» Therefore, the question of the integrated approach [26], for the fair distribution of public funds, remains open and relevant [27].

According to existing methodologies, preference is given to territorial cells (areas) that have a high priority. This approach has raised doubts and questions. Following the experience of India, on the way to eliminating the regional imbalance in the state [13, 14], it is proposed to distribute public funds (state financial support) on the principle of «the largest state support to the weakest», which contradicts the views of researchers-predecessors. Existing funding methods do not provide a clear answer to how to identify weak territorial cells (areas) for funding and in what proportion it is necessary to distribute state financial support among the latter.

In the study [28], the authors discussed in detail some modern financial techniques: intergovernmental financing and credit guarantees. They showed in their article that the financing of large infrastructure projects can be provided not only by the state, but also by regions that are supported by the state. At the same time, the study does not say anything about which regions should be classified as «supported».

In the study [29], the author proposed a methodology that is a standardized structure and mechanisms of financial flows. But this model is specific because it focuses on the management of finances in the municipal housing stock. It also says nothing about the impact of components, such as priority, risk, and the impact of these components on the decision to finance.

The study [30] focuses on the financial security of cities. The authors proposed a financing model based on an indicator of investment attractiveness. This indicator is a key. The method is interesting for the comprehensive approach to assessing the territorial investment attractiveness, based on the rating of which the authors proposed to conduct financing, but did not propose a method of fair distribution of public funds. This part is theoretical in nature, which is a scientific gap of the above study.

The method of state financing is proposed in the study [31]. Here the dependence of financing on territorial attractiveness is proved. Healthy competition of territories for investments is substantiated. The basis of territorial attractiveness is the attractiveness of the land, which will later be able to return on investment.

The results of research [30–32] boil down to the fact that the higher the level of investment attractiveness, the more attractive the region is for financing. If we talk about attractiveness from the

standpoint of «for an investor», then everything is logical and clear. But when it comes to government support, everything should be the other way around. The state is obliged to support less attractive regions, to which an investor may never come and that have no hope of getting into the «top» of investment-attractive regions. Thus, the study [16] proposed a method of financial support of the bridge industry, based on selective regional funding. The authors of [31] consider selective financing as a factor of stabilization and sustainable development of a regional economy, because its main result is not a formal reorganization, but the effect of interaction with the state. At the same time, state support and selective financing of regions is the basis for the development of their economies [33]. In support of point funding the study [34] proposed a method of selecting regions for funding from the standpoint of a set of characteristics. The authors of the study used the approach of quantifying the attractiveness of a region to determine compliance and belonging to specific requirements. The study is indirectly devoted to the method of financing based on the assessment of the investment attractiveness of a region, which was discussed in the study [30]. But the study did not pay attention to the financial component. Namely, it is not indicated how selective state funding is made, how its size is determined. Researchers [33] have also proposed an interesting funding methodology that is based on a combination of private and public funds. But here we are talking about public-private partnership and attention is paid to the method of determining the equity participation of private funds. The issue of fair distribution of public funds on the basis of mathematical calculations is ignored.

To determine the amount of financial support, it is proposed to take into account the strengths and weaknesses of the potential object for funding and clearly identify the public goods and services provided, as well as the positive externalities. This is what is decisive with the support of public funding [35]. But such an approach is unacceptable, because in this case the support of weak regions is completely ignored.

Analyzing the works [16, 28–31, 33–35], it can be argued, that the problem of distribution of state financial support from the standpoint of support for weak regions is not sufficiently considered by other researchers. There is also a lack of a unified approach to determining the share of funding from the standpoint of support for weak regions, which indicates the need for appropriate research and determination of state financial support for non-priority territorial cells.

3.3 THE METHODOLOGICAL BACKGROUND FOR DETERMINING THE STATE FINANCIAL SUPPORT OF NON-PRIORITY TERRITORIAL CELLS

To determine the state financial support of non-priority territorial cells, two most important indicators were needed, namely: the indicator of investment attractiveness of a region (IIA) and the risk indicator.

To determine IIA, the «Methodology for evaluating the work of central and local executive bodies to attract investment, implementation of measures to improve the investment climate in the relevant sectors of the economy, regions and the appropriate form of report» was used [36].

The list of indicators, developed by the Ministry of Economy, is used for calculation – 4 groups, including 36 indicators, characterizing the level of development of a region (**Table 3.1**).

● **Table 3.1** The list of indicators for IIA assessment [36]

Group	Indicator
Economic indicators	Gross regional product per 1 person, million USD Profit from ordinary activities before tax, received by enterprises, million USD Volume of agricultural products (in comparable prices), million USD Share of innovation-active enterprises, % Gross agricultural output per 100 hectares of agricultural land, million USD Area of agricultural land per farm, ha Retail turnover of enterprises on average per month per 1 person, million USD The volume of realized market non-financial services of consumers per 1 person, USD Absorbed investments in fixed assets per 1 person, USD Absorbed investments in fixed assets at the expense of foreign investors, million USD Share of unprofitable enterprises to the total number of enterprises, % Volume of construction works, million USD Growth rate (decrease) of overdue accounts payable, % Growth rate (decrease) of overdue receivables, % Total exports per 1 person, million USD Increase in foreign direct investment per 1 person in the period, million USD Foreign direct investment per capita at the end of the period, million USD Volume of investments from regions to the economy of other countries per 1 person, million USD
Infrastructure development	Total volume of freight traffic, thousand tons Total volume of passenger traffic, thousand persons Provision of the population with home telephones per 100 families, units Total innovation costs for technological innovations, million USD Applications for inventions were submitted to legal entities, units Number of Internet users (contract), thousand persons
Human resources	Commissioning of housing by developers of all forms of ownership, thousand m^2 Wage arrears on average per 1 employee, USD The level of economic activity of the population aged 15–70 years, % Average monthly nominal salary of 1 full-time employee, USD Unemployment rate (according to the methodology of the International Labor Organization), % Level of employment of the unemployed registered population, % Graduation by higher educational institutions of I–II levels of accreditation, thousand persons Graduation by higher educational institutions of III–IV levels of accreditation, thousand persons
Enterpreneur-ship	The average annual number of employees of small enterprises with the number of employees in general at enterprises – business entities, thousand persons Volume of sold products (works, services) of small enterprises, %

The indicators, presented in **Table 3.1**, are open data of the State Statistics Committee of Ukraine. The calculation of IIA was carried out in three stages.

At the first stage, the assessment of IIA is carried out by summing the relative deviations of the indicators, characterizing the relevant activities of a region, to the best values of these indicators of the regions by the formula:

$$S_j = \sum((B_{max} - B_{ij})/(B_{max} - B_{min})) + \sum = \sum((B_{ij} - B_{min})/(B_{max} - B_{min})), \quad (3.1)$$

where S_j – rating of the investment attractiveness of the j-th region for each indicator; B_{ij} – value of the i-th indicator of the j-th region, $1 \le i \le n$; B_{max}, B_{min} – maximum and minimum values of the indicators; n – number of indicators, on which the calculation is made [36].

The first part of the formula is used to assess indicators, whose growth has a positive value (stimulants), the second part – to assess indicators, whose growth has a negative effect (disincentives).

In the second stage, the arithmetic mean value of the sum of rating estimates of IIA for each indicator is determined by the formula:

$$S_{mean} = S_j/n, \quad (3.2)$$

where S_{mean} – arithmetic mean of the sum of rating assessments of the activities of a particular region on the n-th indicators; n – number of indicators, on which the calculation is made [36].

At the third stage, the integrated rating IIA is determined by the following formula:

$$S_{ij} = \sum S_{cp} \times g_n, \quad (3.3)$$

where S_{ij} – integrated rating value of IIA; g_n – weight of the n-th group of indicators [36].

Next, the calculation of the risk indicator – the most important indicator in financing [37–39], which is taken into account when determining the state financial support of non-priority territorial cells. In contrast to the neoclassical approach, where a coefficient of variation is used to assess risk [40], a coefficient of semivariation was used, which allows a better assessment of the degree of risk [19]. Its use is expedient, in particular, when the external economic environment, the risk factors, characteristic of the considered project, is marked by dynamism.

Semivariation is calculated as follows:

$$SV = \frac{1}{P^-} \sum_{i=1}^{n} d_i^2 p_i, \quad (3.4)$$

where p_i – probability of the i-th result; d_i – negative deviations of actual results from the average expected:

$$d_i = \begin{cases} 0, & x_i \ge \overline{x}, \\ x_i - \overline{x}, & x_i < \overline{x}, \end{cases}$$

P – sum of the probabilities, for which d_i are negative.

In case of necessity of distribution of the state financial resources and determination of a share of financing, the corresponding technique, constructed on the basis of the received IIA and risk values, is offered. Its use will allow to make the optimum administrative decision, which will be useful both for the state budget, and for regional ones.

3.4 THE CHOICE OF CONDITIONS FOR CLASSIFYING REGIONS AS NON-PRIORITY IN TERMS OF STATE FINANCIAL SUPPORT

Suppose that a regional program (region development program) consists of n number of projects or regions (within the state) that need support. The index of the project that participates in investment processes will be indicated $i = \overline{1,n}$. Let the impact of the project per unit of investment spent be for the state a_i ($a_i < 1$, $i = \overline{1,n}$).

Since regional economic resources are limited, the most effective way to increase production is to attract additional capital resources [38], namely public funds. Regions are also interested in receiving budget funds. The idea of region's interaction with the state is that budget funds are provided on condition that the region participates in the financing of the project and undertakes to provide its own, regional, resources for financing.

A model for ensuring effective interaction between the state and the region is proposed, which takes into account the amount of public funding (support). The economic interest of the i-th project can be described by the expression:

$$Z_i(S_i x_i) = \varphi_i(S_i) - y_i = \varphi_i(S_i) - (S_i - x_i),\ i = \overline{1,n}, \tag{3.5}$$

where S_i – total amount of funding; $\varphi_i(S_i)$ – income of the i-th project; $y_i = (S_i - x_i)$ – lack of funds for project implementation; Z_i – net profit of the i-th project.

Also for calculation the artificial indicator q_i, which is calculated on (3.6), is necessary:

$$(1 - a_i)/l_i = q_i, \tag{3.6}$$

where a_i – efficiency; l_i – priority.

Substituting in formula (3.6) risk indicator (3.4) instead of the efficiency indicator and IIA indicator (3.3) instead of the priority indicator, the calculation of the artificial indicator q_i is performed:

$$(1 - SV)/S_{rj} = q_i, \tag{3.7}$$

where SV – risk (semivariation); S_{rj} – IIA.

To determine the number of regions to participate in regional development programs in general, we found the maximum value of n that would satisfy the inequality:

$$q_i < Q_n/(n-1), \tag{3.8}$$

where Q_n – sum of artificial indicators q_i corresponding to n.

When condition (3.8) is not met, the relevant regions are excluded from the list of candidates.

3.5 IDENTIFICATION OF TERRITORIAL CELLS FOR THE DISTRIBUTION OF STATE FINANCIAL SUPPORT

Based on the statistical data on the indicators, presented in **Table 3.1**, which are in the public domain, using formulas (3.1)–(3.3), IIA was calculated. As this study is conducted on the example of Ukraine, the values of IIA are presented by region of Ukraine (**Table 3.2**).

Table 3.2 IIA of Ukraine (2018)

Region	S_{rj}
Vinnytsia	0.408514
Volyn	0.355415
Dnipropetrovsk	0.422116
Donetsk*	0.458794
Zhytomyr	0.369553
Zakarpattia	0.374684
Zaporizhzhia	0.405340
Ivano-Frankivsk	0.373391
Kiyv	0.406496
Kropyvnytskyi	0.383469
Luhansk*	0.403544
Lviv	0.356200
Mykolaiv	0.398673
Odesa	0.396466
Poltava	0.410794
Rivne	0.361749
Sumy	0.376327
Ternopil	0.352696
Kharkiv	0.395974
Kherson	0.377155
Khmelnytskyi	0.363777
Cherkasy	0.398636
Chernivtsi	0.431203
Chernihiv	0.363765
Kyiv City	0.569373

*Note: * – data on the area, controlled by the territory of Ukraine; generalized by the authors on the basis of research [19, 28]*

It should also be noted, that during the anti-terrorist operation in the Donetsk and Luhansk regions of Ukraine, the data for evaluation were taken exclusively from the controlled areas of these regions.

The results of the calculation of risk (semivariation) are made according to formula (3.4) and are presented in **Table 3.3**.

Table 3.3 Risk calculation by regions of Ukraine [19]

Region	***SV*, %**
Ternopil	0.81
Kyiv City	0.96
Luhansk*	1.28
Khmelnytskyi	1.42
Lviv	1.69
Kropivnitsky	2.03
Chernihiv	2.31
Poltava	2.71
Zaporizhzhia	2.85
Volyn	2.93
Ivano-Frankivsk	3.05
Odesa	3.06
Kiyv	3.65
Kherson	3.70
Rivne	3.74
Zakarpattia	4.07
Kharkiv	4.21
Dnipropetrovsk	4.49
Donetsk*	5.50
Cherkasy	5.58
Vinnytsia	5.58
Sumy	8.78
Mykolaiv	9.65
Chernivtsi	11.37
Zhytomyr	20.03

*Note: * – data on the area, controlled by the territory of Ukraine*

Based on the calculations, the regions are grouped by level of risk, namely:

1. 0–3 % – low-risk regions (Kyiv City, Ternopil, Luhansk, Khmelnytskyi, Lviv, Kropyvnytskyi, Chernihiv, Poltava, Zaporizhzhia and Volyn regions);

2. 3–6 % – regions with an average level of risk (Ivano-Frankivsk, Odesa, Kyiv, Kherson, Rivne, Zakarpattia, Kharkiv, Dnipropetrovsk, Donetsk, Cherkasy and Vinnytsia regions);

3. >6 % – regions with a high level of risk (Sumy, Mykolaiv, Chernivtsi and Zhytomyr regions).

Thus, we get a list of regions – applicants for state financial support, namely: Ivano-Frankivsk, Odesa, Kyiv, Kherson, Rivne, Zakarpattia, Kharkiv, Dnipropetrovsk, Donetsk (controlled territory of Ukraine), Cherkasy, Vinnytsia, Sumy, Mykolaiv, Chernivtsi and Zhytomyr regions.

For the implementation of the program of state financial support, the emphasis was placed on financing the least priority areas. In conditions of a shortage of funds and provided that such regions have less chances to attract an investor than others, it is they who need state financial support.

3.6 DETERMINING THE FUNDING SHARE

To determine the share of funding, it is necessary to calculate q_i. The initial data for the calculation are presented in **Tables 3.2, 3.3**.

The calculation of q_i is carried out according to formula (3.7). When determining state financial support for non-priority territorial cells, according to the proposed methodology, it is necessary to line up applicants in ascending order of q_i value. The calculation results are presented in ascending order in **Table 3.4**.

According to the calculation results, presented in **Table 3.4**, it is possible to conditionally distinguish three groups of areas, applying for funding. Moreover, group 1 is the weakest area. The distribution into groups is as follows:

1) group – Zhytomyr, Donetsk, Chernivtsi, Dnipropetrovsk and Vinnytsia regions;

2) group – Cherkasy, Mykolaiv, Kiyv, Odesa and Kharkiv regions;

3) group – Sumy, Kherson, Zakarpattia, Ivano-Frankivsk and Rivne regions.

The algorithm of the procedure for determining the number of candidate regions for participation in the distribution of state financial support can be represented by inequality (3.8).

Let us check the fulfillment of the given condition for the set of obtained values of q_i. The check is performed as long as condition (3.8) is satisfied.

The calculation results are presented in **Table 3.5**.

Since condition (3.8) is not met for $n=11$, the calculations are terminated. 10 regions for state financial support were identified, namely: Zhytomyr, Donetsk, Chernivtsi, Dnipropetrovsk, Vinnytsia, Cherkasy, Mykolaiv, Kiyv, Odesa, Kharkiv regions.

Further, the values of the share of financing are calculated in proportion to the obtained $Q_n/(n-1)$ and the results are presented in **Table 3.6**.

Table 3.4 The value of q_i in ascending order

Region	q_i value
Zhytomyr	1.62683
Donetsk*	2.09440
Chernivtsi	2.13310
Dnipropetrovsk	2.23895
Vinnytsia	2.29833
Cherkasy	2.33897
Mykolaiv	2.34252
Kiyv	2.35721
Odesa	2.38860
Kharkiv	2.44940
Sumy	2.50048
Kherson	2.53609
Zakarpattia	2.54801
Ivano-Frankivsk	2.58040
Rivne	2.64686

*Note: * – data on the area, controlled by the territory of Ukraine*

Table 3.5 Checking the fulfillment of condition (3.8)

Regions number, n	q_i	$\sum q_i$ corresponding to n, Q_n	$Q_n/(n-1)$	Checking the fulfillment of condition (3.8)
2	2.09440	3.72123	3.721234	$3.721234 > q_2$
3	2.13310	5.85433	2.927168	$2.927168 > q_3$
4	2.23895	8.09328	2.697765	$2.697765 > q_4$
5	2.29833	10.39161	2.597906	$2.597906 > q_5$
6	2.33897	12.73058	2.546120	$2.546120 > q_6$
7	2.34252	15.07310	2.512187	$2.512187 > q_7$
8	2.35721	17.43031	2.490049	$2.490049 > q_8$
9	2.38860	19.81891	2.477368	$2.477368 > q_9$
10	2.44940	22.26831	2.474261	$2.474261 > q_{10}$
11	2.50048	24.76879	2.476883	$2.476883 < q_{11}$

● **Table 3.6** The results of calculating the share of financing at $K=1$

Region	Share of financing at $K=1$
Zhytomyr	0.1382
Donetsk*	0.1087
Chernivtsi	0.1002
Dnipropetrovsk	0.0965
Vinnytsia	0.0946
Cherkasy	0.0933
Mykolaiv	0.0925
Kiyv	0.0920
Odesa	0.0919
Kharkiv	0.0920

*Note: * – data on the area, controlled by the territory of Ukraine*

Thus, state financial support will be distributed according to the principle of «the greatest state support to the weakest», which corresponds to the goal of the study – to eliminate the regional imbalance in the state on the way of its innovative development.

3.7 DISCUSSION OF THE RESULTS OF DETERMINING STATE FINANCIAL SUPPORT FOR NON-PRIORITY TERRITORIAL CELLS

A large number of funding methods was proposed by researchers [19, 26–28, 31, 33–35]. In contrast to them, where preference for financing is given to objects that have high investment attractiveness and, accordingly, high priority, the proposed author's methodology is focused on determining financial support for non-priority territorial cells (regions). This became possible by applying the integrated approach to determining state financial support for the latter, which are not leaders in priority for an investor and have a high level of riskiness of investing funds. Comprehensiveness is ensured by the use of IIA and risk. Based on statistical data on the indicators, presented in **Table 3.1**, which are in the public domain, with the help of formulas (3.1)–(3.3), the calculation of IIA has been carried out. The results of calculating the risk have been made according to formula (3.4), based on the results of which the regions are grouped by the level of risk. The results of calculating IIA and risk have been summarized. The list of regions – applicants for state financial support has been received. Further, the values of the share of financing have been calculated in proportion to those, obtained in **Table 3.5** results.

Unlike existing methods, the author's methodology allows providing financial state support for regions that have the worst values of IIA and risk, which makes it possible to eliminate the regional

imbalance in the state on the way of its innovative development. Funding is carried out according to the principle of «the greatest state support to the weakest».

The results of the author's study are a laconic continuation of studies, carried out both at the local level [19, 41, 42] and in Africa [43] and Asia [44–46].

This study is practically interesting for public authorities in determining and allocating public funds, and theoretically – for researchers, involved in the financial support of the components of the road transport complex and public administration. The general provisions of the section are covered in [47].

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4 TRANSPORT AND LOGISTICS SERVICES AS A COMPONENT OF THE TRANSPORT COMPLEX AND THEIR QUALITY MANAGEMENT

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ABSTRACT

Section 1 of this monograph discussed the impact of the quality of education on the development of both the individual sector and the country as a whole. In this section we will talk about one very powerful component of the transport complex of each country – transport and logistics services. During the transition of Ukraine's economy to an innovative path of development, the processes of specialization, concentration and cooperation of industrial, agricultural and other industries should be strengthened, which leads to continuous growth of cargo transportation and requires further improvement of transport and logistics management methods, introduction of advanced logistics technologies. That is, the key to the development of logistics and the market of transport and logistics services is the effective management of their quality. The main problems of quality of Ukrainian logistics are considered in the work. Quality management of transport and logistics services is a permanent purposeful process for the formation and development of relations with consumers, associated with the provision of a range of logistics services. The basic principles of quality management have been substantiated: orientation on requirements, constant communication with consumers of logistic services; building mutually beneficial relationships with consumers and staff of an enterprise; flexibility of the system of transport and logistics customer service and others. Methodological support for quality management of transport and logistics services has been developed, which includes a certain procedure and a set of appropriate methods for implementing this activity based on the application of the scenario approach and algorithmization of procedures for obtaining possible states of operation of modern transport and logistics sector.

KEYWORDS

Quality, transport and logistics service, quality management, quality management process of transport and logistics services, quality of the logistics process, order terms, quality management strategies.

4.1 TASKS OF QUALITY MANAGEMENT IN TRANSPORT AND LOGISTICS SYSTEMS

Under modern conditions in connection with the expansion of economic ties, international trade, globalization of companies the market of transport and logistics services is actively developing [1]. There is a natural increase from 4 % to 10 % annually. The largest volumes of transport and logistics services are in the United States, the European Union and China, accounting for 23 %, 20 % and 17 % of the world, respectively. Among the EU countries, Germany has the largest share (4 %).

By 2024, the global logistics services market is projected to reach $ 236 billion. There will be an annual increase in CAGR from 7.5 % in monetary terms and 6 % in quantitative terms.

Ukraine's share in the world logistics market does not exceed one percent. The domestic market of logistics services is at the stage of formation and consolidation of the industry; significantly inferior to Western countries not only in volume but also in quality and complexity of services.

The transport sector of Ukraine's economy meets only the basic needs of enterprises and the population in transportation. At the same time, the level of safety, quality and efficiency indicators of passenger and cargo transportation, energy efficiency, technogenic load on the environment do not meet modern requirements: standards and requirements of the European Union.

It should be added, that the coronavirus pandemic has caused a forced reduction in traffic, intensified the struggle for the client. The transportation market has become more competitive. Priorities in the choice of logistics operator and transport service provider have changed significantly. When choosing a transport service provider, the main attention is paid to the reliability and guarantees of timely execution of orders, contrary to the fact that before the pandemic the main factor in choosing a transport company was the cost of transportation. In this regard, the key to winning markets and customers is the quality of the company's offer in the field of products and services. Its constant improvement becomes the main task of quality management in transport and logistics systems.

4.2 PROBLEMS AND PROSPECTS OF QUALITY MANAGEMENT OF TRANSPORT AND LOGISTICS SERVICES

Problems of quality of Ukrainian logistics and quality management of transport and logistics services are the attention of many domestic and foreign scientists.

Many studies with a practical focus are primarily related to the quantitative assessment of the logistics services market, logistics efficiency, the ranking of logistics companies in terms of gross turnover, consumer feedback, and so on.

The logistics market of Ukraine includes various types of freight: rail, road, air, water (sea and river). The most developed is the type of rail transport, which according to 2020 is 56.1 % of the market. The smallest share of this market is occupied by air transport (0.1 %). It should be noted, that the structure of freight traffic has changed over the last 5 years (**Fig. 4.1**).

There is a tendency to reduce the share of rail transport from 61.85 % in 2015 to 56.1 % in 2020, and, as a consequence, increase the share of road transport from 10.9 % to 20.8 %, respectively.

The World Bank publishes the Logistics Performance Index (LPI) in its research every two years. With the help of this indicator it is possible to make comparisons between the countries of the world and to define problems and opportunities in the field of logistics. The following are used as the main evaluation criteria: efficiency of customs and border clearance (customs);

quality of trade and transport infrastructure (infrastructure); simplicity of organization of international transportations at competitive prices (international shipments); quality and competence of logistics services (logistics quality and competence); tracking of cargoes (tracking & tracing); timeliness of cargo deliveries (timeliness) – **Table 4.1** and **Fig. 4.2**.

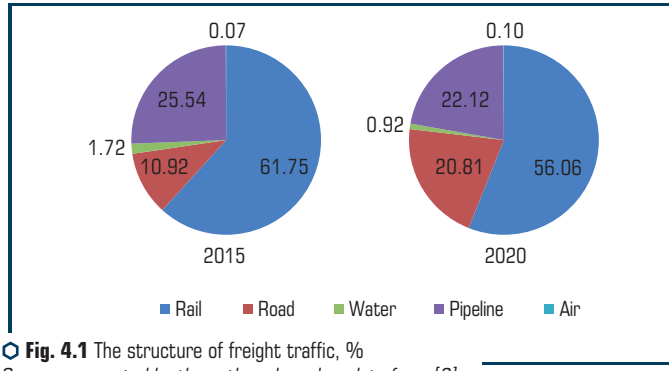

Fig. 4.1 The structure of freight traffic, %
Source: generated by the authors based on data from [2]

Despite the positive dynamics in relation to the rating of Ukraine on this indicator (from 102 place in 2010 it rose to 66 place in 2018), in 2018 the overall level of logistics services in Ukraine is estimated at 2.83 points out of 5 possible. In particular, the assessment of the level of quality and competence was 2.84 points.

In Ukraine, the most developed indicator is the timeliness of cargo deliveries (as of 2018 it is 3.42 points), and the least developed is the infrastructure indicator (2.22 points).

Table 4.1 The dynamics of the Logistics Performance Index (LPI) in Ukraine*

LPI components	Years				
	2010	2012	2014	2016	2018
LPI Rank	102	66	61	80	66
LPI Score	2.57	2.85	2.98	2.74	2.83
Customs	2.02	2.41	2.69	2.30	2.49
Infrastructure	2.44	2.69	2.65	2.49	2.22
International shipments	2.79	2.752	2.95	2.59	2.83
Logistics competence	2.59	2.85	2.84	2.55	2.84
Tracking & tracing	2.49	3.15	3.2	2.96	3.11
Timeliness	3.06	3.31	3.51	3.51	3.42

** Source: generated by the authors based on data from [3]*

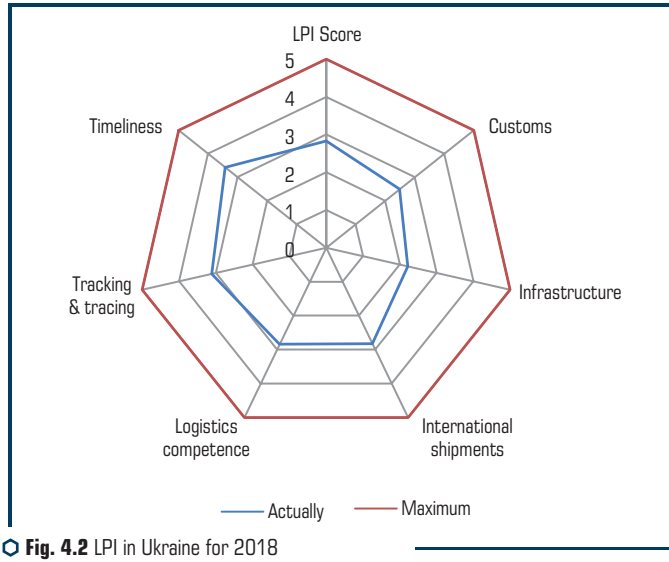

Fig. 4.2 LPI in Ukraine for 2018

The editorial board of one of the leading profile media magazines MINTRANS has prepared a list of the largest logistics companies, operating in Ukraine (**Table 4.2**).

Table 4.2 The general characteristics of the largest logistics companies in Ukraine

Company name	Country of origin	Staff number, pers.	Strengths	Gross turnover, 2019
1	**2**	**3**	**4**	**5**
Küehne + nagel (1992)	Switzerland	450	maritime and aviation logistics, automotive and contract logistics with a focus on integrated logistics solutions	1100
DSV logistics (2013)	Denmark	180	international road transport, sea container transportation, air transportation, design, warehousing logistics, distribution, customs brokerage services and cargo insurance	900
FM logistics Ukraine (1996)	France	900	distribution of consumer goods, cosmetics and beauty, industry and healthcare; manages operations on more than 57,000 m^2 of Class A warehouse platforms	800
Raben (2003)	Netherlands	500	warehousing logistics, international and domestic freight, customs and sea freight, Fresh Logistics (service of fresh products that require temperature from 0 °C to +6 °C)	600

● **Continuation of Table 4.2**

1	2	3	4	5
Ekol Ukraine (2012)	Turkey	680	Rainbow goods accounting system, which allows a customer to see the actual quantity of goods, the need to replenish stocks, allows you to track the history of goods at all stages of the logistics chain	550
Zammler (2007)	Ukraine	625	services in the field of road, sea, rail, air transportation, customs brokerage and a full range of warehousing services	550
Pakline logistics (2004)	Ukraine	882	logistics consulting services, fulfilment using conveyor lines, storage and warehousing logistics services, express courier delivery in Ukraine and the world, cold logistics for pharmaceuticals and FMCG, services for online stores	500

There is a rating of logistics companies in Ukraine, which is based on the analysis of reviews, left in Google maps, company websites, specialized forums, etc.

The leaders of the rating are Ubi-logistic and Wheltrans – **Table 4.3**.

● **Table 4.3** The rating of logistics companies in Ukraine*

Rating position	Company name	Work directions
1	Ubi-logistic	full cycle of logistics services; emphasis on speed, reliability and convenience
	Wheltrans	
2	YURIS GRUP	freight transportation by various modes of transport, warehousing logistics services
3	PROFI CARGO SERVICE	professional in the field of foreign economic activity, customs brokerage services; international sea freight – one of the priority services in the range
4	KOSMOS LTD (Dnipro)	road transport within Ukraine, import/export, sea container transportation under one-time and long-term contracts, as well as projects «Outsourcing of the transport problem», transportation of oversized cargo, consultations on any issues of delivery
5	GREIMAR, LTD (Odesa)	organization of international transportation by road in all directions; warehousing and forwarding services in the port of Chernomorsk

** Source: generated by the authors based on data from [4]*

Theoretical research on quality management of transport and logistics services is mainly limited to coverage of the evaluation and organization of logistics services; implementation of qua-

lity standards, studying the experience of implementing quality management systems in logistics companies, etc.

Most publications of domestic and foreign authors [5–9] deal with the application of various methods of assessing the quality of logistics services, establishing the reasons for non-compliance with the requirements, stated by consumers, and so on. For example, [5] presents the results of the study of how logistics services affect customer satisfaction. The following factors of quality of logistics services were measured: contact with the staff quality, order status, timeliness, processing of discrepancies in an order and exchange of operational information in logistics services. It has been proved, that there are significant links between timeliness, order conditions, quality of contacts with staff, prompt exchange of information and perception of customer satisfaction in logistics services.

In [6], a service model was developed in logistics services for the delivery of documents and packages by studying the relationship between the elements of service and customer perception (ie Kansei); in [7] the quality of ground staff service at Don Muang International Airport was evaluated by comparing the perception of ground staff quality by service (quality criteria reliability, kindness, confidence, empathy and perceptivity were used).

Works [8–12] are devoted to the development of general theoretical provisions of quality management of transport and logistics services.

In [10] the general theoretical provisions concerning quality management of services of transport and logistics companies are resulted. The concept of quality management as «the process of influencing the production of services by the top management of a transport and logistics company, middle and lower managers who perform management functions to ensure the required quality» is presented [10]. The debatable points of this definition are, first of all, the emphasis on the fact that the process is carried out only by the management of various links, all employees of an enterprise should be involved in quality management. Secondly, there is no purposefulness of such a process (ensuring the required quality does not fully reflect all the goals of modern management) and the specifics of the activities in the logistics sector.

The undoubted merit of the authors of this work is the development of an algorithm for managing the quality of services of transport and logistics companies in order to improve the clarity of processes and mechanisms that arise in the process. This algorithm allows you to assess the current and forecast levels of quality of logistics services and develop the necessary measures to improve quality. At the same time, it should be noted, that the implementation of activities according to this algorithm requires refinement of the principles and methods of quality management, establishing the concept of logistics management, etc.

The main provisions of the implementation of the integrated approach to quality management of transport services are contained in [11]. The quality management system is considered as an effective system that combines the activities of different divisions of a logistics provider with its business partners and customers, which ensures the maintenance of the required or achieved level of quality, as well as its improvement to ensure production and logistics services at the most economical level to meet customer requirements completely. This approach is implemented

through the Gap-model for estimating differences in the quality of customer service of the logistics provider.

In modern research, much attention is paid to the standardization of quality management activities, including logistics companies, given that for Ukraine, which aspires to join the EU, there is a requirement to implement at the national level at least 80 % of existing standards of the EU.

Thus, in [12] the role of standardization as a way to improve the quality of logistics services is highlighted, the main European standards of quality management in freight chains are considered: CEN/TR 14310:2002. Freight transport services. Declaration and reporting on environmental performance in freight chains; EN 12507:2005 Transport services; EN ISO 9001:2000 Transport services. Appropriate transport chains System for declaring the conditions of activity; EN 2798:2006 Transport quality management systems. Road, rail and inland water transport. Quality management system requirements in addition to EN ISO 9001 for the transport of dangerous goods in terms of safety; EN 3876: 2002 Transport. Logistics and services. Appropriate transport chains; EN 5696: 2007 Individual storage. Specification for individual storage services [13].

In order to establish the quality management systems, most effective and implemented in the activities of logistics companies, relevant studies are conducted, the results of which are presented in [14, 15]. The paper [14] presents the results of the implementation of quality management systems in 2016–2017 in Lithuania. At the same time, 66 logistics companies, operating in the field of freight transportation, warehousing, production and trade, were analyzed. The study showed that most companies have implemented ISO quality management systems. The second most popular quality management system is LEAN, with just over 3 percent of companies surveyed using Agilesystem.

In [15] a similar study was conducted on logistics companies in Bulgaria and proved that the introduction and certification of quality management systems is a necessity to ensure the competitiveness of products. It has been established, that 12.5 % of companies in the field of logistics are certified in accordance with ISO 14001: Standard Environmental Management 2015. For manufacturing companies, this percentage is 20.5 %, which is much higher.

Occupational safety and health management system BS OHSAS 18001:2007 is used by 17.9 % of manufacturing companies and only 5.9 % of companies in the field of logistics.

The analysis of practical experience and theoretical provisions on quality management of transport and logistics services indicates a low level of scientific and methodological support of this activity, which indicates the need to improve them, taking into account modern requirements.

4.3 METHODOLOGICAL ASPECTS OF QUALITY MANAGEMENT OF TRANSPORT AND LOGISTICS SERVICES

The theoretical position of this research is the conceptual approach to quality management of transport services, which is presented in [12]. It is based on the principles of logistics management, customer relationship management, harmonization of the enterprise management system

based on quality and the use of the principles of a synergistic system approach. It provides for the integration of the principles of TQM and logistics, the application of the variable approach to the choice of technologies to improve the processes of transport and logistics services; comparison of evaluation by consumers of motor transport services with evaluation of the quality of its formation processes.

The quality of transport and logistics services is primarily determined by the needs and demands of consumers. In this case, a provider of such services (logistics operator) is obliged to present to the client the maximum possible set. Transport and logistics service will be high-quality only when consumers have the opportunity to choose for themselves the operations they really need from the wide range of services offered.

The list of offered types of transport and logistics services includes logistics activities, related to the transportation of goods or passengers and the provision of additional services. For example, the complex of services for loading and unloading of goods includes: loading and unloading of vehicles, respectively, at stations (ports) of departure and destination, in the warehouses of consignors and consignees; formation and development of packages; repair of transport packaging; packing, binding, covering of cargoes; loading of cargoes into containers and unloading from them.

The list of warehousing services includes the following: storage and transshipment of goods; their sorting, marking; reception and delivery of goods, checking the number of seats, weight, appearance of the cargo, the condition of the container and packaging; acquisition of small consignments of goods or consolidation of cargo units; unbundling of shipments for delivery to consignees.

Based on the analysis of definitions of the concept of quality, highlighting their essential characteristics, we provide the following interpretation. The quality of transport and logistics services (service) is a set of properties and characteristics that arise as a result of consumer interaction with suppliers (other stakeholders), RTE (other transport and logistics companies), associated with the movement of goods and (or) passengers in space and in time with the use of vehicles, providing the necessary set of services, the degree (level) of which allows to meet various socio-economic needs that are constantly changing.

The set of such properties and characteristics (delivery time, delivery speed, service rhythm, cargo storage, route flexibility, etc.) is formed as a result of interconnected activities, resources and system. A chain of relationship between resources, system, processes and results is formed.

Quality management of transport and logistics services is a permanent purposeful process of formation and development of relations with consumers, related to the provision of a range of logistics services that meet the needs of consumers.

In the management of the quality of transport and logistics services, in our opinion, the main principles should be considered the following: focus on requirements, constant communication with consumers of logistics services; building mutually beneficial relationships with consumers and staff of an enterprise; the relationship of customer service logistics with marketing, financial management and quality management; flexibility of the system of transport and logistics customer service; basing decisions only on facts and not on the situation or experience of employees of an organization;

attention to processes, considering them as the optimal maximization of product value for a consumer and minimization of its cost, both for the consumer and a provider.

The implementation of these principles is combined with specific principles of logistics (**Table 4.4**).

Table 4.4 The principles of quality management of transport and logistics services

General principles of quality management	Specific principles of logistics
Focus on requirements, constant communication with consumers of logistics services	Determination of the end result as the purpose of a flow in accordance with the economic, technical and other requirements of the system
	Establishment of consumer value
	Research of customer behavior models
	Compliance with a set of environmental requirements
	Systematization and use of complaints in further work as a learning material for employee training
Setting of mutually beneficial relationships with consumers and staff	Coordination of actions of all participants, involved in the formation and management of a flow, including direct and indirect
	Data personalization
Relationship of logistics customer service with marketing, financial management	Formation of all types of provision and maintenance of a flow, ie its infrastructure
	Implementation of flow management and achievement of the goal with minimal cost
	Use of modern technical means of management – control and regulation of flow parameters
decisions based only on facts	Strengthening the calculation principle at all stages of flow management, including planning, regulation, accounting, control, analysis
	Flow scheduling – continuous tracking of movement and change of each object of a flow and adjustment of its parameters
Procedural approach	Formation of a flow as a control object
	Ensurance of flow reliability
	Regulation of the process of providing transport and logistics services

The algorithm of the process of quality management of transport and logistics services, based on the main directions of meeting the needs of the modern transport and logistics sector, is built in the form of a block diagram and is shown in **Fig. 4.3**.

Block 1 is designed to enter all the source information, needed to make optimal management decisions. Such information is a set of data on the quality of logistics services by their respective types in terms of three components: quality of the logistics process (service), duration of services (service time) and price compliance.

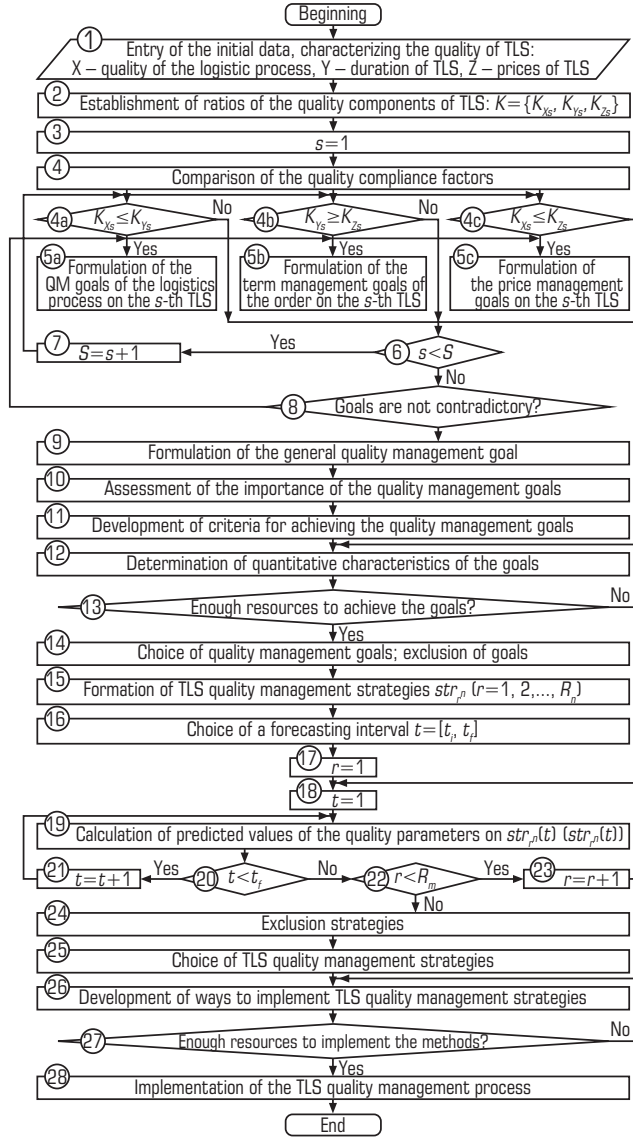

Fig. 4.3 The algorithm of the process of quality management of transport and logistics services

The quality of the logistics process (service) includes the implementation of various types of consumer requirements for the complex of declared services. The criteria for assessing the quality of the logistics process should include:

– availability of goods in stock (possibility of instant delivery from stocks that are in stock at a supplier);

– flexibility of supply (ability to adapt time (for example, time of day and night), size, range and method of supply to customer expectations: willingness to deliver at night, small batches of goods, environmentally hazardous goods, etc;

– frequency of deliveries (during the day, day, week, month);

– reliability of deliveries (competence and punctuality of expected deliveries, timeliness of deliveries with a small number of errors and losses);

– convenience of documentation and others.

The next criterion for assessing the quality of transport and logistics services is the duration (service time), ie the interval between the receipt of an order for the supply of products and the receipt of the ordered products by the consumer.

This indicator should also be considered from the consumer's point of view as the compliance of transport and logistics services over time (maximum delivery speed is not always required if it will lead to increased logistics costs and higher service costs). In this case, such compliance should be considered in terms of time of ordering, time of order processing, time of preparation of the order for shipment and time of delivery of the ordered goods.

The price of logistics services should be considered as a means of ensuring compliance with customer requirements (high quality at the best price); flexibility and adaptability of the service to market conditions and one of the ways to optimize the total logistics costs.

The initial data for modeling the process of quality management of transport and logistics services will be the appropriate sets:

$$X=\{x_{is}\};\ Y=\{y_{js}\};\ Z=\{z_{rs}\}, \tag{4.1}$$

where X – set of data on the quality of the logistics process when providing s-logistics service $i=\overline{1,n}$, n – number of quality indicators of the logistics process; Y – set of data on compliance with the deadlines for the provision of s-logistics service $j=\overline{1,m}$, m – number of indicators that assess the compliance with the deadlines; Z – set of data on the price of s-logistics service, $r=\overline{1,k}$, k – number of indicators that assess the compliance of the price of logistics services to the stated requirements; $s=\overline{1,S}$, S – number of transport and logistics services.

The level of satisfaction of the relevant requirements for the quality of the logistics process is set by surveying consumers to provide transport and logistics services on a five-point scale (1 point – the requirement is insignificant; 2 points – the requirement is below average; 3 points – the requirement at the average level; 4 points – the requirement above the average level; 5 points – the requirement is high) with the following assignment of appropriate relative values: 0.2; 0.4; 0.6; 0.8 and 1.0.

Conformity of performance over time is assessed by comparing with the average value in the market of transport and logistics services on the following scale:

– delivery time is less than the average by more than 10 %;

– delivery time is less than the average by less than 10 %;

– delivery time is equal to the average;

– delivery time exceeds the average by no more than 10 %;

– delivery time exceeds the average by more than 10 %.

It is also proposed to compare the price compliance indicator with the average industry level. The rating scale is similar to the previous scale.

As a result of work of this block of algorithm we will receive matrices of data on quality of transport and logistic services:

$$\text{A. } X\begin{pmatrix} x_{11} & x_{12} & \dots & x_{1i} & \dots & x_{1n} \\ x_{21} & x_{21} & \dots & x_{2i} & \dots & x_{2n} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ x_{s1} & x_{s2} & \dots & x_{si} & \dots & x_{sn} \\ x_{S1} & x_{S2} & \dots & x_{Si} & \dots & x_{Sn} \end{pmatrix},$$

$$\text{B. } Y\begin{pmatrix} y_{11} & y_{12} & \dots & y_{1j} & \dots & y_{1m} \\ y_{21} & y_{21} & \dots & y_{2j} & \dots & y_{2m} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ y_{s1} & y_{s2} & \dots & y_{sj} & \dots & y_{sm} \\ y_{S1} & y_{S2} & \dots & y_{Sj} & \dots & y_{Sm} \end{pmatrix},$$

$$\text{C. } Z\begin{pmatrix} z_{11} & z_{12} & \dots & z_{1r} & \dots & z_{1k} \\ z_{21} & z_{21} & \dots & z_{2r} & \dots & z_{2k} \\ \dots & \dots & \dots & \dots & \dots & \dots \\ z_{s1} & z_{s2} & \dots & z_{sr} & \dots & z_{sk} \\ z_{S1} & z_{S2} & \dots & z_{Sr} & \dots & z_{Sk} \end{pmatrix}. \quad (4.2)$$

Block 2 involves procedures for establishing indicators (coefficients) that characterize the ratio of quality components, namely the conformity of process quality to timing, the conformity of price processes and the ratio of timing and price:

$$K = \{K_{Xs}, K_{Ys}, K_{Zs}\}, \quad (4.3)$$

where K_{Xs}, K_{Ys}, K_{Zs} – coefficients that characterize the ratio of quality components, namely the compliance of process quality with deadlines, the compliance of price processes and the ratio of terms and prices when performing *s*-transport and logistics services.

Blocks 3–7 are cycles of comparison of coefficients of conformity for different transport and logistics services. Block 3 begins this cycle, ie the first ($s=1$) transport and logistics service, provided by a logistics company, is considered.

Blocks 4a–5a, 4b–5b and 4c–5c can be implemented in parallel.

Block 4a presents a comparison of the coefficients that characterize the ratio of quality indicators of the service process and the timing of the order on the s-th transport and logistics service. If this ratio does not exceed 1, ie there are shortcomings in meeting the quality requirements of the service process, it is necessary to decide on the goal of quality management (increase reliability, ensure flexibility of delivery, etc.) and define these goals (block 5a). At the same time, attention should be paid to the unambiguity of the goals, ie their content, size and timing; operability – their measurability.

Otherwise (if all comparisons are made for the s-th transport and logistics service) – go to the comparisons of indicators on the next ($s=s+1$) transport and logistics service (blocks 7a and 7b), provided that no comparison has been made for all types of transport and logistics services ($s<S$ – block 6).

Similarly, a comparison of the coefficients that characterize the ratio of time and price and the ratio of service quality and price on the s-th transport and logistics service is carried out.

We obtain the initial data for the analysis of the ratio of quality indicators of transport and logistics services $P_1'(\tau=[t_i,t_f])$, where t_i – initial, t_f – final moments of modeling (**Table 4.5**).

Table 4.5 The initial data for the analysis of the ratio of quality indicators of transport and logistics services

Actions	Comparison					
	X* and *Y		***Y* and *Z***		***X* and *Z***	
Comparison made	$K_{X_s} \le K_{Y_s}$	$K_{X_s} > K_{Y_s}$	$K_{Y_s} \ge K_{Z_s}$	$K_{Y_s} < K_{Z_s}$	$K_{X_s} \le K_{Z_s}$	$K_{X_s} > K_{Z_s}$
decision on the goals of quality management made	yes (decision on goal setting)	no	yes (decision on goal setting)	no	yes (decision on goal setting)	no

Block 8 implements the verification of the goals of quality management in terms of its various components for consistency. Consistency means compatibility, absence of contradiction – a logical criterion of correctness of the formulated goals of motivation. Thus, the comparison is carried out in pairs on the corresponding types of goals by assignment of signs «+» – at consistency of the goals and «–» – in the opposite case (**Table 4.6**).

If the goals of quality management of the logistics process and the goals of quality management at the time of an order do not contradict each other, we move on to the next block, otherwise – it is necessary to return to the formulation of relevant goals (blocks 5a and 5b) and either adjust them or exclude some.

Table 4.6 Checking the goals of quality management in terms of its various components for consistency

Quality management goals of the logistics process	Quality management goals for order time			
	G_{p1}	…	G_{pj}	G_{pm}
G_{p1}	+(–)	…	+(–)	+(–)
…	…	…	…	…
G_{pi}	+(–)	…	+(–)	+(–)
G_{pn}	+(–)	…	+(–)	+(–)

Block 9 formulates the overall goal of quality management of transport and logistics services (QMG) of an enterprise. The goal formation process is implemented «bottom up» (as opposed to the traditional sequential hierarchical distribution of the main goal in sub-goals – «top down»), ie goals of a lower hierarchical level – quality management goals of the logistics process and quality management goals at the time of an order form a higher level goal. Therefore, the overall goal of quality management of transport and logistics services consists of many goals of quality management of the logistics process, and quality management of the time of ordering, quality management of the price of services, which are included in the overall set of quality management goals (G):

$$GQM = <\{G_{pm}\}, \{G_{tm}\}, \{G_{prm}\}> \cup G. \quad (4.4)$$

Blocks 8 and 9 are logical operations, performed by specialists. The effectiveness of their implementation depends on many factors: the degree of knowledge of the problem, scientific foresight, personality traits and qualifications, behavior, intuition, and others. These operations are the mental conclusions of experts and are not subject to automation.

Block 10 provides an assessment of the importance of goals. The degree of importance of goals, the numerical characteristics of which are called priorities – the prerogative of a person who makes such decisions. Priorities, assigned by specialists, are called coefficients of relative importance of goals.

The procedure of pairwise comparison method can be a tool for assessing the importance of goals [16–18].

For p goals, a matrix of size $p \times p$ with elements:

$$F_{fq} = 1, \text{ if } G_{qmf} > G_{qmq}; \quad (4.5)$$

$$F_{fq} = 0, \text{ if } G_{qmf} < G_{qmq} \ (f, q = \overline{1,p}). \quad (4.6)$$

This means: if the goal of quality management of transport and logistics services G_{qmf} is not less than the goal G_{qmq}, ie $G_{qmf} > G_{qmq}$, then at the intersection of the f-row and q-th column is 1, if the goal of G_{Mq} is better than the goal G_{Mf}, then put zero.

Next, the procedure consists of calculating the sum of the elements F_{fq} for all columns, ie the number of quality management goals, in comparison with which the G_{qm} is more important:

$$Fq = \sum_{q=1}^{p} F_{f,q};\ (f,\ q = \overline{1,p}). \tag{4.7}$$

Summarize the values of F_{fq} on all lines and set the coefficient of relative importance of the goals of quality management of transport and logistics services:

$$k_{B_f} = \frac{F_f}{\sum_{f=1}^{p} F_f},\ (f,q =). \tag{4.8}$$

In block 11, criteria for achieving the goals of quality management of transport and logistics services are developed. In this case, the criteria must adequately reflect the degree of achievement of goals, be measurable. Such criteria are the criteria-requirements (U_g), in accordance with which decisions are made on the adoption and implementation of goals.

The criteria for achieving the goals of quality transport and logistics services can be the parameters of different types of resources: financial (costs, required to achieve the goals); time (time, for which the goals are expected to be realized); human (whether the necessary qualifications, experience and so on in the staff who will implement the goals), etc. These parameters are determined based on restrictions on the use of resources, ie the criteria for achieving quality goals are the maximum possible management costs:

$$\sum_{f=1}^{p} G_{M_f} \le \left\{U_g \subset R_1, R_2, R_3, R_4\right\}. \tag{4.9}$$

Block 12 involves the definition of quantitative characteristics (if possible) of the quality management goals of transport and logistics services. The characteristics of the quality management goals are the necessary means to achieve them. For example, for the goal of «developing a system of rewarding employees of an enterprise for quality» the parameters of the goals will be: the availability of information resources that characterize the achievement of quality by individual employees; availability of financial resources – bonus fund; availability of human resources – employees, engaged in bonuses; availability of material resources – technical means for calculations, stationery, etc.

In general, we obtain the following matrix of goals (**Fig. 4.4**).

Block 13 provides an assessment of the quantitative parameters of the goals according to the relevant criteria, ie it is checked whether there are enough resources of different types, needed to achieve the goals. With sufficient resources – goals are accepted (1), otherwise – rejected (0). In case of insufficient resources, it may be necessary to return to block 12 and adjust the quantitative parameters of the goals or to blocks 5a and 5b and specify or exclude certain types of goals.

Goals	Goals parameters by criteria			
	R_1	R_2	R_3	R_4
G_{qm1}	$P_{G_{M11}}$	$P_{G_{M12}}$	$P_{G_{M13}}$	$P_{G_{M14}}$
. . .	. . .	. . .	. . .	. . .
G_{qmf}	$P_{G_{Mf1}}$	$P_{G_{Mf2}}$	$P_{G_{Mf3}}$	$P_{G_{Mf4}}$
G_{qmp}	$P_{G_{Mp1}}$	$P_{G_{Mp2}}$	$P_{G_{Mp3}}$	$P_{G_{Mp4}}$

Fig. 4.4 The goals matrix

In block 14, the final selection of quality management goals for transport and logistics services is carried out. The following options are possible:

1) if at the previous stage a decision was made to adopt goals, and these goals are important, they are included in the list for further development;

2) if at the previous stage a decision was made to exclude the goals, and these goals are unimportant, they are not included in the list for further development;

3) if at the previous stage it was decided to exclude the goals, and these goals are important, they are included in the list for further development, but require the search or attraction of additional funds for their implementation.

Block 15 provides for the development of quality management strategies for transport and logistics services in accordance with consumers and employees of an organization as possible options for achieving the selected goals:

$$str_{r_n}\ (r = 1,2,\ldots,R_n);\ str_{r_m}\ (r = R_{n+1},R_{n+2},\ldots,R_m), \tag{4.10}$$

where R_n – number of possible quality management strategies for transport and logistics services, related to consumers; R_m – number of possible quality management strategies for transport and logistics services, aimed at employees of the logistics company.

Currently, in the modern literature, a list of typical strategies for quality management of transport and logistics services is not developed; in practice, logistics service strategies are used.

The most common approach to the selection of types of logistics service strategies is to use the classification of strategies of M. Porter. According to this approach, the following service strategies are distinguished:

1) low service costs (cost leadership);

2) selection of a client (for example, strategy of a highly profitable client or strategy of «elimination» for consideration of buyers undesirable from the point of view of difficult and expensive logistical needs;

3) logistics skills, ie the formation of the ability to generate original knowledge in the future (for example, skills in the field of logistics information management or unique performance of one or two service elements, etc.);

4) the most important element of service (replacement parts supply strategy);

5) trade-offs, ie the art of using the relationship between costs and benefits of service, the achievement of which involves the implementation of a strategy of low costs and high standards of service.

For the purpose of practical realization of strategies of quality of logistic service and maintenance of a choice of more effective administrative decisions, it is offered to allocate such strategies concerning an object, ie that, on which realization is directed first of all, and a subject (on which to direct supposed changes in logistic service) – **Table 4.7**.

At the next stage (block 16) it is necessary to choose a forecasting interval $t = [\tau_i, \tau_f]$, that reflects the implementation of this strategy of quality management of transport and logistics services.

Then the cycle of calculation of forecast values of quality parameters is realized under the condition of realization of each developed strategy str_r. Block 17 begins this cycle by considering the first type of strategy $r=1$. In block 18, the first time period from the prediction interval $t=1$ is taken for calculations. Block 19 provides for the calculation of forecast values of quality parameters according to the strategy option str_r, of the formation of the forecast $F_1(t+1)$.

To calculate the predicted values of quality parameters for each strategy option, we build a matrix of changes in quality indicators for processes S. In this case, if the achievement of the indicator in the process S_1 contributes to the achievement of quality indicators in other processes, the influence with a sign «+» is put, if on the contrary, interferes – a sign «–». The strength of the interaction will be estimated by linguistic formulations and expressed in quantitative terms from the interval [–1; +1] in accordance with the scales, presented in **Table 4.8**.

Matrices for changing the forecast values of quality parameters for each strategy (str_r) will look like this (**Table 4.9**).

The change in the values of quality parameters for each strategy (ΔK_{str_r}) is determined taking into account the ratio of the various components of quality by the formula:

$$\Delta K_{str_r} = \sum_{r=1}^{R} \sum_{s=1}^{S} K_{X_s} ORK_{Y_s} \cdot b_{sr}, \qquad (4.11)$$

where OR – operator, which means the use of the values of the quality indicators of the logistics process K_{Xs} or TLS deadlines K_{Ys} or TLS price K_{Zs} in the formula; b_{sr} – influence degree of the strategy str_r on the change of quality parameters for different types of transport and logistics services.

Blocks 20–21 are designed to calculate forecast values for the entire forecasting interval $t < \tau_f$, ie if there is the transition to the calculation of the forecast for the next forecasting period, otherwise – to block 22: calculation of forecast values for the next strategy of motivating the quality of consumers or employees of an enterprise.

● **Table 4.7** The types of strategies for ensuring the quality of transport and logistics services

Strategy type	Realization direction	
	TLS consumer	**Worker**
Improvement of the logistics process quality	Creation of a TLS quality management system	Introduction of a bonus system for the quality of transport and logistics services
	Certification of the company's quality management system in accordance with national and international standards and procedures (in particular, ISO 9000)	Delegation of responsibility, involvement in decision-making (creation of autonomous working groups, quality circles), use of «Job» – factors (increase of content, enrichment of work)
	Development and use of customer logistics standards	
	Benchmarking	Application of payment systems according to goals and results, taking into account the degree of effort
	Use of logistics technologies to support the product life cycle	Implementation of the system of internal communications
	Organization of client selection	Encouragement of employees to perform high-quality tasks on time
	Identificatiion and use of the most important element of service	
Optimization of TLS realization terms	Ensurance of a minimum delivery time	Implementation of programs, aimed at reducing working hours, its regulation by various methods, increasing the number of vacation days (depending on working conditions and years of service)
	Optimization of logistics infrastructure location	Adjustment of work schedules
	Selection of the optimal transportation option	Use of the system of working off (penalty working hours)
Price strategy for TLS	Application of a flexible pricing system	Improvement of the level of qualification of employees (according to their personal capabilities and production needs)
	Reduction of logistics costs	Use of the system of fines: for administrative violations (lateness, non-fulfillment of the plan, etc.); deprivation of the prize for unsatisfactory results

● **Table 4.8** The scales of interaction strength

Linguistic scale	Numerical scale – b_s
Absent interaction	0 (empty cell)
Very weak	0.1
Weak	0.3
Middle	0.5
Strong	0.7
Very strong	0.9
Absolute	1.0

Table 4.9 The matrix of change of the forecast values of quality parameters at str realization

S	*S*				Forecast of changes in quality parameters
	1	2	...	*S*	
	Coefficients of quality components ratios				
	$K_{X_{s1}}(K_{Y_{s1}})$	$K_{X_{s2}}(K_{Y_{s2}})$	$K_{X_{s3}}(I_{Y_{s3}})$	$K_{X_{s5}}(K_{Y_{s5}})$	
1	+1	b_{1_r}	...	b_{1_r}	$\Delta\sum_{s=1}^{S} K_{X_s} ORK_{Y_s} \cdot ORK_{Zr} \cdot b_{1r}$
2	b_{2_r}	+1	...	b_{2_r}	$\Delta\sum_{s=1}^{S} K_{X_s} ORK_{Y_s} \cdot ORK_{Z_s} \cdot b_{2r}$
...	...	...	...	...	...
S	b_{S_r}	b_{S_r}	...	+1	$\Delta\sum_{s=1}^{S} K_{X_s} ORK_{Y_s} \cdot ORK_{Z_s} \cdot b_{Sr}$
Totally					ΔK_{str_r}

Blocks 22–23 are implemented similarly, presenting a list of all options for quality management strategies for transport and logistics services.

In block 24, the exclusion of options for strategies that do not allow to achieve the maximum possible quality indicators is carried out. In block 25 – quality motivation strategies are selected. At the same time it is possible to choose several options of a strategy at the same time, taking into account the need to achieve quantitative parameters of the formulated goals.

According to the selected variants of the strategy, ways (methods) of quality motivation are developed (block 26), the decision on their application is made on the basis of the conclusion about the sufficiency of resources for their implementation (block 27).

The adopted methods of quality motivation are subject to implementation and realization (block 28).

Thus, the methodological bases of modeling the process of quality motivation in the organization of transport and logistics services, based on the creation of structural scenarios; the developed algorithm of their realization and the corresponding methodical maintenance of performance of the corresponding stages, have been developed.

The main limitation of this section and all previous ones (Sections 1–4) is the lack of emphasis on one of the fundamental components of each sector, each industry of all countries without exception – an enterprise. The level of «enterprise» is the lowest, but most important. It is the functioning of enterprises that ensures the activities of both the sector and the industry in particular, and the country as a whole.

Therefore, the following sections of this study will be devoted to the issues of quality management with elements of innovation.

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5 MANAGEMENT OF A VIABLE ENTERPRISE ON THE BASIS OF THE APPROACH TO MANAGEMENT OF A «LIVING» ORGANIZATION AND THE CONCEPT OF VIABLE SYSTEMS

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ABSTRACT

The innovative vector of development is a modern approach to production, sales of services, etc., their adaptation to current societal requirements. It is provided by the transformation of scientific research and development, other scientific and technological achievements into a new or improved product, introduced to the market, into an updated or improved technological process, used in practice. Consequently, approaches to enterprise management are also transformed into modern realities and acquire shades of innovative approaches. Effective management is necessary to ensure the viability of enterprises, and new tools, methods and approaches to management are especially important here. The aim of the article is to develop theoretical provisions for the formation of a viability management system based on the concept of viable systems and the approach to managing an organization as a «living» system. The work identifies that effective viability management requires the creation of an organizational structure in an enterprise that will function as a «living organism». The representation of the enterprise system in the form of a living organism is considered. To form a holistic system of an enterprise, the systems of the human body are considered in more detail and the corresponding systems of the enterprise are determined. A set of functional subsystems of an enterprise by analogy with the systems of a living organism, the activity of which is interdependent, which ensures the stability of the «living organism» of the enterprise to the influence of external conditions has been formed. It has been determined, that in order to fully maintain the viability of an enterprise, it is necessary to study not only the «physical body» of the enterprise as a set of functional subsystems, but also its «soul» – corporate culture, which must be developed on the basis of paradigms of sustainable development and social responsibility.

KEYWORDS

Viable system, «living» organization, functional subsystem, management system, model, operating element, metasystem, biological system, economic system.

5.1 MANAGEMENT OF A VIABLE ENTERPRISE IN THE CONTEXT OF THE MANAGEMENT SYSTEM OF A «LIVING» ORGANIZATION

One of the most effective approaches to building an enterprise management system is the concept of a viable system of a firm. The multilevel recursive viable model of the enterprise management system, which is built on the basis of the concept of viable systems, has been improved. The object

in the management of a viable system is a set of basic systems of an enterprise, which are defined by analogy with the biological system. This model of the system is proposed as fundamental for the construction of other types of systems, which allows to form a management system at each level of recursion, ie the corresponding systems of an enterprise. The model allows the top management of an enterprise to generate, coordinate and adjust decisions on the functioning of the enterprise.

In the current economic crisis, caused by the coronavirus pandemic, the problem of ensuring the viability of enterprises is relevant, emphasizing the need to use new approaches to enterprise management. The coronavirus pandemic has broken the usual links between producers and consumers around the world and has made major changes in the business of transport and logistics companies. The spread of COVID-19 and the intensification of the coronavirus crisis have dealt a severe blow to global logistics and the supply chain of raw materials and finished products. This has put a large number of trucking companies in Ukraine and the world on the brink of extinction. From the point of view of management, the viability of enterprises in unstable conditions should provide effective management. Therefore, road transport companies need to look for new approaches to management. Perception of the new, adaptation to change and reasonable prediction of future development become the most important factors in the viability of enterprises as complex systems. Effective management is needed to ensure the viability of road transport enterprises, and new management tools, methods and approaches are especially important here.

Effective viability management requires the creation of an organizational structure in an enterprise that will function as a «living organism». Thus, the author A. Talalaev [1] determined that the management of an organization from the standpoint of living systems should be based on the principles of existence of living systems at different hierarchical levels of the organization, as well as cybernetic, structural-functional, systemic and informational approaches.

In his study, A. De Gius [2] contrasts the values of a «living» organization, the basic goals of which are to survive and succeed in the long run, maintaining the spirit of collectivism based on common values, openness to the outside world, willingness to accept new people and creative ideas, which allows you to better adapt to changing working conditions in the market, to patterns of a usual «economic» enterprise, whose priorities are determined solely by financial and economic indicators. It is the approach to managing a «living» organization that will allow modern managers to cope with crisis situations.

5.2 THE BASIC FOUNDATION OF A VIABLE ENTERPRISE MANAGEMENT SYSTEM

In the past, the view of organizations as mechanistic formations led to increased production and success. But the mechanistic style of leadership creates problems with organizational adjustment. The need to plan all changes and impose them leads to bureaucratic backwardness, ignoring collective learning and development, the inability to survive in today's complex information-oriented and turbulent environment. The speed and complexity of the business environment force companies to

take a different approach. In his work, A. De Gius [3] studied large corporations that existed for over a hundred years, which have managed to survive radical changes and continue to thrive without losing their unique identity. The author [3] concluded that they were helped in this by the fact that they were all inherently flexible and easily adapted to changes in the environment, similar to the behavior of living beings. Thus, businesses that want to thrive must be able to adapt to changing conditions, just as living organisms evolve in response to changes in the environment.

The concept of organizations as living systems is not new. The analogy between an enterprise and living organisms has already been considered in [2–15]. Much work, especially in the field of systems thinking, has brought this perspective into the spotlight. By studying biological models of human physiology, we can gain understanding and generate new ideas for business management. But S. Beer approached this question most thoroughly in his works «Brain of the firm» [16, 17] and «Heart of the enterprise» [18]. In order to understand the principles of viability, as a model S. Beer chose systems, known as viable, the author examined in detail how the human body is built and how it is controlled by its nervous system. The author took as a basis the work of the human nervous system, which regulates all other body systems, and compared it with the management system of a firm. S. Beer considers the human brain as a viable system. By analogy with the human system, S. Beer identified five management systems. But the author paid most attention to only one of the body's systems, and other systems considered superficially. Among scientists there were attempts to compare the organs or systems of the human body with departments, strategic business units or other structures of the organization [19–21], or certain body systems with economic processes [22]. The main disadvantage of these studies is the lack of systematicity, because some bodies are compared with departments of an organization, some with systems or functions. But most authors [2, 7–14] considered not so much the structure as the principles, on which the functioning of a «living organization» or organizational development is based. Thus, we can conclude that the representation of the enterprise system in the form of a living organism has many aspects, many of which are practically not taken into account in modern economics.

Traditionally, activities of an enterprise are considered through the organizational structure of management. Based on the analysis of the works of M. Khammer, Dzh. Champi, T. Boidell, A. Beklemishev [23–25], it can be concluded, that currently the functional approach to management, based on a hierarchical organizational structure of management, which is the distribution of functions between units, is traditional for enterprises. The disadvantages of this approach are: the complexity of linking individual tasks in the technology of production of goods or services; lack of a common vision of the results of their work in performers of certain functions; the complexity of interaction between performers of related functions; lack of responsibility for the final results of an enterprise; conflicts of interest between different departments; lack of customer focus and high overhead. This requires the development of an enterprise management system based on the application of not only functional but also other approaches to management.

One of the most effective approaches to building an enterprise management system is the concept of a viable system by Stafford Beer [16]. S. Beer described a model of a viable system in the

form of a neurocybernetic model, the prototype of which was the architecture of the human central nervous system where in the normal state is the autonomous work of units and only in extreme circumstances «dictatorship of the center» is switched on. S. Beer proved the expediency of the proposed model based on the elementary laws and principles of cybernetics.

A significant number of works of scientists is devoted to the formation of a viable enterprise management system from the point of view of the concept of viable systems [26–31]. However, despite the prevalence of this approach [6, 32–35], it should be noted, that the concept of viable systems is abstracted from practical activities of specific enterprises, which significantly complicates its application.

Given the dynamism of the external environment, special attention should be paid to building a viable management system of a self-organizing road transport enterprise. Complications of management functions and tasks, democratization of relations, availability of information, knowledge-intensive technologies and the speed of technological change reveal the shortcomings of hierarchical structures. They lack dynamism and imbalance – the main signs of self-organization. The response time to changes is longer than the time of manifestation of the consequences of these changes and the interval between successive changes. Delayed reaction is the death of any organism and any organization.

In a typical hierarchical system, the task is divided into many small components, by individual specialists, who solve them in isolation from the whole task, and top management then connects and evaluates the contribution of each. Tasks, rights and responsibilities of all participants are defined and known, interaction is provided only vertically. S. Beer's model of a viable system [16] is a compromise option. However, the classical concept of viable systems has a number of shortcomings: the distribution of management functions between the subsystems of economic entities does not correspond to the organizational structure of real enterprises; the system of information flows of an enterprise cannot fully correspond to the information channels of the human nervous system; the use of the functional approach does not correspond to the trends of research in the field of enterprise development, because in economically developed countries process and system approaches to management are dominant. Therefore, when forming a model of RTE management based on the concept of viable systems, it is advisable to proceed from the basic business processes of an enterprise, ie to use process management.

5.3 FORMATION OF A VIABLE ENTERPRISE MANAGEMENT SYSTEM BASED ON THE APPROACH TO THE MANAGEMENT OF A «LIVING» ORGANIZATION AND THE CONCEPT OF VIABLE SYSTEMS

Viability is a synthetic feature of an enterprise of the highest level of commonality, as the level of viability of the enterprise accumulates the action of all factors, influencing its functioning [36]. Since viability is a synthetic trait, and ability itself in the theory of viability is understood as a possibility of a certain activity, as a possibility to achieve a certain result in this activity, viability as the

ability to generate acceptable income on the long basis can be considered a superposition of simpler abilities. At the heart of such ideas is the possibility of presenting the process of life (functioning) of an enterprise as a whole in the form of a superposition of simpler processes (activities) [36].

To form a holistic system of enterprise activities, it is necessary to consider in more detail the systems of the human body. The systems of human organs are connected anatomically and functionally and together form a whole human body. An organism is a certain complex or system that reacts as a whole to various changes in the external environment, it is relatively stable, despite the fact that it consists of many organs. Organs, in turn, consist of tissues, tissues – of cells, cells – of molecules. In the body, organs and organ systems occupy a certain position and perform their inherent functions. The mechanisms of neurohumoral regulation are responsible for the coordinated work of all organs and systems, as well as for their interaction. This ensures the body's resistance to external environmental conditions. First, consider the basic systems of the human body and the functions they perform (**Table 5.1**).

Based on the approach to enterprise management as a «living» system, we determine which enterprise systems correspond to the systems of a living organism.

The nervous system consists of the brain and spinal cord, nerves and nerve nodes. It regulates the work of bodies, ensures their coordinated activities and adaptation to environmental conditions. Through the senses, it communicates with the environment. Due to the nervous system, person's mental activity is carried out, his/her behavior is determined. S. Beer [16] has already compared the nervous system with the management system of an enterprise. The control subsystem of strategic management is represented by management bodies (guidance), which perform specific functions of forming a comprehensive strategy for the operation of an enterprise and a strategic plan of its development. The organizational subsystem (strategic management) through the development of the production structure allows the rational use of equipment, labor, information, factory space and labor resources, creates optimal conditions for continuous production, using advanced techniques and methods (flow production, subject-closed areas, traffic of product flows etc.). RPE is managed by creating an organizational and managerial structure – a set of units of the enterprise that are interconnected and interact together, but the purpose of each of them to ensure the implementation of a specific management function: the analysis function is responsible for economic analysis; for the function of accounting and control – accounting; for operational production management – control room; the production service is responsible for the organization of production (if a large amount of equipment is involved in the production process – production and technical); technical service maintains vehicles and technical devices in good technical condition, etc. That is, this subsystem activates and regulates the activities of all departments or divisions of an enterprise.

The integumentary system – consists of skin and mucous membranes. The function of this system is to protect the body from temperature fluctuations, drying, mechanical damage, penetration of pathogenic bacteria. It is this system that is the first to face influences of the external environment.

● **Table 5.1** The basic systems of the human body

System/apparatus	Organs	Fuctions
Nervous system	brain and spinal cord, nerves, nerve nodes, receptors	communication with the external environment, coordination of the work of organs, response to signals, coming from the external environment or from internal organs
Musculoskeletal (motor) system	skeletal bones and muscles	support, movement, protection, determination of the shape and size of the body, energy processing
Circulatory (cardiovascular) system	heart and vessels	power, transport, protection, regulation
Lymphatic system	lymphatic vessels and nodes	additional drainage system
Digestive System	intestinal tube (mouth, esophagus, stomach, small and large intestines) and digestive glands, liver, gallbladder	grinding, movement, chemical treatment of food, absorption of nutrients, removal of undigested residues
Respiratory system	airways or respiratory tract (nasal and oral cavity, trachea, bronchi) and alveolar lungs	gas exchange, intake of oxygen, excretion of carbon dioxide and gaseous metabolic products
Urinary system	kidneys, ureters, bladder, urethra	excretion of metabolic products maintenance of water-salt balance in the body, regulation of blood pressure
Integumentary system	skin and skin (exocrine) glands	protection against mechanical damage, UV rays, penetration of foreign bodies; excretion of metabolic products; thermoregulation
Sensory system	sense organs – eyes, ears, nose, etc.	perceive various kinds of stimuli and convert them into nerve impulses
Endocrine system	endocrine glands (pituitary gland, thyroid gland, adrenal glands, pancreas, gonads)	regulation of organs, metabolism, affect all life processes, affect organs and nerves
Reproductive system	gonads and excretory ducts	reproduction
Immune system	immune organs (bone marrow, thymus, lymph nodes, spleen)	protection against foreign bodies, infectious agents (bacteria, viruses, protozoa); destruction of altered cells, tumors, etc.

Source: generated by the author based on data [37–40]

From the standpoint of the systems approach, the most appropriate is the marketing subsystem, which seeks to build relationships within an organization (in the interests of creating value, demanded by consumers), as well as with other organizations, including suppliers, distribution channels, intermediaries and shareholders. Just this subsystem in the process of activity performs representative functions, forms the image of an enterprise and actively interacts with the subjects of external and internal environments. The marketing subsystem actively integrates the relevant components: sales policy management; product policy management; pricing policy management;

marketing communications management; commodity portfolio management; innovation management in product and sales policies and others. The efficiency of management of the marketing subsystem of an enterprise depends on the harmonious interaction of these components.

The musculoskeletal system consists of the skeleton and the muscles, attached to it. It allows a person to perform complex work, move, stand, protects internal organs from damage. From the point of view of an enterprise, the most appropriate is the technical and technological subsystem. The technical subsystem is an interconnected, interdependent set of equipment (machines and groups of machines, mechanisms, tools, production lines), which is located in an agreed proportional state and has the purpose of solving a specific problem. Coordination is to equalize the capacity of the main production process (respectively equipment), which serves the main and auxiliary operation processes. It is less mobile than other subsystems and is slower to adapt to changes in the environment. The mobility of the technical subsystem is determined by both the physical wear and tear of the equipment and its obsolescence. The technological subsystem is a set of rules, which specifies the sequence of operations and production processes, during which products are created with certain parameters and quality. The technological subsystem requires strict compliance with these rules at all stages of production. The main task of management in the technological subsystem is the detailed development of technology, its further improvement if necessary and systematic control over the quality of work throughout its duration. Technological subsystems include advanced means of converting input elements (raw materials, capital, information, etc.) into output (services, goods, staff satisfaction, profits, development of new markets, etc.). It, in comparison with the technical subsystem, is more flexible, more susceptible to influences, more quickly adapts to changes, made by technical progress in production. The complex of technical and technological subsystem of RTE includes a set of rolling stock that carries out the transportation process, and units (shops, sections, zones, etc.), whose activities are aimed at storing rolling stock and perform a set of necessary repair and prophylactic work to maintain and partially restore its working capacity.

The digestive system consists of the digestive tract and digestive glands. The functions of the digestive system are the digestion of food and the absorption of nutrients into the blood. That is, this system receives nutrients and converts them into energy. The most appropriate in an enterprise is the production subsystem, which covers all actions that result in goods, services, offered by the enterprise in certain markets. Without this function, a company can not exist. The production system is created and operates, taking into account the strategy of production activities, which, in turn, is one of the functional strategies of an organization. In RTE it is a system of providing transportation services. The operation service or commercial service is responsible for the organization and execution of transportation of goods and passengers at RTE. For the proper organization of transportation, the market of transport services is first studied, taking into account the assessment of customer needs, and then contracts for transportation are concluded with consignors and consignees.

The circulatory system consists of the heart and blood vessels. This system provides the organs of our body with nutrients and oxygen, removes from them carbon dioxide and other unnecessary products of life, performs the protective function, participating in the immune system.

The most appropriate system in an enterprise, which manages various flows of resources, is the logistics subsystem. It combines all areas of activity, related to the passage of material flows from producer to consumer, into a single set of actions, called a complex of logistics. The mechanism of action of economic laws is manifested in an enterprise in the process of movement of its funds in monetary, production and commodity forms. The transfer of enterprise resources is the material basis of socio-economic and technical-technological activities at the enterprise. Logistics policy is based on two factors – the minimum amount of logistics costs and the desired level of logistics service, and the goal of the logistics management subsystem is to achieve a balance between these two components, beneficial to both a material flow generator and a consumer. The stages of procurement, production and marketing are united in a joint process by the logistics subsystem of an enterprise. It also includes integrated and strategic logistics, logistics of resource provision. One of the tasks of the logistics subsystem is also the organization of the logistics service and warehouse, which perform an important function not only in the normal course of the production process, but also increase the share of costs for maintenance and creation of resources, needed for basic production, while ensuring their proper storage, accounting and warehousing, replenishment and use.

The lymphatic system is formed by lymph nodes and lymph vessels. It participates in the formation of immunity and maintaining the stability of the internal environment of the body. It plays an important role in metabolism and cleansing of cells and tissues of the body. Sustainability of the internal environment of an enterprise is most supported by the subsystem of staff management (social). The social subsystem is a connection between people at all stages of production. These relations between people are the basis for the existence of production and economic systems. The social subsystem characterizes the use of the human factor in an enterprise, the system of staff policy and motivation of employees. The staff of an enterprise is its main and quite active component, it must solve not only technical and economic problems, but also the task of educating people, improving cultural and educational needs, knowledge and more. Traditionally, the staff management system has the following components: subsystem of staff planning and marketing; staff selection and accounting management subsystem; labor relations management subsystem; subsystem for ensuring normal working conditions; staff development management subsystem; staff behavior management subsystem; social development management subsystem, etc. The combination of these subsystems determines the specifics of an enterprise and is unique to each organization.

The respiratory system consists of the respiratory tract (nasal cavity, nasopharynx, pharynx, larynx, trachea and bronchi) and the respiratory part – the lungs. The function of the respiratory system is to ensure gas exchange between the environment and the body. This is the basis for maintaining the body in the viable state, because for comparison, without water and food the body can survive for several days, and without air – a few minutes. If we transfer the analogy to an enterprise, it is money that provides the exchange with various subjects of the external and internal environment. The financial subsystem is responsible for providing financial resources at the right time and in the right amount. The financial subsystem of any organization enters into relations with the following elements of the internal and external environment: government agencies (mandatory

sale of export earnings, payment of taxes, etc.); other organizations (payment for goods, supplies of raw materials, other tangible assets, sales, obtaining loans and capital investment, etc.); founders (in the distribution of profits); labor collective (distribution of income and profit, wages, payment of dividends on shares, interest on bonds, etc.). The basis of the financial subsystem is a financial strategy and financial policy of an enterprise, which stimulate the implementation of specific tasks in the relevant areas of its financial activities.

The urinary system is formed by the kidneys, which produce urine, containing harmful metabolic products, and the urinary organs – ureters, bladder and urethra. It is the environmental (environmental management) subsystem of an enterprise is responsible for environmental aspects of operation. The purpose of the subsystem of environmental management is to reduce the values of environmental loads, associated with the operation of an enterprise, while maintaining the volume of products or services. This is a management system of production processes, aimed at achieving a balance between economic and environmental performance of an enterprise.

The reproductive system consists of the gonads, internal and external genitalia. The function of the reproductive system is to ensure the process of childbirth. An analogue of an enterprise should be chosen the system that provides the functions of reproduction and development of the enterprise. The innovation and investment subsystem is responsible for this. An enterprise as a complex dynamic system is in constant development. Most companies have their own research bases (research laboratories, design offices, etc.), which, along with external research and design organizations, conduct research, aimed at further development of production. As a rule, works on technical re-equipment of production are also carried out at enterprises. This is done by the innovation subsystem. During the functioning of the economy on the market basis, the only way to ensure the competitiveness of enterprises is the implementation of innovative development strategies. The investment subsystem of an organization determines the sources of investment financing; evaluates the effectiveness of investment projects, carries out financial investment management and the formation of a portfolio of financial investments.

The endocrine system is formed by endocrine glands, such as the pituitary gland, thyroid gland, adrenal glands and some other glands. They secrete hormones and affect all processes and organs of the body. All subsystems of an enterprise are affected by the quality management system, which is an integral part of the overall management system of the enterprise, which should ensure the stability of the quality of products or services, as well as increase consumer satisfaction. The process of implementing a quality management system includes a range of works. All this can affect various aspects of an enterprise. In addition, the implementation process can also affect the subsystem of logistics, production subsystem, subsystems of strategic management, staff management and many others.

The sensory system consists of receptors, neural conduction pathways and parts of the brain responsible for processing the received signals. The most well-known sensory systems are sight, hearing, touch, taste and smell. It is with the help of the sensory system that a person receives information from the external environment. In an enterprise, this corresponds to the information subsystem, which serves as the source base of all subsystems, using a variety of information as a specific resource

of production. It creates the necessary conditions and prerequisites for making scientifically sound management decisions. In this case, the systematic use of information as a resource is predicted.

Enterprise management is impossible without the creation of an information system (IS), which alternates between information about the state of the internal and external environment of an enterprise, their interaction, accumulates information for statistical, accounting, production, economic, property and other types of analysis, accounting and control of enterprise activities. As components the modern information system contains: a software complex, representing the information technological platform; devices that ensure safety control of the main production processes, etc. at an enterprise; a set of standard programs, such as office software, and special ones, such as devices for monitoring at sites and in services during the production process; router programs, control programs, software for tracking the movement of rolling stock, including online, etc.

The immune system is a system of biological structures and processes of the body that protects it from infections, toxins and malignant cells. That is, it is a complex defense system that usually responds to the intrusion of an alien force that poses a threat to human health. A similar system is possible at an enterprise – the security subsystem, which is responsible for the integrated security of the enterprise. The security subsystem of an enterprise performs certain functions: detection, mitigation, prevention of threats and dangers, forecasting, ensuring the safety of the enterprise and its staff, elimination of the consequences of losses, preservation of property, creating a favorable competitive environment and others. The subjects of security of an enterprise are those persons, bodies, divisions, departments, services, institutions that are directly involved in business security.

Based on the above, we offer an analogy of biological and economic subsystems in **Table 5.2**.

Table 5.2 The analogy of biological and economic systems

Human organism systems	Road transport enterprise systems
Nervous system	Strategic management system (organizational)
Musculoskeletal (motor) system	Technical and technological system
Circulatory (cardiovascular) system	Logistics system
Lymphatic system	Social system (staff management)
Digestive system	Production system (service delivery system)
Respiratory system	Financial system
Urinary system	Ecological system
Integumentary system	Marketing system
Sensory system	Information system
Endocrine system	Quality assurance system
Reproductive system	Investment and innovation system
Immune system	Security system

Source: generated by the author

The organ systems don't work in isolation, their activity is interdependent. This ensures the viability of the entire human body. In the same way, the subsystems of an enterprise are interconnected and form a complex system, ie the enterprise is characterized by structural complexity. That is, an enterprise is considered as a «living organism», which is a set of economic subsystems («body systems») that function together. Certain departments or structural economic units («organs») are responsible for the stable and adaptive functioning of the «living organism».

Authors Y. Buleev, N. Briukhovetskaia [41] believe that in a transition economy it is advisable to move to the concepts of «holism» and «animalism». Holism (from the Greek Holos – whole – according to the mystical and philosophical tradition, based on the principle of subordination of all parts of a single whole; at this time one of the fundamental principles of systems theory) is the view that the world is seen as a complex whole, including areas of psychological, biological and physical reality [42]. The concept of «animalism» is the development of the concept of «holism», when a company is seen as a spiritual system that has a corporate culture, values, a balanced attitude to collective and external institutions [41].

In his work, G. Kleiner [43, 44] emphasizes that the work of researchers who use the analogy between an enterprise and a living organism can be represented as the concept of «animalistic management». To denote the driving force that coordinates the actions of subsystems, the author proposes to use the concept of «soul» of an enterprise. Manifestations of the «soul» of an enterprise are diverse and include the peculiarities of the internal climate, interaction with customers and partners, reactions to external factors and corporate culture. In his other work [45], the author develops this idea and proposes a new section of strategic management, the subject of which would be the «soul» of the economic system. This type of management (by analogy with risk management) the author proposes to call soul management.

Thus, to fully maintain the viability of an enterprise, it is necessary to study not only the «physical body» of it in the form of a set of functional subsystems, but also its «soul» – corporate culture, which must be developed based on paradigms of sustainable development and social responsibility. Thus, it is necessary to form such a management system of a «living» organization, which took into account the possibility of sustainable operation, development and adaptation of the enterprise to the influence of external conditions on the basis of self-organization.

The further development and use of Stafford Beer's cybernetic model (VSM – viable system model) has great prospects for the formation of a viable management system of a «living» organization [16]. The model of a viable system consists of three groups of elements: operating elements, metasystems and environment. The operating element and the metasystem were divided by the author into five interacting systems. In order to be viable, a firm, like a living organism, needs five levels (subsystems) of management, which can be reflected as aspects of the organizational structure. Each level has contractual powers of autonomy and operates within its competence. The flow of information goes from the bottom up, gradually filtering out unnecessary details. Management levels are activated as needed. If any level of management comes to a standstill and does not find a solution, the upper level is included in the work.

When modeling a viable system and reflecting its integrity, the graphical method is used mainly, which allows to present the model more clearly (**Fig. 5.1**).

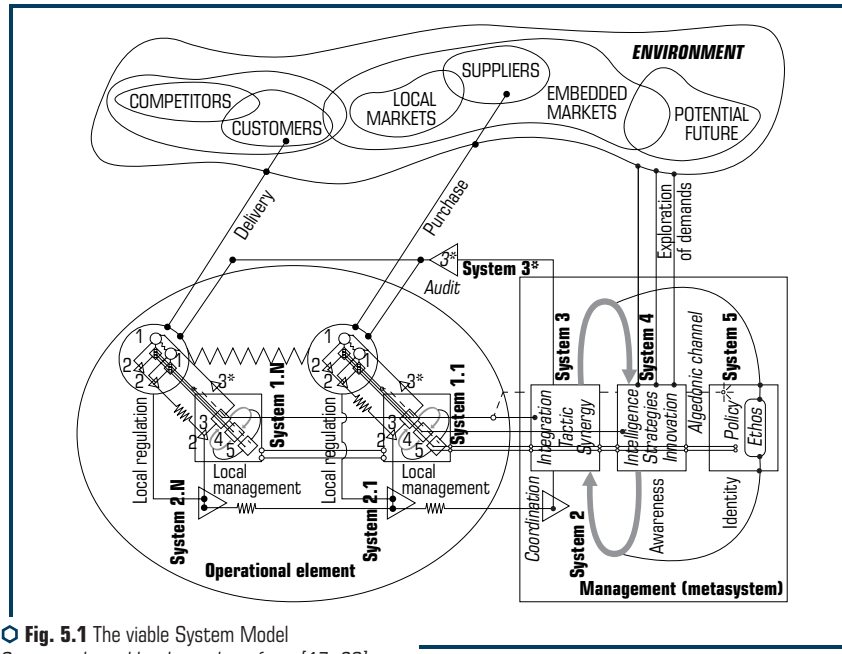

Fig. 5.1 The viable System Model
Source: adapted by the authors from [17, 29]

The figure presents three elements – the environment, the operating element and the metasystem, as well as various connections (interactions) between them. Each element of the system consists of: (1) control unit (square shape); (2) operations responsible for interacting with the environment to offer their products and services (round shape); and (3) a local coordination system (triangular shape) [46].

The Viable System Model (VSM) offers the ability to scientifically design any organization as a system with the regulatory, learning, and adaptive capabilities necessary to ensure its survival (viability) in the face of changes that may occur in its environment over time, although they are not provided for in its design. A viable system contains five subsystems that interact with each other and can be reflected as aspects of the organizational structure. System 1 in the model of a viable system represents the operational (autonomous) control units of various elements of production. Each System 1 is first and foremost a viable system according to the recursive nature of the system. System 2 plays an important role in coordinating other subsystems, provides information channels and bodies that allow the subsystems in System 1 to communicate with each other

and with System 3. System 3 is responsible for monitoring the performance of each operating unit, defining directives, allocating resources, rights and responsibilities of the units of System 1, as well as to identify potential synergies and ensure interaction with Systems 4 and 5. Next to System 3 is System 3*, which is responsible for performing audit activities in the operational units of System 1.

The bodies in System 4 are responsible for monitoring the environment, forecasting the future and identifying potential risks, in order to monitor how an organization must adapt to remain viable. Finally, System 5 sets out the principles and objectives of the system, playing a key role in preserving their identity. Also, to balance needs, it is responsible for policy decisions within an organization as a whole and the requests of different parts of the organization and the management of the organization in general.

The whole viable system can be represented as part of a viable system (parts that make up operations or System 1). Each viable system is part of a larger viable system. Recursion offers a new way of manifesting the purpose of a business or organization. The vertical deployment of the system supports the recursion of operational units to smaller subsystems [17, 28, 29, 47, 48].

Depending on the stage of cognition of objects or processes, on the aspect of their consideration, the purpose of creating the same system can be represented by different structures. In this case, a simplified principled generalized structure of the management system of a viable enterprise is proposed, which is shown in **Fig. 5.2**.

The main systems of an enterprise are given in accordance with the proposed systems of an enterprise, in accordance with their analogy with the «living» (biological) systems of the organism (**Table 5.2**). The general viable enterprise management system in the literature [16] is compared with the nervous system, which regulates all other body systems and processes all signals, makes decisions.

The subject of management (control subsystem) is a set of subsystems to support production, technical and technological, economic, social and other systems of an enterprise, which are defined in **Table 5.2**. The metasystem contains two levels of management: strategic and tactical. System 5 is responsible for goal setting, develops strategic goals, mission, and System 4 – decisions, related to strategic planning of an enterprise, model development, adaptation to the external environment. System 3 – optimizes the functioning of the system as a whole, coordinates the distribution of efforts and resources between departments. System 3* – audit management, monitors, controls and internal audits of an enterprise.

It is proposed to form the operational element on the basis of a set of basic subsystems of an enterprise («physical body») and subsystems of corporate culture («soul» of the enterprise). Each viable system is part of an even larger viable system. In **Fig. 5.2** we can see that the operating element also has a structure in the form of certain systems 1.1,…, 1.N, similar to a viable system. Each viable system is part of a larger viable system. Twelve subsystems of management of certain processes of an enterprise are separated: production, technical-technological, logistic, ecological, financial, marketing, social (staff), information, investment-innovative, maintenance of quality, safety and formation of corporate culture. These subsystems are interconnected and form the overall system of an enterprise. Recursion offers a new way of manifesting the purpose of a business or organization. Vertical deployment of the system supports recursion of operational units to smaller subsystems.

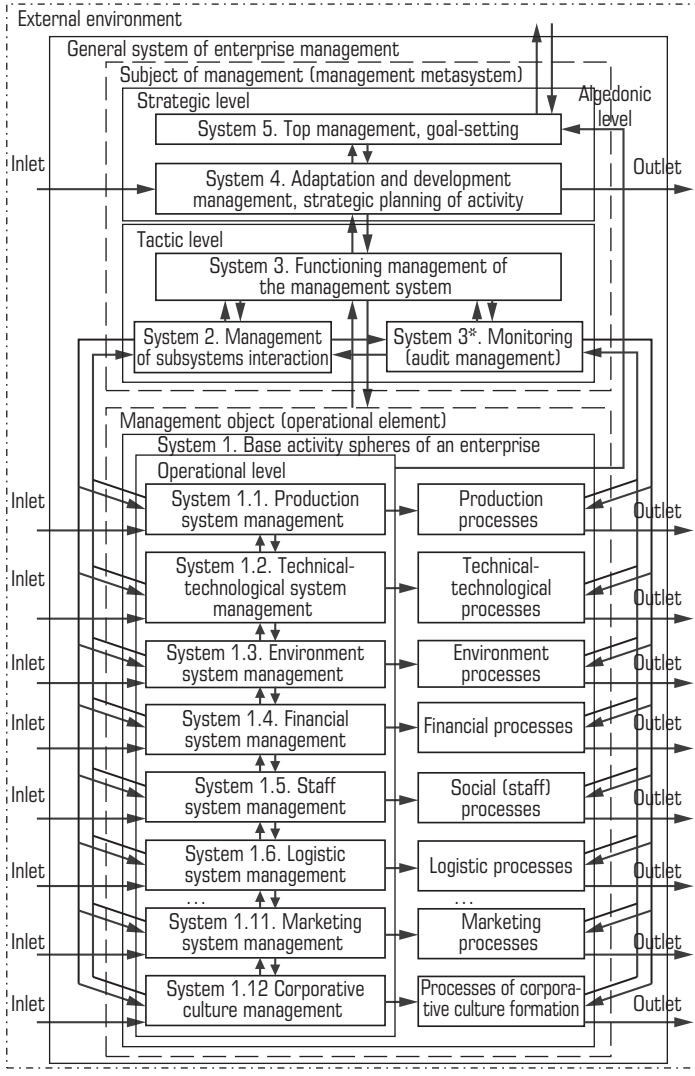

Fig. 5.2 The management system of a viable enterprise
Source: generated by the author

The representation of the enterprise system in the form of a living organism has been considered. To form a holistic system of an enterprise, the systems of the human body have been considered in more detail and the corresponding systems of the enterprise have been determined. A set of functional subsystems of an enterprise by analogy with the systems of a living organism, the activity of which is interdependent, which ensures the stability of the «living organism» of the enterprise to the influence of external conditions has been formed. It has been determined, that in order to fully maintain the viability of an enterprise, it is necessary to study not only the «physical body» of the enterprise as a set of functional subsystems, but also its «soul» – corporate culture, which must be developed on the basis of paradigms of sustainable development and social responsibility.

The multilevel recursive viable model of the enterprise management system, which is built on the basis of the concept of viable systems, has been improved. The object in the management of a viable system is a set of basic systems of an enterprise, which are defined by analogy with the biological system. This model of the system is proposed as fundamental for the construction of other types of systems, which allows to form a management system at each level of recursion, ie the corresponding systems of an enterprise. The model allows the top management of an enterprise to generate, coordinate and adjust decisions on the functioning of the enterprise.

However, within the framework of this section, no situational attention was paid to the elements of anti-crisis management, which in the era of turbulence is crucial and, as is customary, a «must have». The next section will focus on this direction.

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6 CONTINUOUS CVP-ANALYSIS AS A KEY TOOL OF ANTI-CRISIS MANAGEMENT OF AN ENTERPRISE IN THE CONDITIONS OF SUSTAINABLE DEVELOPMENT IN THE VUCA-WORLD

Ya. Dohadailo, I. Kyrchata, T. Kovalova, I. Dmytriiev, P. Lošonczi

ABSTRACT

As mentioned in Section 5, an enterprise is the foundation of each sector of the economy of each country without exception. Therefore, the methods of managing the latter to ensure its smooth and competitive activities do not lose their relevance at all times. It should be noted, that the management of an enterprise, in all its manifestations, is a complex process that requires managers to have the necessary knowledge and skills relevant to the time, in which such management is carried out. It is the provision of modern approaches to management that will enable it to survive in the harsh realities of today. One such approach is continuous CVP analysis.

In the section based on the study, the main features of the modern business environment have been identified, in accordance with which it has been proposed to use CVP-analysis on a continuous basis as a key tool for crisis management. To implement the latter, the article deepens the theoretical and improves methodological foundations of CVP-analysis by ensuring their compliance with the principles of sustainable development of an enterprise, organization and implementation of VUCA-solutions that act ahead. The essence of continuous CVP-analysis has been specified and the periodicity of its carrying out has been substantiated.The method of statistical analysis of accounting has been improved, taking into account the dynamic nature of the enterprise environment. Approbation of the latter allowed to classify the costs of fixed and variable by item, which will allow you to perform without much effort operational analysis of not only actual but also future activities. The proposed research results can be used by employees who are interested in effective management of the enterprise in modern business conditions.

KEYWORDS

VUCA-world, sustainable development, CVP-analysis, crisis management, cost classification.

6.1 PREREQUISITES FOR IMPROVING THE METHODOLOGICAL FOUNDATIONS OF PRACTICAL APPLICATION OF ENTERPRISE MANAGEMENT TOOLS

The global challenge of 2020 was the COVID-19 pandemic, which the United Nations called a global crisis, affecting the sustainable development of all countries [1]. COVID-19 has caused an unexpected shock to economies around the world and sharply increased uncertainty in business [2], as a result of which the world economy is experiencing the largest downturn in 50 years [3]. The collapse of the world economy has revealed colossal local problems. Measures, aimed at supporting the functioning

of countries, unfortunately, did not prevent the decline in income, bankruptcy and the largest decline in GDP in the last decade [3], it did not bypass Ukraine [3, 4]. In turn, the Federation of Employers of Ukraine in the period from 10 to 27 April 2020 conducted a survey «Business and COVID-19: you can not die to survive», among the owners/managers of 121 companies from all regions of Ukraine (companies were founded before 2018), 83 % of which were private enterprises. The main results include:

– 53 % of respondents did not have a plan to ensure their continuous work for the period before the end of restrictive measures;

– 80 % of respondents could be viable in quarantine only up to six months (10 % – less than a week; 19 % – from 1 to 8 weeks; 31 % – from 2 to 3 months and 20 % – from 3 to 6 months) and only for 6 % of respondents COVID-19 did not affect the work of the enterprise;

– 81 % of respondents were forced to change operations to protect companies from the effects of the pandemic;

– decisions on business support, made by the Ukrainian authorities after the announcement of the COVID-19 pandemic, fully met the needs of only 2 % of respondents (did not meet the needs of the company – 58 %; partially met – 40 %);

– about 90 % of respondents indicated a decrease in income due to the negative impact of COVID-19, of which 53 % – income decreased by more than 50 %, and 38 % – a decrease of 20 to 50 %. At the same time, none of the respondents noted the positive impact of the pandemic on the conditions of doing business and only 2 % of respondents indicated that «the pandemic did not affect the level of income/sales»;

– for 42 % of respondents it will take from one month to three months to fully resume business, and for 28 % – it will take more than three months [5].

These results indicate the inconsistency of the applied enterprise management tools with modern conditions of the business environment and the need to make an informed choice or improvement of enterprise management tools, according to these features. For Ukrainian enterprises, the problem of independent organization of effective work in the pandemic without hoping for significant support from the state is urgent. This requires management decisions, aimed at the timely prediction of adverse situations and preventive orientation of enterprises on their prevention and achievement of positive outcomes that allow not to lose or to strengthen the position of enterprises in the business environment. Thus, there is a need to identify the features of the modern business environment, substantiate the tool of enterprise management that would meet these conditions, and if necessary, improve the methodological basis for the practical application of this tool in an enterprise.

6.2 METHODICAL SUPPORT OF CVP-ANALYSIS AS A KEY TOOL OF CRISIS MANAGEMENT OF AN ENTERPRISE IN THE CONDITIONS OF SUSTAINABLE DEVELOPMENT

Modern humanity is at a turning point in its evolution on the planet, which requires a reorientation to a paradigm of development that will support human life and the environment, and it is the

concept of sustainable development that provides such a chance [6]. Therefore, it is considered as a paradigm of social development [7, 8].

In turn, globalization is the main tool for overcoming uneven development and environmental problems in achieving the global Sustainable Development Goals [9]. In accordance with the global challenges that constantly arise in the context of globalization, the concept of sustainable development is constantly evolving [7–10]. Today, this concept envisages the implementation by all countries of the world of seventeen global Sustainable Development Goals (SDGs), which cover three aspects of sustainable development: social, economic and environmental, as well as aspects, related to peace, justice and effective institutions [7]. Ukraine has all the prerequisites for the implementation of sustainable development [11] and is taking certain actions in this direction [11–18]. They create conditions for using the opportunities of globalization and overcoming the existing global threats and challenges to the sustainable development of the country and the integration of Ukraine into the world space in accordance with the objective trends of globalization [10].

It is believed, that everyone today, in principle, lives in the VUCA world [12–15]. That is, the modern business environment is determined by four key characteristics (VUCA-challenges): Volatility (instability, variability, instability), Uncertainty (indeterminacy), Complexity (confusion) and Ambiguity (dualism). But K. Roberts formulated VUCA-response (-solution, -Prime) to VUCA-calls, namely: «Vision» (idea), «Understanding» (comprehension), «Creativity/Clarity» (innovation), «Agility» (flexibility, self-determination, efficiency) [13–15]. The essence of each challenge and decision is presented in **Table 6.1**.

As noted earlier, globalization is seen as a key tool for overcoming uneven development in achieving the global Sustainable Development Goals. According to the author, the global challenge of 2020 pandemic COVID-19 can be considered a challenge to the environment Volatility (instability, variability, instability). Thus, based on this the modern business environment can be characterized by two main features:

– first, it is the sustainable development of all countries of the world by fulfilling the seventeen Sustainable Development Goals (SDGs);

– secondly, this is the VUCA world.

In conditions of sustainable development, the activities of organizations and enterprises should ensure the implementation or compliance with the SDGs, which can be achieved using the effective approach to management [16].

According to the established essence of each challenge and decision, it can be stated, that in the VUCA-world an enterprise, an organization will succeed if carries out conscious (vision), flexible (efficiency) and continuous (understanding) transparent (clarity) management of the results field, adequate to present and future state of both external and internal environment of the enterprise, ie the effective approach to management. Its prerequisite for implementation is the introduction of controlling. Controlling is a subsystem of enterprise management that coordinates the subsystems of information support, accounting and control, analytical, planning and motivation for the comprehensive implementation of specific functions: commenting and development, which

provide management of both operational and strategic goals and focus on future development through continuous systemic improvement of an enterprise, which is a prerequisite for preventing the crisis and long-term existence in the market.

Table 6.1 The concept of VUCA-world (challenges and solutions, acting in advance)*

Abbreviation	Essence	
	Challenge	**Solution, acting in advance**
V	Means unstable situations and unpredictable changes – by their nature, speed, volume, dynamics. The duration of this state of affairs is unclear. What was relevant yesterday is no longer relevant today. Brutal increase of four dimensions of change: type, speed, volume and scale	A clear vision and understanding of the long-term direction of movement. Definition of vision. The use of intuitive thinking, which allows you to flexibly and quickly respond to complex uncertainties in a particular area of all involved strategy developers. Clarity of the set goal; faith, supported by facts and evidence; consistency and focus on finding the relationships, trends and patterns of influence of factors
U	Means a lack of information to predict the consequences and plan the necessary actions. Managers can no longer base their decisions on past experience and as a result it is impossible to plan anything in the long run	Continuous monitoring of expectations of service recipients; research of new ideas and their reflection in actions; ability to cooperate; ability to respond to constructive criticism; mastering of new IT technologies; understanding of the behavior of people in situations of great stress and strain; understanding of what governs a person
C	A very large number of factors significantly complicates the decision-making and planning process. Complexity «without a clear link between cause and effect affects all organizations»	Ability to simplify and clarify. Application of system thinking based on a global vision of the result, understanding the interaction and interdependence of system elements. Use of intuition; application of interdisciplinary knowledge; critical perception of events. Flexibility to implement changes, innovations and readiness to realize them
A	Means ambiguity in the interpretation of certain events – in cases where they can be interpreted in two ways. It is difficult to answer the question «who, what, when and why». This is a lack of accuracy and the existence of multiple values in the conditions around us	Speed and flexibility of processes helps to increase business efficiency. Confidence in the need to find new original ways to solve all problems, improve processes. Determination in decision making; innovation, formation of network connections; constant improvement

** Source: generated by the authors based on data from [13–15]*

One of the components of operational controlling tools is the analysis of the relationship «cost-volume-profit» or CVP-analysis («Cost-Volume-Profit Analysis», operational analysis, break-even analysis, margin analysis, analysis of «cost-output-profit») activities of an enterprise. It is understood as a tool of management accounting, which helps to make management decisions by studying the relationship between changes in costs, production and sales [17]. It is used to prevent unprofitable enterprises in conditions of increased competition, instability and increased corporate

social responsibility, so it is advisable to use it as one of the tools of crisis management in today's business environment. Today, its application for the proposed purpose requires the development of theoretical and methodological foundations of CVP-analysis, taking into account the identified features of the modern business environment.

The existing theoretical and methodological bases of CVP-analysis do not take into account the peculiarities of sustainable development of an enterprise, an organization in the VUCA-world.

6.3 DEVELOPMENT OF CONTINUOUS CVP-ANALYSIS AS A KEY TOOL OF CRISIS MANAGEMENT OF AN ENTERPRISE IN THE CONDITIONS OF SUSTAINABLE DEVELOPMENT IN THE VUCA-WORLD

According to the current Decree of the President of Ukraine «On the goals of sustainable development of Ukraine for the period up to 2030», it is necessary to ensure compliance with the following goals: overcoming poverty; overcoming hunger, development of agriculture; good health and well-being; quality education; gender equality; clean water and proper sanitation; available and clean energy; decent work and economic growth; industry, innovation and infrastructure; reduction of inequality; sustainable development of cities and communities; responsible consumption and production; climate change mitigation; conservation of marine resources; protection and restoration of terrestrial ecosystems; peace, justice and strong institutions; partnership for sustainable development [11]. In accordance with the goals of sustainable development, the principles of sustainable development of an enterprise have been formed (**Table 6.2**).

CVP-analysis is an integral part of operational controlling tools. The latter is a subsystem of enterprise management that coordinates the functions of information support, accounting and control, analytics, planning and motivation for the integrated implementation of specific functions: commenting and development, which provide management of the operational goals of an enterprise and focus on future development through continuous system improvement of the enterprise operation, which is a prerequisite for preventing the crisis and long-term existence in the market. Based on this, the authors of the article join the opinion of scientists S. Kondratova and M. Umrykhina [19] that operational analysis is a management tool. The authors believe that CVP-analysis can be considered as one of the components that provide management of the process of achieving operational goals of an enterprise through continuous systematic improvement of the enterprise, which is a prerequisite for crisis prevention and long-term existence in the market. CVP analysis should be performed on the continuous basis. This will ensure compliance with two VUCA responses – «Understanding», «Creativity/Clarity». Thus, continuous CVP analysis is a tool to manage the process of achieving operational goals of an enterprise by continuous systematic improvement of the enterprise on the basis of systematic tracking and study of the relationship between changes in volume, total sales, costs and profits. I. Narchemashvili believes that it is advisable to determine the value of break-even weekly [20], so continuity means the implementation of CVP-analysis on the weekly basis.

Table 6.2 The principles of sustainable development of an enterprise*

No.	Sustainable development principles	Essence
1	Systematicity	consideration of an enterprise as a system that provides, on the one hand, the presence of links between the structures of the elements, their interdependence, and, on the other hand, allows to distinguish between external and internal environment effects
2	Integrity	as the basis of self-preservation of the system
3	Adaptivity	as the ability to change under the influence of environments
4	Economic rationality	the main goal of a company is to make a profit in the short and long term, respectively, any sustainable development measures should be considered from the standpoint of this goal
5	Purposefulness	compliance of the mechanism and management process with the sustainable development of an enterprise to ensure its continuity
6	Innovation	as a source of self-development, extensive methods at the present stage can not meet the main purpose of an enterprise in the long run
7	Cautions	as a condition for the preservation of human civilization, this principle should be extended to both environmental and social spheres and act as a kind of filter – measures to achieve the main goal of an enterprise should be tested for their possible impact on the environment and society
8	Economization of environmental and social impact	transformation of external environmental and social factors, formed under the influence of an enterprise, into internal production costs and their integration into the market pricing process, which in the long run will help increase the competitiveness of those enterprises that are responsible for their activities
9	Complexity	the comprehensive involvement of all elements of an enterprise, links between them and the environment of the enterprise in the management mechanism of its development
10	Relationships and interdependencies	the functioning of a single element causes the peculiarities of the action of another, and the mutual influence and purposefulness of the whole set of elements ensures the effectiveness of the process of sustainable development management
11	Flexibility	rapid adaptation to changes in operating conditions
12	Compatibility	harmonious interaction of sustainable development management elements
13	Epimorphism	The desire to ensure the sustainable development of the elements of the system, ensuring the reliability and rhythm of their operation

** Source: generated by the authors based on data from [7, 8, 11, 18]*

To perform CVP-analysis it is necessary to have separate data on fixed and variable costs of an enterprise, but the organization of accounting in Ukraine does not provide such a classification,

so it is necessary to determine which method is best to determine the value of fixed and variable costs. The experience of successful enterprises in market conditions [21–24] and the essence of VUCA-answers indicate the feasibility of planning total costs with their division into fixed and variable by item. Given that operational analysis is considered as one of the most effective methods of planning and forecasting an enterprise, the authors consider it necessary to choose a method that would allow for itemized classification of costs, which would be the basis for planning. This will provide an opportunity to determine fixed and variable costs in the future without the use of methods for classifying costs into fixed and variable.

Many methods are used to classify costs according to the criterion of their response to changes in the volume of activity: direct calculation, graphical, statistical, technical analysis and others. The analysis of the technology of cost classification for each method, identified advantages and disadvantages of existing methods, which are presented in **Table 6.3**, will allow to rank methods in order of increasing accuracy and objectivity of results of classification of expenses by them.

Their analysis must be carried out by identifying their compliance with the six requirements:

1. Correspondence of the method of economic essence of the concepts «Variable costs» and «Fixed costs».

2. The presence of a statistical sample of data, when receiving the results of the study, which ensures their objectivity.

3. The possibility of itemized classification of costs.

4. The level of simplicity of calculations.

5. The level of reliability of classification results.

6. Low cost of implementation. Based on the comparison of the level of compliance of the methods, presented in **Table 6.3**, and the formulated requirements, shown in **Table 6.4**, the method to be used for CVP analysis is selected.

Thus, the analysis of the technology of cost classification by each method, the identified advantages and disadvantages of existing methods allowed to rank the methods in order of increasing accuracy and objectivity of the results of their cost classification. Based on the comparison of the level of compliance of the methods with the developed criteria, a list of methods was selected (methods No. 3–9), from which it is necessary to choose the most appropriate for the classification of fixed and variable costs for implementation in further operational analysis in modern business conditions. To do this, each of the methods should be tested and the probability of the results should be evaluated. Approbation of the selected methods will be carried out according to the work of a road management organization.

The obtained cost functions for each method and evaluation of their reliability are presented in **Table 6.5**.

According to the results of the research (**Table 6.5**) it can be seen, that the largest coefficient of determination is inherent to the statistical method, the standard error of the coefficient is the smallest.

● **Table 6.3** The analysis of methods for classifying costs into fixed and variable*

No.	Method name	Other names	Method essence	Advantages	Disadvantages
1	2	3	4	5	6
1	Linear, logarithmic and polynomial approximation	–	Construction of the trend function of costs, the argument of which is not the value of the volume of activity, and time, or rather the reporting data of observations that have ordinals	1. Possibility to perform with Microsoft Excel	1. Contradictions between the concepts of «variable costs» and «fixed costs»
2	Analysis of the linear relationship between revenue and expenses	–	Determination of the linear dependence of total costs on the share of variable costs per unit of output in the price of the latter	1. Average simplicity of the calculation	1. Lack of statistical data sampling. 2. Lack of itemized classification of costs. 3. The complexity of the solution at a wide range
3	Analysis of accounting	Analysis of accounting data; method based on entries in the accounting registers	Determination by an accountant-analyst of the function of costs by their article-by-article division into fixed and variable, based on their own experience (Cost function is a mathematical description of the relationship between total costs and volume of activity)	1. Article-by-article costs classification	1. Lack of statistical data sampling. 2. Average labor intensity. 3. Subjectivity of the research results (experience and intuition of an accountant-analyst)
4	Direct calculation	Higher and lower points; maximum and minimum points; interpolation; minimax	Determination of the cost function based on the condition that variable costs per unit of output are the ratio of the differences between costs and volumes of activity at the highest and lowest levels of enterprise activity	1. Simplicity of the calculations. 2. Slight time. 3. Availability of statistical data sampling	1. The research objectivity depends on the minimum and maximum points with other data of statistical sampling. 2. Lack of itemized classification of costs
5	Graphical	Visual inspection; adaptation; estimates of the coefficient of proportionality «at a glance»; visual	The graphical approach to determining the cost function, in which an analyst visually draws a straight line that takes into account all cost points	1. Simplicity of the calculations. 2. Slight time. 3. Availability of statistical data sampling	1. A certain degree of subjectivity of the research results (significant dependence on eye and hand steadiness of an analyst). 2. Lack of itemized classification of costs

● **Continuation of Table 6.3**

1	2	3	4	5	6
6	Simplified statistical analysis	Simplified statistical analysis by Chumachenko	Provides for the division of data on costs and volume of activity into two groups based on the growth of the value of the volume of activity and the calculation of fixed costs based on the average values of the volume of activity and total costs	1. Average reliability of the results. 2. Average simplicity of the calculations. 3. Availability of statistical data sampling	1. Lack of itemized classification of costs. 2. At significant deviations from the average values, you can get a negative value of fixed costs
7	Constructive-analytical	The Improved regression method	Based on calculations of the corresponding linear regression equation. In this case, the basic zero level of the argument is the minimum level of activity, at which it is possible to continue the activity	1. Average reliability of the results. 2. Eliminates the lack of No. 3 regression analysis	1. Labor intensity and complexity. 2. The algorithm for implementing this method is not specified. 3. It is unclear how to determine the minimum level of activity, at which it is possible to continue 4. Lack of itemized classification of costs
8	Statistical	Least squares; linear regression analysis; regression analysis	Finding the cost function that describes the behavior of the line, in which the sum of the squares of the vertical deviations of all cost points from the obtained line will be minimal	1. High reliability of the results. 2. Availability of statistical data sampling	1. Labor intensity and complexity. 2. Lack of itemized classification of costs. 3. You can get a negative value of fixed costs with significant deviations from the average values
9	Statistical analysis of accounting	–	Cost classification is carried out by determining the correlation between each cost item and the volume of activity	1. High reliability of the results. 2. Availability of statistical data sampling. 3. Article-by-item classification of costs. 4. Disposability	1. Labor intensity and complexity. 2. Insufficiently substantiated approach to calculating the value of fixed costs
10	Technical analysis	Engineering; based on technological schemes	For each item of expenditure based on technological necessity, standards are set for the consumption of resources in kind, costs are planned by multiplying these standards by prices	1. High reliability of the results. 2. Focus on the future. 3. Article-by-item classification of costs	1. Labor intensity and complexity. 2. High cost. 3. The difficulty of determining some types of standards. 4. Use only for new activities

** Source: generated by the authors based on data from [25]*

Table 6.4 Compliance with the established requirements of the methods of costs classification according to the criterion of response to changes in the volume of activity

No.	Method name	Method correspondence to the requirement No.						Correspondence level	
		1	2	3	4	5	6	un	%
1	Linear, logarithmic and polynomial approximation	–	+	–	–	+	+	3	50
2	Analysis of the linear relationship between revenue and expenses	+	–	–	–	+	+	3	50
3	Analysis of accounting	+	–	+	+	–	+	4	67
4	Direct calculation	+	+	–	+	–	+	4	67
5	Graphical	+	+	–	+	–	+	4	67
6	Simplified statistical analysis	+	+	–	–	+	+	4	67
7	Constructive-analytical	+	+	–	–	+	+	4	67
8	Statistical	+	+	–	–	+	+	4	67
9	Statistical analysis of accounting	+	+	+	–	+	+	5	83
10	Technical analysis	+	–	+	–	+	–	3	50

Table 6.5 The functions of costs and evaluation of their reliability

Method name	Costs function	Realiability evaluation	
		Determination coefficient, %	Standard error of the coefficient
Analysis of accounting	$y=215.89x+24054.17$	53	26.56
Direct calculation	$y=251.61x+25438.55$	62	22.4
Graphical	$y=255.37x+34525.32$	71	21.31
Simplified statistical analysis	$y=261.25x+27839.56$	75	19.11
Constructive-analytical	$y=235.98x+31378.25$	77	22.52
Statistical	$y=225.96x+41303.25$	86	14.91
Statistical analysis of accounting	$y=229.65x+32535$	85	18.15

Under these conditions, it can be considered the most accurate method, but it makes it possible to determine the variable and fixed costs only in quantitative terms and does not allow the breakdown of costs by article. The method of statistical analysis of accounting has a similar coefficient of determination and slightly higher values of the standard error of the coefficient, but it allows to distribute costs article by article, which is important in modern conditions. Therefore, as a tool for CVP-analysis, it is advisable to use the method of statistical analysis of accounting. It allows not only to obtain a cost function with a high degree of reliability, but also allows you to classify

costs by item. The latter is important for planning the activities of modern enterprises and flexible response to inflationary changes in the country. However, in modern conditions it is necessary to clarify the approach to determining the value of fixed costs, which proposes to calculate the value of fixed costs as the average for the year (I approach), since fixed costs can be calculated in two more ways: as a determination of fixed costs in the month, in which the volume of activity was maximum (II approach), or as a weighted average of fixed costs (III approach).The third approach takes into account seasonal fluctuations in the volume of activity of road management enterprises.

To substantiate the most appropriate methodological approach to determining fixed costs, the authors of the article classified costs and determined the cost function for each of the three approaches. The criterion for choosing the approach was the level of reliability of the obtained cost functions. To determine the degree of reliability for each cost function, the coefficient of determination and the standard error of the coefficient were calculated (**Table 6.6**).

● **Table 6.6** Estimation of reliability of cost functions by the three approaches

Parameter name	Value		
	I approach	II approach	III approach
Cost function	$y=229.65x+32535$	$y=211.93x+31350$	$y=231.25x+32945$
Standard error of the coefficient	18.15	20.21	18.12
Determination coefficient	0.85	0.81	0.87

All the obtained coefficients of determination exceed 30 %, ie the cost functions are quite reliable. The largest coefficient of determination is inherent to the cost function, calculated by the third approach (0.87), with the smallest standard error of the coefficient. Therefore, the third approach should be used in determining the value of variable and fixed costs when applying the method of statistical analysis of accounting. The high labor and complexity of the calculations can be eliminated by using MS Excell, and this calculation must be performed only once. The algorithm of realization of the improved method of the statistical analysis of accounting according to this approach is presented in **Fig. 6.1**.

As a result of the implementation of the proposed methodological approach to the classification of costs according to the criterion of response to changes in the volume of activity, the costs of the road industry were classified as follows:

– variable costs: costs of basic materials and raw materials, labor costs of road workers and drivers with charges, the cost of operation of machinery and equipment, depreciation of road machinery, payment for the traveling nature of the work;

– fixed costs: labor costs of managers with accruals, labor costs of ETW on accruals of labor costs of management staff with accruals, depreciation of other fixed assets, maintenance costs of buildings and premises, costs of materials and low-value perishable items, bank services, taxes and fees and other expenses.

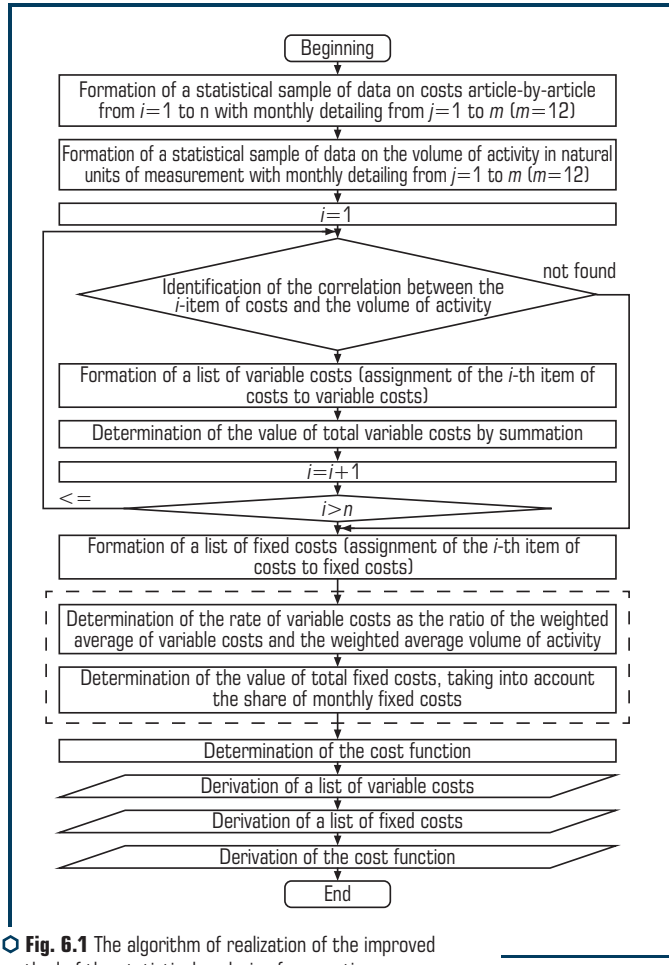

Fig. 6.1 The algorithm of realization of the improved method of the statistical analysis of accounting

Sharing Narchemashvili's view on the need to form a reserve fund [20], the funds of which will allow organizations to function during, for example, the COVID-19 pandemic, it is proposed to add contributions to the reserve fund, which will range from 5–10 % of proceeds from the sale of the organization.

Cost planning in this form will allow you to easily perform operational analysis of not only past but also future activities, which will significantly facilitate the process of enterprise management in terms of sustainable development in the VUCA-world.

Thus, the theoretical and methodological bases of CVP-analysis were deepened by ensuring their compliance with the principles of sustainable development of an enterprise, organization and feasibility of VUCA-solutions that work in advance. Namely:

– the essence of continuous CVP-analysis has been specified by the comprehensive consideration of its destination, purpose, tasks and features of functioning of enterprises in the conditions of sustainable development in the VUCA-world;

– the frequency of CVP-analysis has been determined;

– the expediency of using the method of statistical analysis of accounting as a tool of modern CVP-analysis has been substantiated. It allows you to classify costs by the criterion of responding to changes in the volume of activity, taking into account the dynamic nature of the enterprise environment. Using MS Excell eliminates the high labor and complexity of calculations. In this case, the calculations need to be made only once, because the planning and control of costs by item allows you to determine at any time the variable costs per unit of activity and fixed costs without using the method of cost classification. In addition, the chosen method has been improved by using a different approach to determining the values of variable and fixed costs, which allows to take into account the dynamic nature of the enterprise environment and seasonal fluctuations in the volume of enterprise activity during the year.

In the future it is planned to offer a mechanism of crisis management of an enterprise in the modern business environment based on the principles of sustainable development of an enterprise and the essence of VUCA-solutions, which will be discussed in the next section of this study.

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7 METHODOLOGICAL SUPPORT OF DETERMINATION AND EVALUATION OF COMPETENCES OF EMPLOYEES BY THE METHOD «ASSESSMENT CENTER»

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ABSTRACT

In order to continue the study of sustainable development of an enterprise, conducted in Section 6, and to ensure the quality of education, conducted in Section 1, the mechanism of crisis management of an enterprise in the modern business environment is proposed. The modern developments of leading scientists and practitioners regarding the definition and assessment of competencies of employees of an enterprise have been studied. It has been established, that the methodological support of this process is imperfect and needs to be specified and modernized in accordance with modern market requirements and trends. The main stages of determining and assessing the competencies of employees have been identified and the content of actions on each of them has been revealed. An appropriate block diagram has been drawn up, which highlights the sequence of actions for determining and assessing the competencies of employees of an enterprise. It, unlike the existing ones, has a logical sequence of actions, is based on the principles of «Assessment center» according to a certain set of methods (interviews, «Brainstorming», «Business game», testing) and involves bringing the level of existing competencies to reference values. Methodological tools have been developed and its practical application has been carried out to determine key competencies, as well as the existing and necessary level of their values has been diagnosed.

KEYWORDS

Competence approach, employee competencies, key employee competencies, employee competency assessment, Assessment Center method.

7.1 DETERMINATION AND ASSESSMENT OF EMPLOYEE COMPETENCIES

Currently, socio-economic sectors of development in Ukraine are characterized by the implementation of transformation processes in them, caused by integration into the European space, digitalization, globalization of the economy and increased competition. These processes encourage changes in the management of enterprises, increasing the requirements for employees and, as a consequence, the need for highly competent professionals [1]. To meet this need, it is necessary to identify and assess the list of competencies of certain categories of workers, which today are the most widely used characteristics of both existing and necessary qualities of professionals in their selection, dismissal, internal transfer, evaluation, career advancement, promotion, training, etc.

At the moment, the vast majority of enterprises and organizations in any sector of the economy really use the competency-based approach to employee evaluation. At the same time, the process of assessing the competencies of specialists is of a general descriptive nature; there is no universally accepted list of competencies for each category of staff; there is no methodological support and tools for assessing the competencies of employees. Therefore, there is a need to develop such guidelines and effective tools for this process.

7.2 STATEMENT OF THE PROBLEM OF METHODOLOGICAL SUPPORT FOR DETERMINING AND ASSESSING THE COMPETENCIES OF EMPLOYEES BY THE METHOD OF «ASSESSMENT CENTER»

In the modern scientific and scientific-practical literature [2–17] a really important issue is to assess the level of competence of specialists. The works of leading foreign and Ukrainian scientists and researchers are devoted to this topic: M. Armstrong, L. Spencer, S. Uiddet, V. Petiukh, I. Voloboeva, V. Zaitsev, E. Kolesnikova, Ye. Zharyk, O. Poltavska and others.

The analysis of the relevant literature revealed that scientists did not agree on the definition and evaluation of employee competencies. There is no universal approach to its solution: the authors propose to determine the list of competencies of employees and evaluate them by different methods. However, in most cases it is not specified by which algorithm and in what way such an assessment is carried out; the chosen method of determining and assessing such competencies is not properly substantiated; the proposed methodological principles are quite general and require clarification of actions at each stage, etc.

Thus, the work of V. Petiukh and I. Voloboeva [3] proposed a quantitative multidimensional model for assessing competencies on the example of functional staff of a bank. This model involves the assessment of the competencies of the staff of primary, secondary, high and top levels of bank management using the methods of scoring and integrated indicators; staff of the strategic level of responsibility – applying the modified Alpha-Jensen coefficient. The authors [3] provide general theoretical aspects of such an assessment, but there is no methodological support for this process: it is not specified how to directly allocate a list of competencies inherent in specialists of a certain category (position); there are no mathematical calculations according to the proposed model, etc.

The scientific article by V. Zaitsev [4] contains scientific developments on the formation of a model of certification of industrial enterprises as a new technology for assessing the competencies of employees. It provides:

– determination of corporate requirements to the level of competencies of specialists separately by their categories on the basis of the selected list of key indicators, characterizing the efficiency of certification (growth of production volumes, increase of product quality, decrease of prime cost, increase of enterprise profit);

– establishment of the actual level of competence of employees;

– analysis of deviations and establishment of the reasons of occurrence of discrepancy.

Based on the obtained results, measures are developed to increase the level of competencies of company's specialists, as well as their implementation and monitoring.

In general, one should agree with this idea of assessing the competencies of employees. However, the proposed developments are purely theoretical in nature, there are no guidelines and examples of practical application of this model. It is not specified how the corporate requirements for jobs and competencies of employees are developed, and the scale and conditions for assessing their actual level are not given.

In the dissertation research Ye. Zharyk [5] provides a methodology for assessing the leadership competencies of managers, based on expert assessment of the proposed list of leadership competencies. The presented calculations contain an assessment of 10 leadership competencies of the heads of four machine-building enterprises on a scale from 1 to 5 points (1 point – no competence; 2 points – very rare; 3 points – rare; 4 points – frequent; 5 points – persistent, systematically, visually [5]). Based on its results, the relevant conclusions on the further development of each of these leadership competencies are formulated, and for the validity of the obtained expert assessments, their consistency is checked by calculating the standard deviation in accordance with the law of normal distribution.

The proposed developments require a graphical representation of the process of such assessment with a clear separation of each stage, as well as justification of the chosen method of assessment of competencies (expert). The dissertation does not indicate how exactly 10 units of certain leadership competencies were selected. In addition, the methodology is not universal, as there are questions about the possibility of its use to assess the competencies of other categories of staff.

The scientific article by E. Kolesnikova [6] developed a method for assessing the competence of steel furnace staff in the design of a computer simulator, which provides for the registration of compliance with all operations of the steelmaker regulations. The proposed method consists of two stages: the division of the project into stages and their evaluation by applying Markov chains with the calculation of the probability of transition by solving the inverse problem [6]. The main idea of work – the success of operations, performed by an employee, corresponds to the level of competence of the specialist.

This technique is complex, does not involve the separation of individual (key) competencies of a specialist and can be used to assess the competence of employees of those categories who perform the same type of regulated work (operations).

Imperfection and a rather low level of methodological support for determining and assessing the competencies of employees require its scientific improvement and modernization in accordance with modern requirements and trends.

Therefore, there is a scientific task to develop methodological support for determining and assessing the competencies of employees with the preparation of methodological tools for this process and its practical application in real conditions on the example of a particular enterprise.

7.3 THE RESEARCH OF METHODOLOGICAL SUPPORT FOR DETERMINING AND ASSESSING THE COMPETENCIES OF EMPLOYEES BY THE METHOD OF «ASSESSMENT CENTER»

In the previous study of the author on this issue [7] it has been substantiated, that the most appropriate method of determining and assessing the competencies of employees is the method «Assessment Center» – «comprehensive multicomponent technology for assessing professional competencies and personal qualities of employees and their potential» [8]. Applying its principles, the process of determining and assessing the competencies of employees is proposed, which contains three stages: preparatory, the stage of evaluation and the stage of processing the results (**Fig. 7.1**).

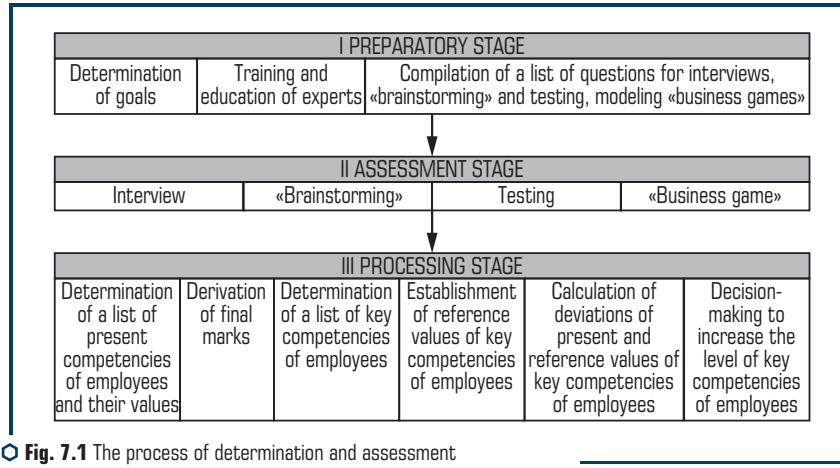

Fig. 7.1 The process of determination and assessment of the competencies of employees [7]

Preparatory stage I involves setting goals for the assessment of competencies; training and education of experts in order to acquire certain skills and abilities to work within the «Assessment center» and further staff work; forming a list of questions for research.

Assessment Stage II is implemented using a set of methods (interviews, brainstorming, business games and testing), which allows to obtain comprehensive complementary information on the results of the assessment to formulate a general conclusion. These methods are included in the technology «Assessment center», because they, compared with all other methods of staff evaluation, are characterized by a significant number of criteria for their selection (simplicity; insignificant material costs; general availability; systematization of the obtained results; comprehensive assessment; the ability to predict the results of employee's activity; assessment of personal qualities; assessment based on knowledge, experience, qualifications; motivation and others [7]).

Stage III Processing of results involves the definition of existing competencies (knowledge, talents, abilities and personal qualities of an employee, his/her professional skills, qualifications

and experience that the employee used in the work process); expert calculation of final estimates by appropriate methods; determining the list of key competencies of employees; setting their reference values; calculation of deviations of values of key available competences from reference; formulation of decisions on the level of development of competencies of employees of an enterprise.

The above process of determining and assessing the competencies of specialists has a general form, so it requires clarification of actions at each of its stages and the development of appropriate tools. The composition of the necessary actions and the sequence of its implementation is given in the form of a block diagram (**Fig. 7.2**).

Block 1 covers the setting of goals for determining and assessing the competencies of specialists. Objectives can be different: deciding on the selection of employees of a certain category, the formation and development of human resources, staff training planning, determining a set of basic competencies, assessing the level of competencies of employees individually and the team as a whole, and so on.

The determination of employee competencies is carried out cyclically by the *i*-th category. In block 2, this cycle begins and the first category of workers ($i=1$) is considered (block 3).

The staff of a road transport enterprise (RTE), as a rule, is classified into production workers (main and auxiliary) and office ones. In turn, the production staff includes drivers, repair and support staff; office workers – managers, specialists and other employees. Thus, the definition of competencies of RTE employees should be carried out in the following six categories: managers, specialists, other employees, drivers, repair and support staff.

The choice of the source of expert involvement to assess the competencies of employees of the *i*-th category (block 4) is based on the matrix of choice of the source of involvement of an expert (**Fig. 7.3**), which takes into account the objectives of determining the competencies of employees of the *i*-th category.

The choice of the source of expert involvement is carried out according to one of two possible options (block 5): an employee of an enterprise acts directly as an expert or he/she is involved from a third-party specialized organization.

In the first case, the company's management carries out a number of activities (trainings, seminars, webinars) for the training and education of employees, which will further evaluate (block 6).

In the second case, a search is made for a specialized company that provides the relevant services, and an appropriate contract is concluded (block 7). The involved experts are acquainted with all the features of the customer's company and prepare them for the «Assessment Center» for employees of the first category (block 8).

The next step in the sequence of determining and assessing the competencies of *i*-th category employees is to formulate a list of questions for interviews, brainstorming and testing (block 9). Each question that an employee needs to answer should provide for the possibility of identifying the relevant competence and assessing the strength of its manifestation in a particular employee (weak, middle, strong).

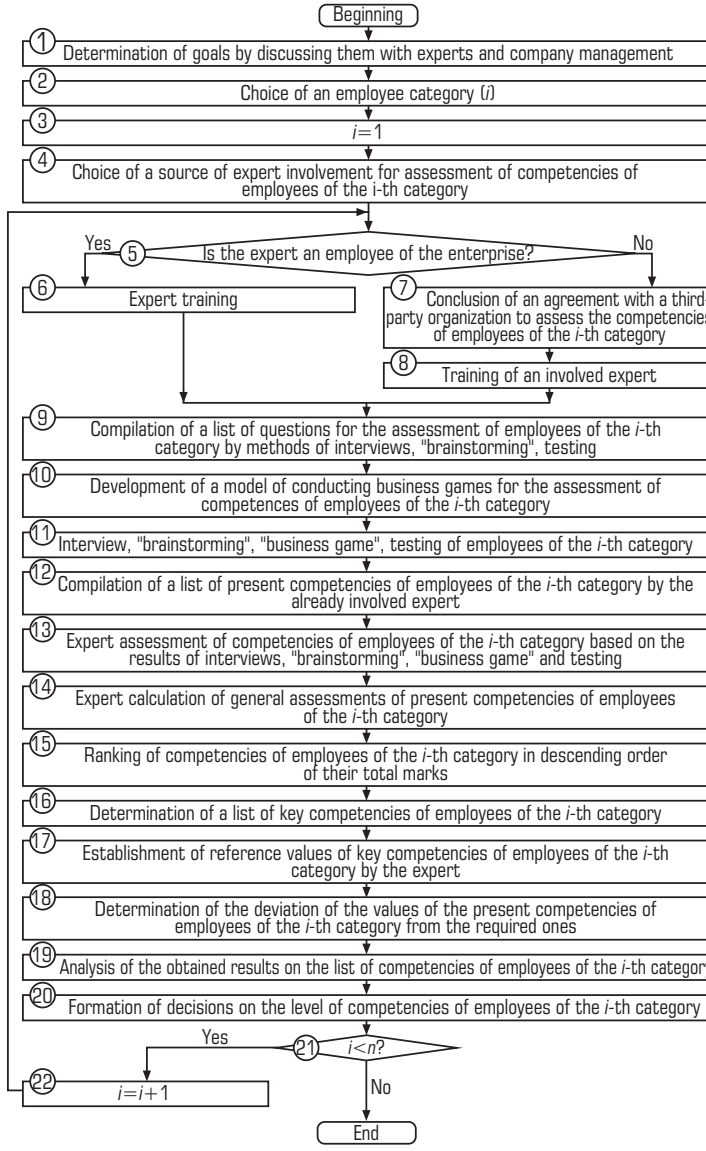

Fig. 7.2 The proposed block diagram of the determination and assessment of the competencies of employees of an enterprise

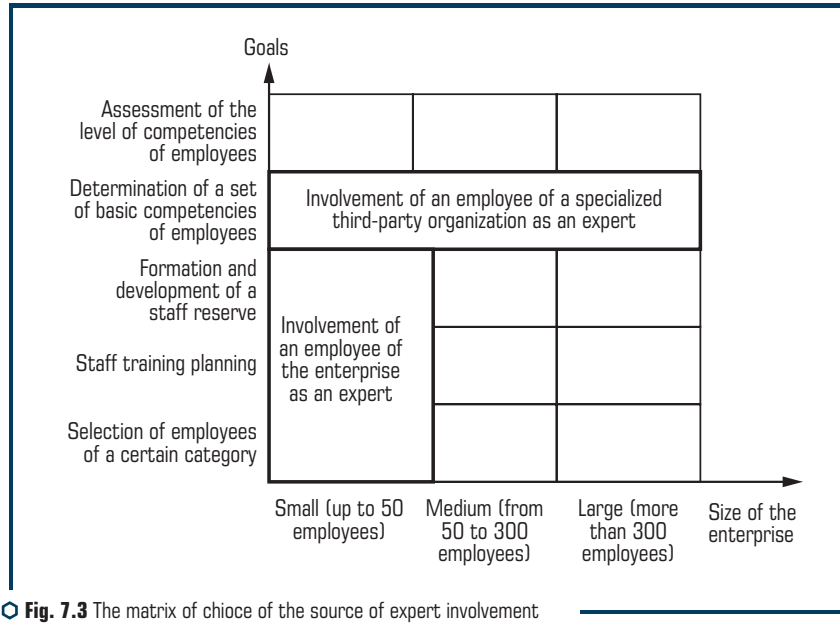

Fig. 7.3 The matrix of chioce of the source of expert involvement

Block 10 provides for the development of a model for conducting a «Business Game» to determine and assess the competencies of employees of the *i*-th category. The «Business Game» model or game scenario is a conditional reflection of a situation and an object. Within such a model, the content of a scenario is formulated (goal, description of tasks, directly description of the «Business Game»), the result of which is the separation of a number of competencies of each participant in the game with their inherent strength.

Block 11 of the block diagram for determining and assessing the competencies of employees of an enterprise outlines expert's interview, «Brainstorming», «Business Game» and testing of employees of the *i*-th category of an enterprise.

At the beginning of the interview, each employee of the *i*-th category is asked to tell about themselves and their own professional experience. After that, the interviewer (expert) asks a number of pre-defined questions and records the competences, selected by him/her as a result, as well as assesses the level of their manifestation in a particular respondent (employee of the *i*-th category).

During the «Brainstorming» employees of the *i*-th category express all their ideas and opinions on the proposed issues. The expert takes a direct part in the discussions and observes their progress. After the Brainstorming session, the participants discuss many of the ideas expressed and have the opportunity to put forward new ideas, as well as to supplement, modify and concretize those already expressed.

According to the pre-built scenario of the «Business Game», the expert acquaints employees of the *i*-th category with its topic, purpose, objectives, relevance of the study, as well as distributes roles among the participants. During the event, the expert can adjust the actions of the participants if they deviate from the main goal of the game.

Before testing, the expert instructs employees of the *i*-th category, then directly tests them on the basis of the developed list of test questions (block 9) and control the independence of the tasks, set by the participants.

In block 12 of the sequence of determining and assessing the competencies of employees of an enterprise is a list of available competencies of employees of the *i*-th category, identified during the interview, «Brainstorming», «Business Game» and testing.

Block 13 is intended for expert assessment of the competencies of employees of the *i*-th category based on the results of interviews, «Brainstorming», «Business Game» and testing, identified in block 12 of the block diagram by applying the matrix method. To do this, build a matrix for assessing the competencies of employees of the *i*-th category, the rows of which indicate a list of identified competencies of specialists, and the columns – the methods, used to assess employees of the i-th category (**Table 7.1**).

To build such a matrix, it is advisable to use the following scale for assessing the strength of the present competencies of employees of the *i*-th category (**Table 7.2**).

Table 7.1 The matrix for assessing the competencies of specialists

Present competencies	Methods of assessing specialists				Totally, points	Average mark, points	Rank
	Interview	«Brainstorming»	«Business game»	Testing			
1.							
2.							
…							

Table 7.2 The scale for assessing the strength of competencies manifestation [9]

Strength of competence manifestation	Symbol	Mark (points)
Weak	△	1
Middle	◯	3
Strong	◎	9

Block 14 of the sequence of determining and assessing the competencies of employees of the *i*-th category involves the calculation of the expert's overall marks of the present competencies of employees of the *i*-th category by a set of methods: interviews, «Brainstorming», «Business Game» and testing. The general marks are established by summation of points on

manifestation of the present competences in each method of competences estimation of workers of the *i*-th category. The average value of the manifestation strength of each present competence of specialists is also determined:

$$\bar{O}_j = \frac{\sum O_j}{n}, \quad (7.1)$$

where O_j – mark of the *j*-th present competence of employees of the *i*-th category, points; *n* – number of methods, used to determine and assess the competencies of employees of the *i*-th category within the «Assessment Center».

In block 15 of the block diagram, the identified competencies of employees of the *i*-th category are ranked in descending order of the values of their total overall marks. Based on the ranked number of present competencies of employees of the *i*-th category, a list of their key competencies is determined in block 16 of the sequence. For this purpose, a diagram is constructed, which shows the ranking of average marks of the present competencies of employees of the *i*-th category with their distribution by zones (groups). The whole range of competencies of repair workers should be divided into zones with low, middle and high importance (strength of manifestation) by the criterion of deviation of values from the average value (*M*) to 1/2 standard deviation (1/2σ) (**Fig. 7.4**) [10, 11]. According to such a strict criterion, the «middle» group includes about 38.2 % of competencies, the extreme groups – 30.9 %.

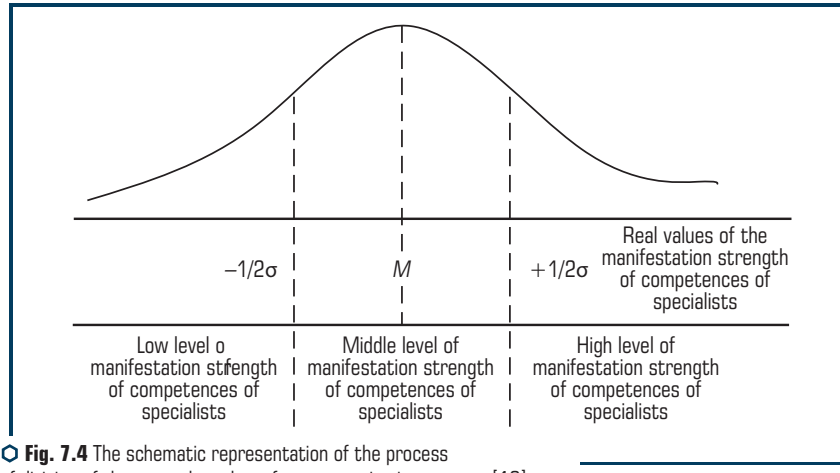

Fig. 7.4 The schematic representation of the process of division of the general number of competencies into groups [10]

The key competencies include those that fall into the group with a high level of manifestation (their importance degree).

Block 17 of the proposed block diagram covers the establishment by an expert of the reference values of the number of key competencies of employees of the *i*-th category, already formed in

previous block 16. The maximum reference value for each key competence of specialists is 9 points, because according to the applied scale of competence assessment (**Table 7.2**) the highest mark of the strength of a certain competence – strong – is estimated as 9 points.

The next step in the sequence of determining and assessing the competencies of employees of the *i*-th category (block 18) is to calculate the deviation of the present key competencies of employees of the *i*-th category from the reference values by calculating the absolute differences:

$$B_j = \overline{O}_j - O_j^E, \tag{7.2}$$

where $\overline{O}_j$ – average value of the *j*-th present key competence of employees of the *i*-th category according to the methods, points; O_j^E – reference value of the *j*-th key competence of employees of the *i*-th category, points.

Block 19 of the block diagram analyzes the obtained values of key competencies of employees of the *i*-th category and sets the type of calculated deviations. In the case when $B_j<0.5$ points – the deviation is considered acceptable; when $B_j>0.5$ points – inadmissible.

On the basis of information on the type of deviations in the values of key competencies of employees of the *i*-th category, decisions are made on the level of development of key competencies of specialists (block 20). For key competencies of employees, in the values of which an unacceptable type of deviation is set, it is advisable to develop actions and solutions that will increase their existing values.

Next block 21 is designed for the cyclic sequence of actions. It provides for the selection of all categories of employees ($i<n$), ie if $u<n$, then determine the competencies of the next *i*-th category of employees ($i=i+1$) (block 22); if not – complete the algorithm.

For an example of the application of the developed theoretical provisions and methodological support for determining and assessing the competencies of employees by the method of «Assessment center» consider PJSC «RTE-16365» (Kharkiv, Ukraine). Its main activity is cargo transportation; others – maintenance and repair of vehicles, retail trade in parts and accessories for vehicles, non-specialized wholesale trade and others.

To determine and assess the competencies of specialists of PJSC «ATP-16365», the necessary data were collected by interviewing and analyzing data on the work of the enterprise.

According to the proposed block diagram of determining and assessing the competencies of employees of the enterprise by the technology «Assessment center» (**Fig. 7.2**), its initial stage is to set goals. At PJSC «ATP-16365» the goals of the «Assessment Center» are to determine the set of key competencies and assess the level of competencies of each employee individually and the team as a whole. All calculations and computations were performed in the category of «repair workers».

PJSC «RTE-16365» refers to small enterprises (staff – 35 persons). According to the matrix of choice of the source of expert involvement (**Fig. 7.3**), an employee of the same enterprise – an inspector of the staff department was chosen as an expert. In order to prepare him for the assessment of the competencies of repair workers by the technology of «Assessment center», he was trained by attending relevant trainings and online webinars. Applying the

acquired knowledge and skills, the expert developed a list of questions for interviews (**Table 7.3**), «Brainstorming» (**Table 7.4**) and testing (**Fig. 7.5**) with each specialist (repair worker).

● **Table 7.3** The list of questions for interviews with repair workers using the «Assessment Center» technology

No.	Questions	Revealed competences
1	You see that the workflow can be significantly improved, but you understand that your idea may not impress. What are your actions?	initiative in the work process
2	Why do some professionals tend to follow accepted procedures and rules, while others often seek to make changes?	organization
3	Is it necessary to follow the technology of work when, by giving them up, you can achieve a quicker result?	focus on quality of work
4	The manager has assigned you a task, you do not have time to complete it before the end of the working day. Your actions?	responsibility
5	How many tasks did you have to solve in one day? Describe these tasks. How was your day planned?	ability to work in a multitasking environment
6	You come to the company. There is already a system in place, but you can see that it can be improved, although it takes a lot of effort and may not impress everyone. Your actions?	strive for innovation
7	What do you think are the advantages and disadvantages of having strict technological rules and procedures?	ability to follow technological rules and procedures
8	Why do some people strive to constantly develop, improve their level, while others prefer a stable sustainable activity that does not require special changes from a person?	focus on self-development
9	Name some basic rules for effective time management	ability to organize working hours
10	What is the most important thing in working in your specialty? How is the efficiency of work in your specialty assessed?	focus on result

● **Table 7.4** The possible answer options and the strength of their manifestation during the «Brainstorming» with repair workers

Possible answer	Manifestation strength	Revealed competences
Discussion topic: *«There was a serious car breakdown. This car was checked by 3 mechanics, but none could find the cause of the malfunction. Identify the cause of the car breakdown and suggest actions to eliminate it.»*		
It is necessary to connect the special equipment and to check up presence of deviations of indicators of the systems, which can influence the specified malfunction of the car (where there is a deviation – there is the reason of malfunction)	strong	determination, observation, logical thinking, the ability to quickly navigate the situation, mobility, experience in determining and troubleshooting a car, the ability to use auxiliary equipment, the ability to use special tools, the ability to apply new knowledge at work, the ability to compromise
To identify a list of all possible causes of the fault and check each one separately for damage	middle	
To replace all operating components of the system that may affect the cause of the failure	weak	

Test questions for testing repair workers

1. How to start to inspect a car?
a) from the car saloon;
b) from components and units of the car;
c) from the car body.

2. What methods are used when starting the car engine?
a) by hand;
b) by means of the electric starter;
c) both ways.

3. Where on the car the necessary pressure in tires can be indicated?
a) on the tire;
b) on the dashboard;
c) on the door rack or fuel tank hatch.

4. At what malfunction it is impossible to begin movement of the car?
a) faulty handbrake;
b) faulty brake lights;
c) punctured brake line.

5. Brass is an alloy:
a) bronze with tin;
b) tin with zinc;
c) copper with zinc.

6. What personal protective equipment is used when performing repair work?
a) safety helmet;
b) safety glasses, safety helmet;
c) gas mask, seat belt.

7. What a workplace should be equipped with, as well as places where is the possible impact on the person of harmful and (or) dangerous production factors?
a) means of individual and collective protection;
b) warning signs and inscriptions;
c) safety instructions.

8. What is pump maintenance?
a) replacement of defective parts and prefabricated units;
b) a set of operations to maintain a pump in working order and serviceability;
c) work performed to restore serviceability and complete or close to complete recovery of the pump life.

9. What detergent should be used to wash parts during disassembly and repair of equipment?
a) petrol;
b) kerosene;
c) diesel fuel, kerosene.

10. Is it allowed to operate equipment, mechanisms, tools in excess of operating parameters above the passport?
a) in exceptional cases;
b) is prohibited;
c) with the permission of the supervisory authorities.

Fig. 7.5 Test questions for testing repair workers

The scale of answers to the test questions for testing repair workers is given in **Table 7.5**.

The test results of repair workers of PJSC «RTE-16365» are contained in **Table 7.6**.

A «Business Game» was held with the repair workers of PJSC «ATP-16365» according to the situation: «A vacant position of chief mechanic has appeared in RTE. Several specialists are applying for this position. Setting tasks: it is necessary to evaluate the qualities of each of the candidates for the position and choose the best one».

To conduct the «business game», an expert from among the participants selected 4 people – candidates for the position of chief mechanic.

Table 7.5 The scale of answers to the test questions

Test No.	Answer option	Manifestation strength
1	a	weak
	b	strong
	c	middle
2	a	weak
	b	middle
	c	strong
3	a	weak
	b	middle
	c	strong
4	a	weak
	b	middle
	c	strong
5	a	weak
	b	middle
	c	strong
6	a	middle
	b	strong
	c	weak
7	a	weak
	b	strong
	c	middle
8	a	weak
	b	strong
	c	middle
9	a	weak
	b	middle
	c	strong
10	a	middle
	b	strong
	c	weak

● **Table 7.6** The test results of the repair workers of PJSC «RTE-16365»

No.	Name	Answers to question No.										The proportion of answers with a strong force of manifestation, %
		1	2	3	4	5	6	7	8	9	10	
1	G. Kulik	b	c	c	b	c	b	b	b	c	a	80.0
2	V. Bogomol	b	b	c	c	c	b	b	b	b	b	80.0
3	D. Omelchenko	b	c	b	c	b	a	b	b	a	b	60.0
4	M. Semko	b	c	c	c	c	c	a	b	c	b	80.0
5	V. Pavlenko	b	a	c	c	b	b	c	b	c	b	70.0
6	K. Litovchenko	b	b	c	c	c	a	b	b	c	a	70.0
7	O. Velichko	b	c	b	c	b	b	c	b	a	b	60.0
8	G. Sereda	b	c	b	c	b	b	b	b	b	a	60.0
9	L. Marchenko	c	c	c	c	c	b	b	c	a	b	70.0
10	P. Dovgan	c	b	c	c	c	a	b	b	c	b	70.0
11	O. Ivanenko	b	c	c	c	c	b	b	c	c	a	80.0
The average percentage of answers with a strong force of manifestation in the category of «repair workers», %												70.9

With the help of the «Business Game» in this scenario, competencies such as the ability to complete a case, stress resistance, purposefulness, attentiveness, persuasiveness, desire for career growth, responsibility, organization, ability to make decisions and ability to work with documentation were revealed, marks of which are presented in **Table 7.7**.

As a result of the actions carried out, the expert compiled a general list of present competencies of the repair workers of PJSC «RTE-16365», identified during interviews, «Brainstorming», «Business Game» and testing (**Table 7.8**) and evaluated them (**Table 7.9**).

● **Table 7.7** The marks of the competencies of the repair workers by the method of «Business Game»

Revealed competences of repair workers	Manifestation strength
Ability to complete a case	weak
Stress resistance	middle
Purposefulness	strong
Attentiveness	weak
Persuasiveness	strong
Desire for career growth,	middle
Responsibility	strong
Organization	weak
Ability to make decisions	middle
Ability to work with documentation	middle

Table 7.8 The present competencies of the repair workers of PJSC «RTE-16365»

No.	Present competences	Symbol
1	Initiative in the work process	K1
2	Organization	K2
3	Focus on the quality of work	K3
4	Responsibility	K4
5	Ability to work in a multitasking environment	K5
6	Strive for innovation	K6
7	Ability to follow technological rules and procedures	K7
8	Focus on self-development	K8
9	Ability to organize working hours	K9
10	Focus on the result	K10
11	Determination	K11
12	Observation	K12
13	Logical thinking	K13
14	Ability to quickly navigate a situation	K14
15	Mobility	K15
16	Experience in car troubleshooting	K16
17	Ability to use ancillary equipment	K17
18	Ability to use special tools	K18
19	Ability to apply new knowledge in work	K19
20	Ability to find a compromise	K20
21	Professionalism	K21
22	Qualification level	K22
23	Knowledge of the technology of car maintenance and repair	K23
24	Knowledge of safety rules	K24
25	Knowledge of the car structure	K25
26	Equipment repair experience	K26
27	Knowledge of the basic mechanical properties of processed materials	K27
28	Knowledge of instructions and regulations on labor protection	K28
29	Knowledge of design features of equipment	K29
30	Inclination to work with technology	K30
31	Ability to bring a case to the end	K31
32	Stress resistance	K32
33	Purposefulness	K33
34	Attentiveness	K34
35	Persuasiveness	K35
36	Strive for career growth	K36
37	Ability to make decisions	K37
38	Ability to work with documentation	K38

● **Table 7.9** The matrix of assessment of the competencies of the repair workers of PJSC «RTE-16365» based on the results of «Assessment Center»

Present competences	Assessment methods				Totally, points	Average mark, points	Rank
	IInter-view	«Brain-storming»	«Business game»	Testing			
K1	◯	◎	△	◯	14	3.5	
K2	◎	◎	◎	△	28	7	2–10
K3	◎	◯	◎	◯	24	6	
K4	◎	◎	◯	◯	24	6	
K5	◎	◎	◎	◯	30	7.5	1–4
K6	◯	◎	△	◯	16	4	
K7	◎	◎	◯	◎	30	7.5	1–4
K8	◎	△	△	◎	20	5	
K9	◎	△	△	◎	20	5	
K10	◯	◎	△	◯	16	4	
K11	△	◎	◎	◯	22	5.5	
K12	◯	◎	△	◯	14	3.5	
K13	◯	◎	△	◯	16	4	
K14	◎	◎	◎	△	28	7	2–10
K15	◯	◎	△	◯	14	3.5	
K16	◎	◎	◯	◎	30	7.5	1–4
K17	◎	△	△	◎	20	5	
K18	◎	◎	△	◎	28	7	2–10
K19	◎	△	△	◎	20	5	
K20	◯	◎	△	◯	14	3.5	
K21	◎	◯	◎	◯	24	6	
K22	◎	△	△	◎	20	5	
K23	◎	◎	△	◎	28	7	2–10
K24	◎	◯	◎	◯	24	6	
K25	◎	◯	◎	◎	30	7.5	1–4
K26	◎	△	△	◎	20	5	
K27	◎	◎	△	◎	27	7	2–10
K28	◯	◎	△	◯	16	4	
K29	◎	◎	◯	◯	24	6	
K30	◯	◯	◯	△	10	2.5	
K31	◯	◎	△	◯	14	3.5	
K32	◎	◎	◎	△	28	7	2–10
K33	△	◎	◎	◯	22	5.5	
K34	◯	◎	◎	△	22	5.5	
K35	◯	◎	△	◯	14	3.5	
K36	◎	△	◎	△	20	5	
K37	◯	◎	△	◯	16	4	
K38	◯	◯	◯	△	10	4	

The division of the existing competencies of the repair workers of PJSC «RTE-16365» based on the results of the «Assessment center» into groups is contained in **Fig. 7.5**. Thus, the average value of the manifestation strength in 38 competencies of specialists:

$$M=(3.5+7+6+6+7.5+4+7.5+5+5+4+5.5+3.5+4+7+3.5+7.5+5+$$
$$+7+5+3.5+6+5+7+6+7.5+5+7+4+6+2.5+3.5+7+5.5+5.5+3.5+$$
$$+5+4+4)/38=201/38=5.3 \text{ (points)}.$$

Standard deviation:

$$\sigma=\sqrt{\frac{\sum\left(x_i-M\right)^2}{n}}=$$
$$=\sqrt{\frac{\left(3.5-5.3\right)^2+\left(7-5.3\right)^2+\left(6-5.3\right)^2+\left(7.5-5.3\right)^2+\ldots+\left(4-5.3\right)^2}{38}}=1.43 \text{ (con. un.)}.$$

1/2 standard deviation: $1/2\sigma=0.5\cdot1.43=0.71$ (points).

Limits $+1/2\sigma=5.3+0.7=6.0$ (points); $-1/2\sigma=5.3-0.7=4.6$ (points).

Then the extremes of the competence groups of the repair workers are as follows:

– with a low level of strength of their manifestation – the interval [1.0; 4.5];

– with the average level of strength of their manifestation – the interval [4.6; 6.0];

– with a high level of strength of their manifestation – the interval [6.1; 9.0];

Therefore, the key competencies of the repair workers of PJSC «RTE-16365» should include the following 10 units: K2, K5, K7, K14, K16, K18, K23, K25, K27, K32 (**Fig. 7.6**).

After the expert established the reference values of the key competencies of the repair workers of PJSC «RTE-16365», their deviations from the present values were calculated and the type of such deviations was identified (**Table 7.10**).

According to the results of calculations, 50 % (5 units) of the key competencies of the repair workers of PJSC «RTE-16365» have a tolerance ($B_j \leq 0.5$ points). However, it is necessary to increase the level of competencies of these specialists as: the ability to quickly navigate a situation (K14), experience in car troubleshooting (K16), the ability to use special tools (K18), knowledge of maintenance and repair (K23), knowledge of the car structure (K25).

To this aim, for the repair workers of PJSC «RTE-16365» it was decided to attend of advanced training and self-study courses by the employees of this category.

The process of determining and assessing the competencies of the employees on the basis of the modern assessment technology «Assessment Center» was formed and the content of the necessary actions at each of its stages: preparatory, assessment and processing of results was detailed.

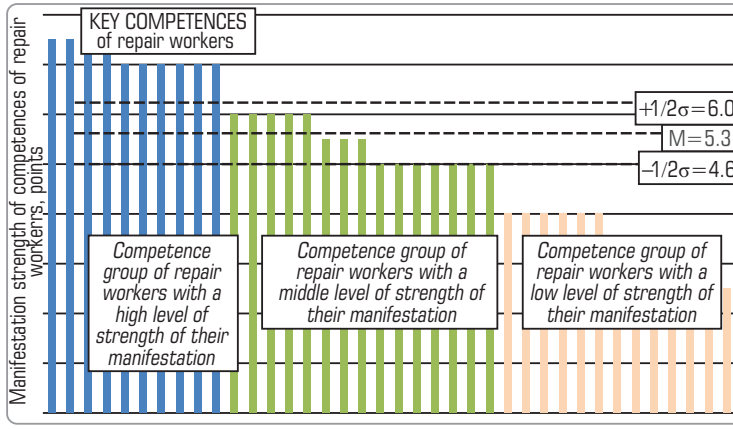

Fig. 7.6 The ranking of values and distribution of the competencies of the repair workers of PJSC «RTE-16365» by zones

Table 7.10 The deviation of present values of the key competencies of the repair workers of PJSC «RTE-16365» from reference ones

Key competences		Value, points			
Symbol	Content	average	reference	deviaton	
				Δ	type
K2	organization	7	7	–	admissible
K5	ability to work in a multitasking environment	7.5	7.5	–	admissible
K7	ability to follow technological rules and procedures	7.5	8.0	–0.5	admissible
K14	ability to quickly navigate a situation	7.0	8.5	–1.5	not admissible
K16	experience in car troubleshooting	7.5	8.5	–1.0	not admissible
K18	ability to use special tools	7.0	8.0	–1.0	not admissible
K23	knowledge of technology of car maintenance and repair	7.0	8.0	–1.0	not admissible
K25	knowledge of the car structure	7.5	8.5	–1.0	not admissible
K27	knowledge of the basic mechanical properties of processed materials	7.0	6.5	+0.5	admissible
K32	stress resistance	7.0	6.0	+1.0	admissible

To specify the actions to assess the competencies of the specialists, a block diagram of the determination and assessment of the competencies of the employees of the enterprise has been

built, which, unlike existing, has a logical sequence of actions, based on the principles of «Assessment center» technology for a set of methods (interview, «Brainstorming», «Business Game» and testing) and is based on bringing the level of existing competencies of the employees to their reference values. The inclusion of assessment methods, such as interviews, brainstorming, business games and testing in the Assessment Center makes it possible to obtain comprehensive and complementary information on the results of the assessment to formulate the overall conclusion.

The appropriate methodological tools for the implementation of such a process have been developed and its practical application to determine key competencies has been realized on the example of repair workers of the road transport enterprise PJSC «RTE-16365», as well as the existing and required level of their values has been diagnosed.

As mentioned in this section and previous sections of this work (Section 1, Section 3), ensuring the quality of education with a combination of innovation is an indisputable path to success and development of each individual industry and the state as a whole. Therefore, the problem of developing the innovative approach to the development of transport infrastructure in particular will be addressed in the next section of this study.

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8 GOAL-SETTING IN THE PROCESS OF FORMING THE STATE STRATEGY FOR INNOVATIVE DEVELOPMENT OF TRANSPORT INFRASTRUCTURE

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ABSTRACT

Sections 1 and 5 discussed innovation as a driving force for development in an era of ephemerality and turbulent challenges. The innovative approach is needed in ensuring the quality of education (Sections 1, 3), in enterprise management (Sections 6, 7) and in the process of forming a state infrastructure development strategy. To improve the quality and validity of strategic actions in the process of public management of innovative development of transport infrastructure, elements of the decision support system for the formation and implementation of an innovative strategy for innovative development of transport infrastructure, which include a set of task blocks (goals, project proposals, strategic alternatives, motivation, communication, controlling) and tool modules (data, expert assessment, analytics, modeling), have been identified. It is proposed to ensure compliance of strategic goals of innovative development of transport infrastructure with dynamic changes in the environment of its functioning due to the implementation of the dynamic-adaptive approach to goal- setting in the system of formation of an innovative strategy of transport infrastructure transformation. The latter involves the creation of a reflective information and communication environment for setting and cyclically adjusting goals by involving a wide range of stakeholders, the use of modern information and analytical systems and foresight research technology.

KEYWORDS

Goal setting, innovative development strategies, transport infrastructure, strategic goals, foresight, public administration.

8.1 STRATEGIC TARGET PRIORITIES AND THEIR IMPORTANCE IN THE SYSTEM OF STRATEGIC PUBLIC ADMINISTRATION

Particular importance in the system of strategic public management of innovative development of transport infrastructure belongs to the stage of defining strategic target priorities. This is due to the presence of different views on the strategic goals of innovative development of transport infrastructure, among which the most priority areas and directions should be identified.

Goal setting is traditionally considered in two guises: as a set of actions and as a process [1]. As a process goal setting is a sequence of subsequent stages of analysis and decision-making, the completion of which is a goal.

The analytical stage begins with the collection of information, needed to make future management decisions. The information in this case is used both insider and external.

It should be noted, that there are three categories of goal-setting [2]: given (passive) goal-setting; competitive goal-setting; value goal-setting.

1. Given (passive) goal-setting – the formation of goals based on objective needs or under the pressure of external circumstances. Inside, you can select several sublevels, according to the degree of increasing independence of goal-setting:

a) goal-setting from tasks. This is the simplest level of goal-setting, the continuation of external goals, which is formed directively;

b) goal-setting from needs. Needs exist as an objectively given necessity. Dissatisfaction with needs can lead to cessation of existence. These goals are not subject to subjective choice;

c) goal-setting from threats. This level of goal-setting arises when you need to decide: what to avoid, what to resist? There is already a certain level of independence: threats need to be identified, to determine the probability. Unlike needs, threats do not manifest themselves;

d) goal-setting from problems. It arises because of failures in the implementation of plans. A problem is not obstacles themselves, but the reason why these obstacles cannot be overcome. The main difficulty at this level is to identify the real sources of problems.

2. Competitive goal-setting.

Such goals arise from comparison with other subjects of the market environment. According to their tasks, this level is divided into:

a) goal-setting from the struggle of interests. Key question: How to win? Since the interests of economic entities do not always coincide, the task of this level is to defend their own interests either by coordinating them with others, or by dominating and subordinating others. Goal-setting from the struggle of interests – one of the main levels of goal development to build an effective system of motivation;

b) goal-setting from mutual comparison. In this case, we focus on some target models and focus on success, compared to other businesses. Mutual comparison is one of the strongest motivators of human behavior.

3. Value goal-setting.

There are three directions in this level:

a) goal-setting from VISION. It is the setting of goals based on an image of the desired future, where the key is the image, not a project or plan;

b) goal-setting from values. Goal-setting of this type answers the question: what should we strive for? What is acceptable in the implementation of goals?

c) goal-setting from the mission. This level is based on the questions: what should we do? What is our purpose?

Various features and bases of their classification and structuring are used for systematization of goals.

In management practice, the following types of goals are traditionally distinguished.

By degree of detail: general; private.

By time, allotted for implementation: short-term (less than a year); medium-term (1–5 years); long-term (more than 5 years).

By scale: strategic; tactical; operational.

A strategic goal is characterized (as opposed to a current goal) by the following features [3]:

– future orientation and uncertainty of choice;

– focus on a situation in the environment;

– proactive (precautionary) behavior of all elements-target carriers;

– the relationship with the method of achievement (strategy) and means of achievement (tactics, resources);

– the possibility of alternatives and changes;

– higher level of managerial influence.

Thus, strategic goal-setting will be understood as a multilateral process of defining, formalizing and agreeing on goals according to their qualitative characteristics, as well as modeling and selection of quantitative values to assess the degree of achievement of goals in the long run.

It should be noted, that from the organizational point of view, there are three basic options for goal-setting [2]:

– authoritarian approach («top down»);

– collective approach («bottom up»);

– stakeholder approach, which combines both of the above approaches.

Based on the analysis of the basic aspects of philosophical and methodological analysis of the evolution of goal-setting in management, we can identify the specifics of goal-setting in the context of classical scientific rationality, which is determined by the following characteristics [4]:

– use of positivism as a philosophical basis;

– monopoly of an external observer of the goal-setting process;

– high degree of structure and complexity of a subject of goal-setting (individual, small group, hierarchical structure);

– dominance of the activity approach, with the presentation of a goal as a system-forming factor;

– object-oriented approach;

– wide possibilities of using analytical models (operations research, game theory, etc.) for the formalized description of processes of optimization of achievement of a goal taking into account controlled, uncontrolled and casual factors;

– limited understanding of goal-setting criteria;

– focus on the information approach;

– dominance of monodisciplinarity based on the approach of technical cybernetics;

– ethics of goals, assuming the principle of «the end justifies the means»;

– risk assessment due to the probability of failure to achieve goals.

Generalized goal-setting in the context of classical scientific rationality can be characterized as linear on the basis of hierarchical structures.

Along with this, modern basic trends in the development of scientific rationality, influencing the increasing role of scientific diplomacy in strategic goal-setting are implemented in the following areas [5]:

– increasing the role of the external approach in the development of science and innovation;
– reflexive-active environments as a basic mechanism of innovative development;
– dominance of reflexive activity;
– from the ethics of goals to the ethics of strategic actors;
– from the monodisciplinary to the transdisciplinary approach.

It should be noted, that in our country the most common approaches to strategic management at the state level are directive and/or purely expert principles.

However, at the present stage of management, none of the goals of the state and, accordingly, the innovative development of the transport industry has a real basis for its implementation in the absence of partnerships between the main subjects of goal-setting. This is because the goals of the stakeholders, who will represent a certain type of informal coalition, must be taken into account when setting a goal.

At the same time, there may be certain relations between parties (stakeholders), which are not always cooperative, ie they can be competitive. However, stakeholders can always be considered as a single contradictory whole, the equal interests of the parts of which will determine the trajectory of evolution [6]. Therefore, it is the stakeholder approach that allows a more thorough approach to the goal-setting process, as it takes into account the interests of stakeholders.

8.2 IMPROVING GOAL-SETTING IN THE PROCESS OF FORMING A STRATEGY FOR INNOVATIVE DEVELOPMENT OF TRANSPORT INFRASTRUCTURE

Based on the above, to determine the strategic priorities of long-term innovative development of transport infrastructure, it is necessary to use a mechanism that meets a number of criteria:

– reliance on the opinion of competent specialists in the field of transport;

– the interest of the political leadership and the bureaucracy (it depends on whether the results will be used for political decision-making and strategy development);

– taking into account the interests of a wide range of actors: various political forces, scientific and business communities, civil society and others, not just the opinions of a narrow number of experts and the ruling elite;

– transparency of the process of setting priorities in terms of organizing events, choosing long-term goals, as well as in terms of availability of information about the process for all stakeholders.

It should be noted, that partners in social dialogue cannot act on an equal footing, at least at certain stages the priorities of one over the other are set. At the initial stage, the government often has priority, as it is from it that strategic management and the desire to develop a development strategy come [7]. Prioritizing different groups of stakeholders allows you to determine what they

should pay attention to when developing a strategy. At the same time, as with stakeholders in any organization, stakeholder alliances eventually become part of the strategy.

The degree of influence of stakeholders on strategic change depends on a combination of three components: power, desire to achieve specific goals, political influence on decision-making [8].

Given that the modern world is changing at an exponential rate and new discoveries are taking place every minute, it is very important to follow them because there is a lot of information to perceive, and the growing pace of change requires rapid adaptation and response. In addition, it is possible to fix quantitative target indicators only after forecasting the conditions and opportunities for the development of an object. This issue can be solved by dividing a goal into two stages: the task of a goal function, and the definition of a specific quantitative target level of its value – only after analyzing the possibilities and choosing the best alternative.

In such conditions, it is necessary to move from the static approach to goal-setting to the dynamic-adaptive approach, which involves cyclical adjustment of goals based on the use of modern information and analytical systems and the involvement of a wide range of stakeholders (**Fig. 8.1**).

In the proposed mechanism, the efficiency is provided by the following factors [9]:

1) only a goal function of the controlled system, which is a generalized criterion for the usefulness of the studied system is initially set;

2) an information and communication network of interested persons is formed, which creates an environment of reflection;

3) specific quantitative values of the target level of the utility function and private development goals are determined only after forecasting, analysis of opportunities and selection of the optimal concept.

It is important to emphasize the function of reflection because it contributes to the expansion of consciousness: overcoming stereotypes, building a new understanding, rethinking, etc. It is worth noting, that the filters of reflection determine the coexistence of subjectivity, which allows to ensure the adoption of agreed decisions and the possibility of their further effective implementation.

On the part of an individual subject, the filters of reflection are manifested in the identification of other subjects together with their resources and risks of influences. The reflection filter is a coordinated folding of subjectivity processes. Without this function, it is impossible to ensure parity of subjects, especially in a situation of joint creativity, necessary to cope with the challenges of a turbulent environment, as well as with the states of subjects, which are also parameters of the environment (problems and conflicts).

Modern scientific ideas allow us to establish that the basis of goal-setting is the sources of goals and ways to reflect them. As is well known, the sources of goals are needs, interests, and intentions. Based on this, we can conclude that the strategic goal of innovative development of transport infrastructure reflects the need to move to a qualitatively new state to implement its functions in the context of meeting the interests and needs. In turn, needs should be based on the interests of parties (stakeholders). Currently, the interests and needs of society in the innovative

development of transport infrastructure form the following macro- and megaeconomic requirements for the transport system:

– raising the living standards of the population;

– increasing the value of human capital;

– deepening of interregional demographic disparities;

– mixing of demographic and production load on the natural environment;

– reducing the resource intensity of the economy, improving the processing of raw materials, increasing the share of finished products in the structure of transportation.

Taking into account these factors, the global requirements for promising transport systems are speed, safety, including environmental, energy efficiency, the ability to provide flexible customer service and integration into multimodal transport systems [10].

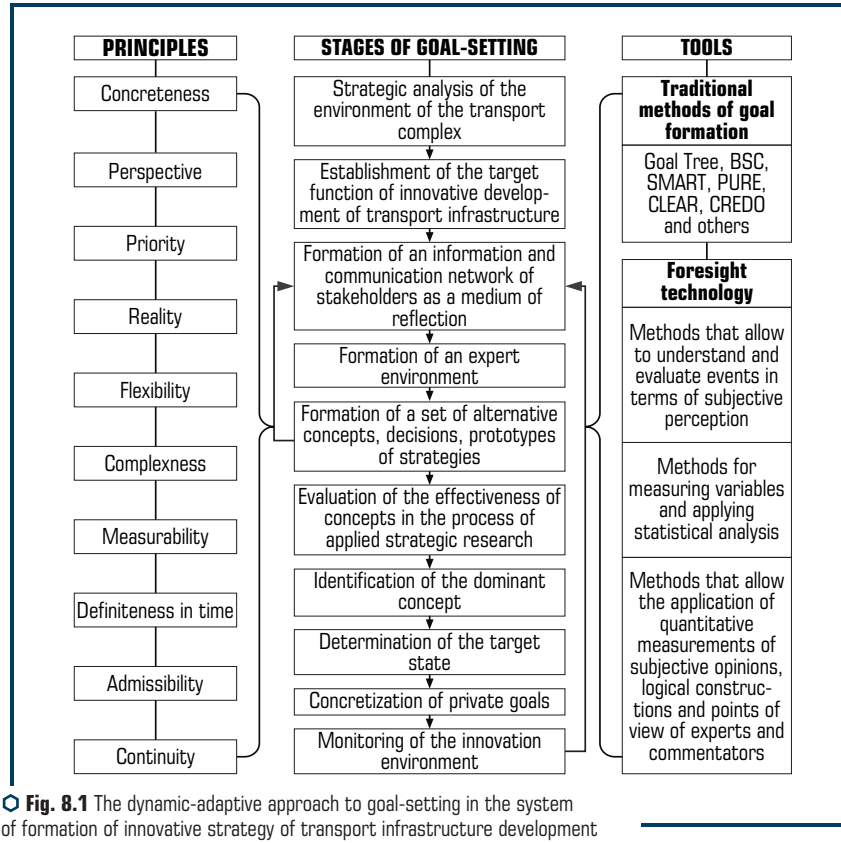

Fig. 8.1 The dynamic-adaptive approach to goal-setting in the system of formation of innovative strategy of transport infrastructure development

** Source: author's development*

It can be concluded, that the innovative development of the domestic transport infrastructure is ensured through the transition of the transport system to a more advanced technological level of freight and passenger transport, which includes competent automation, informatization and electrification of all departments of the transport system in connection «passengers/cargo – management» ensuring the efficiency and safety of transport logistics and the creation of environmentally friendly transport, endowed with the potential to organize high-speed traffic. The main general directions of innovative development of transport infrastructure currently include the following:

– modernization of existing and development of new types and kinds of transport communications (pipelines, roads, railways, tram tracks, etc.);

– modernization of existing and development of new types and kinds of freight and passenger transport equipment;

– modernization, reconstruction of existing and development of new means of communication (for transport);

– modernization, reconstruction of existing and development of new devices in the economy of electrification and energy (for transport);

– modernization and development of new types of track and loading and unloading machines and mechanisms;

– technical re-equipment, reconstruction and strengthening of the existing repair base and development of its new elements and systems;

– creation of a modern system of information support in management.

Identification and further detailing of the goals of innovative development of the domestic transport infrastructure requires the use of special research methods. In particular, the requirement of scientific validity raises the problem of defining quality criteria for goals.

The classical approach [11, 12] to the selection of quality criteria for management goals includes the following requirements.

Scaling goals over time. Carrying out such tactics helps a manager to determine how often it is necessary to conduct inspections, so that in case of deviation from the schedule there was enough time to intensify activities to bring it back to normal. Defining a time frame is important for both long-term and short-term goals.

Concise wording. Most often, this requirement is ignored and the formulation of a goal includes a description of the methods that will be used to achieve this goal, and a number of other «side» information.

A reasonable balance between tension and realistic goals. The practice of management shows that goals that are easily achieved have a weak motivating effect, and this is not satisfying, because people do not put their achievement to their credit. However, there is a «threshold» of complexity of goals, beyond which motivation is also reduced due to the formation of negative expectations of the relationship between the efforts and the results achieved. Studies have repeatedly shown that people work most productively when goals are set at a so-called motivational level – high enough to strive for, but not so high as to fail, and not so low that no effort is required to achieve it. Therefore, the goals must be sufficiently intense, but realistic to achieve.

Flexibility. Goals must be flexible enough to be modified according to the situation in a dynamically changing environment.

Admissibility. Goals are more effective when people are responsible for achieving them, consider them acceptable. This means that the results that performers will achieve must be commensurate with their values and preferences.

Comparability. This criterion presupposes comparability, firstly, between goals of different key spaces, and secondly, between goals of the internal organizational hierarchy, each of which must meet the goal of a higher level.

Measurability. A goal is effective only when it has both qualitative and quantitative expression. Goals that have the qualities, listed above, are more effective than those that do not.

There is a variety of techniques that are aimed at the correct formulation of goals. They partially intersect with each other, but each relates to several different positions, and therefore when choosing a method it is advisable to proceed from the idea of the main goals. A number of techniques not only determine what criteria must meet the goals, but also in what form they can be represented.

Among the methods of goal-setting, the method of American scientists C. Churchman and R. Ackoff, called the «goal tree» [13], has become widely used. It provides for the formulation of goals in the form of a subcontracting hierarchy of tasks of different levels: general; first and second, etc.; sub-goals or intermediate goals; problems that need to be solved to achieve goals; specific tasks that can be set before a performer and their performance can be monitored. All levels are interconnected. The goal tree is usually represented graphically as a pyramid or a branched tree. When compiling the model, it is necessary to follow a strict sequence to create an orderly and visual system.

The method of R. Kaplan and D. Norton [14], which is abbreviated as BSC (balanced scorecard), which translates as a system of goal-setting on balanced indicators, has also proved its effectiveness. The method is that strategic goals are divided into subordinate tasks, expressed in measurable indicators. This is a difficult method to perform, which takes into account not only financial but also other factors: staff, innovative technologies, business processes, work with consumers. The development of the system requires special training, but in most cases this method of goal-setting is highly effective due to the ability to monitor and evaluate the implementation of tasks.

Modern approaches to defining quality criteria for management goals complement the classical approach and clarify some of its provisions. Most methods in their name contain the main criteria that must meet the set goals. The choice of English or other language for the abbreviation is determined by the authors of the method.

The most popular technique is SMART, which is simple and easy to use. The method allows you to formulate goals according to the most important criteria: Specific – accuracy or concretness; Measurable – measurability in specific indicators; Achievable or attractive – achievable and attractive goals; Realistic or relevant – relevance or significance of tasks; Timed-bound – limited in time by specific dates.

The PURE method defines what the goals should be: Positive; Understandable – clear to everyone; Relevant – actual; Ethical – behavioural or moral.

Somewhat different directions are put forward by the CLEAR methodology, according to which the goals should be as follows: Challenge – complex, ie those that challenge others and a team itself; Legal – lawful or valid; Environment – ecological, ie do not pose a threat to the environment; Acceptable – allowable not causing internal rejection; Realistic – reasonable or feasible.

The CREDO method states that the goals should be: C – concrete; R – resulting; E – expressed in units of measurement (monetary, natural, places in a rating); D – doable; O – optimal, limited in time.

The method of publicity is also considered effective, according to which it is necessary:

– openly declare your goals to others;

– to make the list of goals constantly available, ie so that it is constantly in front of the eyes and reminds of itself;

– determine the rewards for achieving the ultimate and intermediate goals.

Such a modern technology as foresight is potentially effective in dynamic-adaptive goal-setting.

Consider several definitions of the term «foresight» [15]:

– systematic joint process of building the future based on strategy and coordination of joint actions (FOREN Guide);

– systematic attempts to look into the future of science, society, economy and technology for the purpose of harmonious development (Asia-Pacific Economic Cooperation-Center for Technology Foresight);

– formalized methodology for assessing the long-term consequences of implemented solutions in the field of science and technology (Technology and Innovation Foresight for Bulgaria and Romania-ForeTech);

– systematic reflection on the future and its impact (Australian Center for Innovation).

The generalization of the above approaches indicates that, in general, foresight (sight in the future) is a methodology for organizing a process, aimed at creating a common vision of the future for its participants.

Foresight allows to develop a scientific idea of the future, taking into account the wishes of society and shows ways to achieve it by supporting innovation and technology, training, required by the economy of a country (region), priority areas of resource use (physical and human capital).

All stakeholders with their current actions seek to support a vision of the future, formed as a result of foresight. This suggests that foresight is a tool for managing technological development, based on the infrastructure, created within it [16]. The basis of foresight is communications of all persons, whose vision affects the future (representatives of ministries and departments, business, science and the public). Thus, the foresight method is a synthetic expert method that combines forecasting with the program-target approach. Foresight is applied every few years and is focused on the long-term and very long-term perspective. Foresight is usually carried out for the long term (20 years), but can be adjusted every 3–4 years. The main resource of foresight is a map of promising areas of innovation and technological development in the sector.

The foresight method is focused on obtaining expert (public or professional groups) assessment of possible scenarios of the state of a research object in the future, and recommendations on pro-

gram steps to achieve the target state of the object («road maps»). Subjects of foresight for the formation of the goals of the strategy of innovative development of transport infrastructure are:

a) government agencies, the purpose of which is to determine the directions of further development and growth;

b) regional authorities that use foresight to restructure and increase the competitiveness of transport infrastructure in the regions;

c) universities, specializing in research in this field and training;

d) industry associations with the necessary analytical qualifications;

e) other institutions.

To participate in foresight must be involved:

a) international and domestic experts in the field of transport;

b) domestic manufacturers, which are leaders in the market of transport engineering;

c) intermediary companies that provide communication with consumers;

d) domestic and international research centers and institutes;

e) educational institutions.

Experience shows that foresight research technology is able to provide solutions to the following problems:

– identification of long-term trends in the development of the transport sector;

– scenario presentation of future changes;

– coordination of development strategies of different hierarchical levels;

– the frequency of updating information and the possibility of using it to adjust policies.

The system of methods, given in table, is used for carrying out a foresight (**Table 8.1**).

Table 8.1 The foresight methods

Methods that allow to understand and evaluate events in terms of subjective perception	Methods for measuring variables and applying statistical analysis	Methods that allow the application of quantitative measurements of subjective opinions, logical constructions and points of view of experts and commentators
Brainstorming Conferences/seminars Expert panels Forecast of genius Interview Literature analysis Goal tree/logic circuits Role-playing, simulation games Scripts/script seminars Sci-fi Simulation games Examination SWOT analysis Weak signals/jokers	Benchmarking Bibliometrics Indicators/analysis of time series Modeling Patent analysis Trend extrapolation/impact analysis	Cross-link analysis/structural analysis Delphi Key/critical technologies Multicriteria analysis Poll/voting Quantitative scenarios Road maps Stakeholder analysis

** Source: generated by the authors based on data from [17–19]*

The following methods are typical for foresight [20]:

– methods of analysis (SWOT and STEEPV analysis became the most widespread);

– methods of forecasting (examination), among which the most common method is Delphi;

– methods of generating ideas (creative), the most famous of which is «brainstorming»;

– methods of interaction (conferences, round tables, role-playing games).

Characteristics of the most used foresight methods are given in **Table 8.2**.

● **Table 8.2** The characteristics of the foresight methods [21–23]

Literature analysis	The method is used to prepare an information base for further analysis procedures. It includes specialized procedures for searching data in various databases and information arrays, as well as the initial preparation of results: comparison, verification, classification, etc
System analysis	A set of methodological tools, used to prepare and justify decisions on complex objects of study, involving their consideration as systems
SWOT-analysis	It is used to identify the strengths and weaknesses of the study area, as well as to identify «windows of opportunity» and threats. The advantage of this method is the possibility of its implementation by a small number of experts
STEEPV-analysis	One of the most popular matrix methods of analysis of factors, influencing the object of study. In it, factors are divided into 6 categories: social, technological, economic, environmental, political, value. To build a sound forecast of the dynamics of the external environment of the subject area as an object of study, possible combinations of these factors are considered and the strength and direction of their influence are analyzed in different combinations
Expert panels	Represent permanent groups of highly qualified experts with well-established communication channels
Simulated expert discussions	This method allows for a comprehensive discussion of various issues, agree on different expert points of view and develop a common solution
Expert interviews and surveys	The application of these methods is aimed at obtaining additional information and clarifying the existing information, required for the implementation of this project
Script analysis	Includes creating pictures of a possible future based on a creative combination of statistical information, facts and hypotheses

However, the specificity of foresight is not only in private methods, but in the methodology as a whole, which can lead to the correct result. Forsight technology methods are carried out in stages. There are 3 such stages, the scheme of implementation of which is given in **Fig. 8.2**:

1. Pre-forsight. At this stage, organizers of the foresight process, stakeholders – and consumers of its end result, form goals and objectives, sources of funding for technology. Pre-foresight differs in the implementation of the characteristics of study conditions, analysis of the internal and external environment for the goals of innovative development of the transport complex, the installation of foresight indicators.

2. Foresight. This stage is characterized by the combined activities of organizational institutions, experts, engaged in work in the field of innovative development of transport infrastructure;

it also explores development prospects, highlights competitive advantages, prepares all necessary intermediate and final documents, conducts seminars and discussions.

3. Post-forsight. At this stage, possible changes in the future are monitored, the implementation of elaborated scenarios of the process development and repeated stages of the study are monitored.

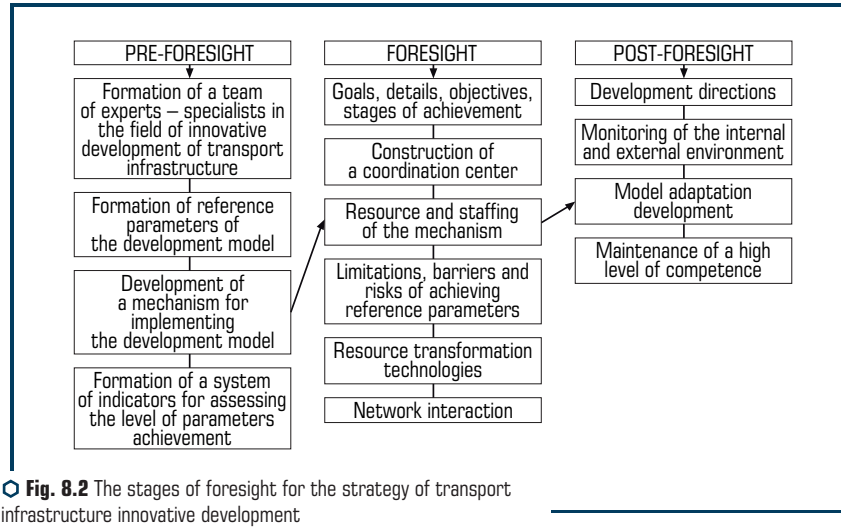

Fig. 8.2 The stages of foresight for the strategy of transport infrastructure innovative development

** Source: generated by the authors based on data from [24, 25]*

The initial stage of foresight (pre-forsight) has a special meaning as it sets the full potential for further work. The implementation of a foresight begins with a number of survey activities (including discussions), which involve representatives of government,expert community, business, science, education, non-governmental organizations, media and others. At the same time, face-to-face activities are often supplemented by conducting large-scale surveys, in which up to 10,000 respondents can participate. During the meetings, participants formulate and analyze alternative scenarios for future transport development, and then collectively choose the best option.

Participants then proceed to prepare recommendations for decision-makers in political, commercial, research and community structures. Based on the established practice, this often involves the selection of priority areas of activity and the formulation of a model plan for the phased implementation of the best scenario of the future (for example, in the form of a «road map»).

The formation of a road map is based on the analysis of existing world trends, domestic experience and taking into account the results of previous projects, implemented in different countries. At the same time, brainstorming is actively used in the work of groups, which is an operative method of solving problems on the basis of stimulating creative activity, where participants are invited to express as many solutions as possible, including the most fantastic ones. In the future, from the total

number of ideas expressed, the most successful ones are selected, which can be used in practice. The success of brainstorming largely depends on the stage of generating ideas, where it is important to exclude any criticism of the views expressed, as the assessment distracts from the main task and knocks down the creative mood. The number of topics at this stage is unlimited. To work, experts must be provided with the latest analytical and information materials and developments.

The formation of expert networks for the survey should be carried out on the basis of nomination, ie each expert of a working group recommends well-known experts and stakeholders in each area, each named recommends known to him/her, etc. However, expert networks unite not all interested, but only those professionals who already have unique competencies in their field. Moreover, members of expert networks must regularly confirm their competencies, including new, acquired knowledge and experience. To some extent (from the point of view of regular confirmation of qualifications) scientific communities are similar to expert networks, but science does not use the competency-based approach to ranking (scientometric indices are not divided by competencies), and the work of scientists is not related to the community as a whole. Both scientists and practitioners take part in expert networks, because expert activity, although built on the scientific basis, but, above all, involves personal experience and knowledge of an expert. Competency classifiers (models) are metrics of expert networks, thanks to which each expert has his/her own unique range of competencies. The uniqueness of an expert is a prerequisite for participation in expert networks, as it avoids competition – each expert is unique. However, within one competence, competition is not only possible but also necessary, as only a comparison can determine the level of competence of a specialist. The latter condition formulates a restriction on an expert network – if the number of professionals with specific competence is small (for example, less than four), it is assumed, that such competence in the network community simply does not exist. An expert network should involve its members in regular activities – at least in summarizing information.

Due to the large number of experts, it is extremely important to organize the form of their work, based on the need to ensure its anonymity and convenience. To do this, you should organize the work so that experts can ask for the necessary clarifications (fax, telephone, e-mail, various Internet protocols).

In parallel, a bibliometric analysis of the state of technology is conducted. This analysis will identify the most trends, as well as the degree of activity and productivity of basic and applied research, their contribution to the development of scientific knowledge. The bibliometric approach to the study of science involves the quantification of documentary information flows, as reliance in these studies is based on quantitative indicators, presented in various bibliographic databases that reflect the state of science as a whole or its individual branches. The objects of study in the bibliometric analysis of science are publications, grouped by different characteristics: authors, journals, thematic sections, countries, etc. The main advantage of this analysis in comparison with other methods, used in foresight, is that the studied phenomena are of an objective nature (published, cited).

Then there is a comparison of the results of expert groups and bibliographic analysis. At this stage, working groups supplement the missing topics based on the results of citation indices. The obtained results are processed – they are divided into areas and further filtered, based on the

specified conditions for conducting foresight research by the scientific council. After that, they begin to compose questionnaires. Lists of specially organized and formed questions are one of the universal ways to obtain the knowledge of specialists for use in monitoring or observation, preparation and decision-making, for forecasting tasks. Questions should be focused on one problem or topic, should be short and clear. All respondents should understand the question in the same way and answer the same question, rather than their options for guessing it. In addition, the list of topics should be open so that experts can make suggestions on the composition of the topics. The questions should be formulated in a neutral tone without any positive or negative assessment of the problem, should not persuade a respondent to give an answer, desired by a researcher. The questions should be presented in a certain logical sequence. First, you should ask questions that can be used to determine the level of competence of respondents in the field of the study (depth of knowledge and degree of involvement in this area).

After the questionnaires are formulated and the composition of experts is approved, a two-round Delphi survey is conducted. After the first round, the obtained data are processed for further acquaintance of experts with the results of the first round. It should be borne in mind, that this method is very tedious for people who participate in it, so an excess of information can negatively affect the number of participants in the second round. Therefore, the obtained data should be presented in a compact, accessible to experts form as structured texts, diagrams, tables, graphs, with emphasis on controversial, extreme, difficult moments. All topics should be ranked in order of importance. The list of questions, criteria and evaluation scales can be adjusted as needed. Thus, in the second round of the survey, experts are offered updated questionnaires and information on the results of the first round. The two-round nature of predictive expert research provides feedback. Experts get acquainted with the results of the previous round: the general group assessment, judgments and arguments of other members of the study. As a result, in the second round, experts, working with updated information, begin to adjust their opinion, increasing the overall consistency in the group, or confirm their previous assessment, having more reason to do so. It should be noted, that those who did not answer the questions in the first round are excluded from the list of experts, participating in the second round. After the second round, the obtained survey data is re-processed. These results are ranked according to the selected priorities and are final.

At the next sub-stage, the data, obtained from the Delphi survey, are subjected to scenario analysis. At this stage, the expert group that worked on the topics, approves two people in each direction to develop a scenario vision of the future based on research (analysis of trends in the modern world based on the main influencing factors (drivers): political, economic, sociological, technological, environmental, demographic, etc.). The interaction of «drivers» creates the dynamics of scenario development. The analysis should identify the most likely events and trends that will later form the basis of the scenarios. Thus, it is necessary to use not classical discrete staging but continuous as a method. In the discrete method, the number of scenarios is small, they are all prescribed, one of them is chosen as the base, the others are considered as undesirable alternatives. You can't drop anything from the selected scenario, you can't add anything to it from other ones.

Continuous staging is based on the concept of «inevitable future», which is determined by decisions, made earlier before staging and the inertia of large systems. This method is based on the fact that a future that is incompatible with the «inevitable» is impossible, and in turn, any future that includes a completely «inevitable future» and does not contain any element of the «impossible future» is a version of the future scenario.

Once the scenarios are written, they are discussed by the group of experts about their likelihood and the risks, associated with using each one. As a result, the most probable development scenarios are selected that are most suitable for modern conditions. Then, based on the data of Delphi analysis and scenario analysis, a draft long-term forecast is prepared. Thus, the implementation of such a structure for the formation of goals of innovative development of transport infrastructure will organize a process, aimed at creating a common vision of the future for participants, which all stakeholders seek to support in their current actions. This methodology will allow not so much to predict the future, but rather to shape it, which will allow foresight to be considered a specific tool for goal-setting in the system of state strategic management of innovative development of transport infrastructure.

It is worth noting, that a truly effective foresight depends on such factors:

1. Creation in the process of foresight of a permanent infrastructure for obtaining, processing, analysis and dissemination of relevant information. This includes specialized centers for tracking and collecting new data on innovative transport development, publicly available Internet resources (such as information repositories and online platforms for maintaining contacts between actors), as well as analytic centers (thinktanks), which along with research can train participants in foresight techniques and provide them with consulting and organizational support in the implementation of multilateral projects. The existence of such an infrastructure in automatic mode provides foresight projects with relevant input data, expert competences (expertise) and channels for interaction between participants. In fact, the elements of the foresight research system are beginning to be institutionalized.

2. Implementation of measures to strengthen trust between foresight participants: the state, business, scientific community and other participants. The presence of trust contributes to the formation of alliances of participants for joint activities, as well as the integration of material results of a foresight into the decision-making system due to the fact that decision-makers begin to take the conclusions of foresight participants seriously and consider their recommendations reasonable.

The effect of these factors can significantly reduce the level of transaction costs within the system itself, and thus make the interaction of participants in the system of innovative development of transport infrastructure more effective and less resource-intensive.

The results of the study allowed us to draw a conclusion about the strategic priorities in the system of state regulation of innovative development of international transport and logistics infrastructure, which include such target characteristics as:

– integration into the world transport system and ensuring stable competitive positions in the world transport market;

– modernization of the existing and development of a new transport and logistics infrastructure of international importance;

– improving the quality of transport and logistics services, as well as ensuring the commercial, socio-environmental and budgetary efficiency of the transport and logistics infrastructure of Ukraine of international importance.

To achieve these goals, two dominant areas of improving the model of institutional support for innovative development of international transport and logistics infrastructure in Ukraine, including motivational and the formation of a digital environment for digital transport corridors, have been established.

The priority instruments of the institutional mechanism for each direction are revealed in **Fig. 8.3** on such components as normative-legal, financial-investment, taxation system, organizational.

The following priority development tools have been substantiated for the formation of an effective motivational state policy of innovative development of the international transport and logistics infrastructure of Ukraine:

1) adaptation of the domestic legal framework and existing institutions to international requirements and standards, strengthening the protection of intellectual property rights and international cooperation in science and technology;

2) increase in investments in the development of transport infrastructure (provision of subventions for the development of transport infrastructure; support for innovation and investment projects; formation of appropriate investment funds; activation of extra-budgetary sources of innovation support);

3) change in the system of taxation of innovation activities and customs procedures through the introduction of various benefits and reorientation to environmental taxes;

4) promoting the initiation of innovations in transport infrastructure (formation of an effective system of interaction between transport infrastructure and the scientific and educational sector, formalization of the state cluster organizational and logistics policy, development of social infrastructure).

The institutional mechanism for the formation of the digital environment includes the development and implementation of such tools of state regulation as:

1) regulations, aimed at removing barriers to digital transformation (including related to the identification of legal entities in the digital environment, electronic document management, data circulation, regulation of artificial intelligence and robotics, information security, installation of special legal regimes, e-commerce), as well as the development and adoption of standards for ecosystems of digital transport corridors;

2) crowdfunding, digital financial assets;

3) tax preferences for manufacturers of digital equipment for software developers, special tax regimes for developers of digital innovations, changes in corporate taxation in the direction of taxes on digital services;

4) formation of virtual structures of state regulation and virtual subjects of infrastructure, generation of professional competencies and diffusion of knowledge of digital transformation.

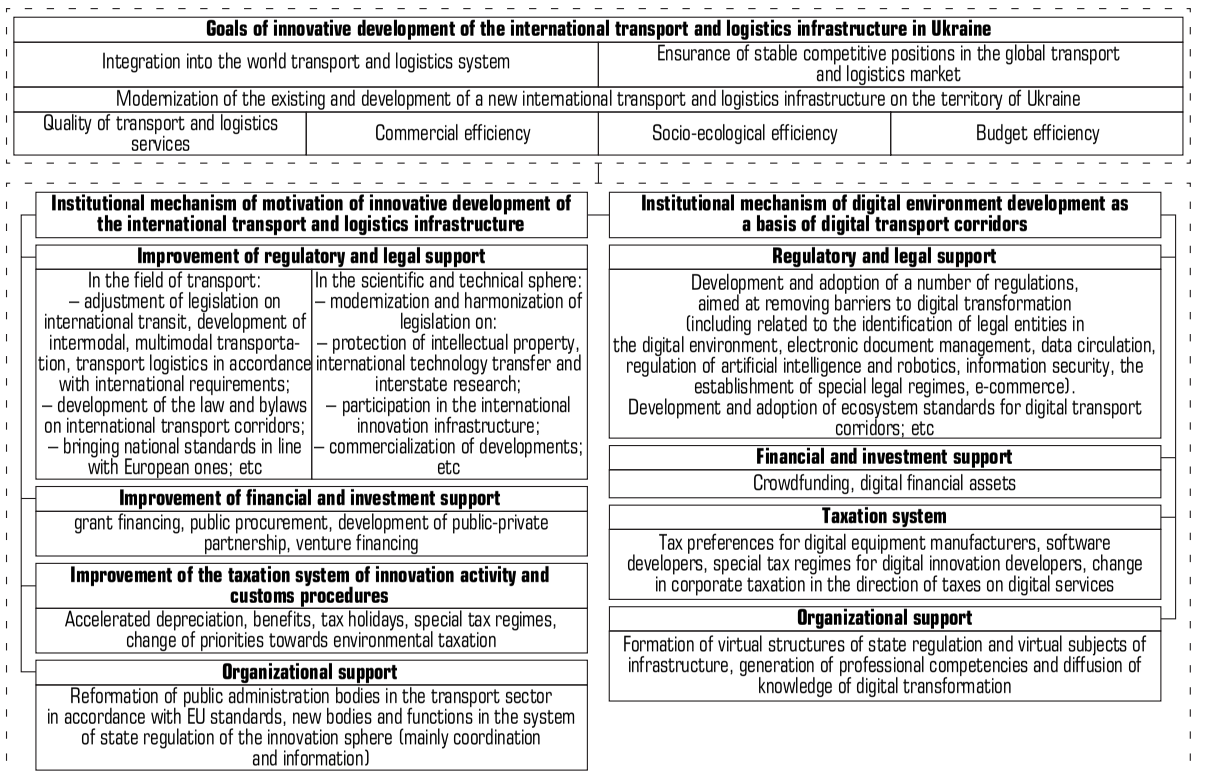

Fig. 8.3 The model of institutional support for innovative development of the transport and logistics system of Ukraine

Thus, it is necessary to focus not so much on the external, secondary manifestations of foresight, but on the internal mechanisms of interaction between its participants to create a transparent and information-rich environment for joint purposeful activities. With this in mind, foresight, or rather interest in its effectiveness, becomes an impetus to close the «gaps» in the information and institutional infrastructure of the system, as well as to create a common atmosphere of trust between key players. In other words, foresight begins to perform the function of increasing the level of self-organization in a complex system of actors and ensuring their interactions. Under such conditions, the purpose of foresight is not to predict the future, but to identify the framework conditions, under which participants and the system itself will be able to painlessly adapt to different development scenarios.

The comprehensive model of institutional support for the innovative development of international transport and logistics infrastructure in Ukraine, which combines the subsystem of motivation for innovation and the formation of a digital environment, is proposed. However, the research can be enhanced by the implementation of corporate social responsibility programs, which on the one hand is an innovative component of Ukrainian realities, and on the other – an integral part of it. The next section of this work will be devoted to the solution of this problem.

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9 PROGRAMMING OF CORPORATE SOCIAL RESPONSIBILITY DEVELOPMENT OF AN ENTERPRISE

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ABSTRACT

Speaking about the essence of the concept of «corporate social responsibility» (CSR), we mean the active social position of a company, which consists in the harmonious coexistence of stakeholders, constant dialogue with society, business participation in addressing pressing social issues. The essence of the concept of CSR is to take into account the interests of society, responsibility for an impact of an enterprise on consumers, employees, local communities and the environment in all aspects of its activities. Social dialogue and CSR is the basis of innovative development of an enterprise. To solve the problem of implementing CSR in the Ukrainian realities, the existing methods for elaborating a program for the development of CSR in the activities of road management and road transport have been studied. The program of CSR development at the internal and external levels of implementation is offered taking into account features of various groups of stakeholders. The main directions of introduction of corporate social responsibility are separated. A number of measures are proposed for each group of stakeholders in each direction of CSR in enterprises of road management and road transport. This will increase the psychological climate of the team, improve the health of staff and well-being, which will increase the overall efficiency of road and road transport companies. The radar method is used to calculate the integrated indicator. A two-dimensional matrix of CSR level estimation is given. A method of integrated assessment of the level of CSR based on a system of partial indicators, determined by a stakeholder survey, is proposed. The proposed method has been tested at the enterprise «VITAL». According to the results of calculations, the level of CSR at the enterprise is assessed as a high level of development of corporate social responsibility. The implementation of the corporate social responsibility development program will allow road management and road transport companies to improve their business reputation and generally promote the country's business development.

KEYWORDS

Corporate social responsibility, road management and road transport enterprises, CSR development program, integrated assessment, environmental aspect.

9.1 THE PROGRAM FOR THE DEVELOPMENT OF CORPORATE SOCIAL RESPONSIBILITY AS A NECESSITY OF TODAY

In the modern directions of Ukraine's integration policy into the European and world space, a very important place should be given to the development of transport infrastructure, creating

conditions to better meet the growing transport needs of the country's economy and its population. The development and implementation of large projects in the field of road construction, the creation of highly efficient road maintenance equipment, special vehicles and technologies that meet international standards of technical and environmental safety should be set as strategic goals.

Road management is the main area of public investment in the transport sector. The road network is the most important element of Ukraine's economy. Its effective functioning and sustainable development is a necessary condition for the transition to economic growth, ensuring the integrity and national security of the country, raising the level and improving the living conditions of the population. The problem of economic growth is central to the country's development strategy. The approach from the standpoint of the quality of the economic space, its uneven development, preservation of the integrity of the national economy in the conditions of spatial heterogeneity is extremely important for Ukraine.

The state and level of development of the country's roads directly affect the main economic indicators, gross national product, price level, budget revenues, employment rate, etc.

The formation of a system of new economic relations, deepening of theoretical and methodological bases of complex development of road management, on the basis of which strategic directions of resource, including financial maintenance of the road branch in the conditions of market transformation could be developed, is extremely actual task at the present stage of development of the Ukrainian economy.

Today, for the development of road management and road transport positive features are the application of the basic provisions of corporate social responsibility (CSR), which will benefit society and the economy as a whole, reduce negative environmental impact, establish sustainable relationships with the environment, improve economic performance activity and image of an enterprise as a whole [1]. It would be very useful for road management and road transport companies to determine the level of CSR and compare it with other companies. This requires an integrated assessment of the level of corporate social responsibility of enterprises. Today, there is a small number of examples of elaborating CSR development programs for road management and road transport companies, in particular, they contain very few recommendations for stakeholders to implement them. Therefore, it is necessary to form a program of CSR development at an enterprise with individual recommendations for each group of stakeholders, which will offer specific measures that take into account the specifics of each area of CSR.

A significant contribution to the study of the peculiarities of the formation of programs of corporate social responsibility in the activities of enterprises was made by foreign and domestic authors, such as: B. Bataeva [2], O. Bilan [3], Iu. Blagov [4], I. Buleev [5], O. Vorona [6], P. Druker [7], A. Carroll [8, 9], F. Kotler [10], M. Meskon [11], P, Francesco [12], M. Rudenko [13], L. Selivestrova [14], M. Friedman [15] and others.

Different scholars have different arguments for implementing corporate social responsibility programs. M. Meskon cites «the following:

1) favorable long-term prospects, as even significant social investments in the future can stimulate profit growth, which is associated with an attractive image of a company in the eyes of consumers, suppliers and local authorities;

2) availability of resources to assist in solving social problems;

3) moral obligation to behave socially responsibly, because a company is a member of society, and therefore moral norms should be at the heart of its behavior in the market» [11].

However, there are arguments against corporate social responsibility, to which the above-mentioned scientist «includes:

1) violation of the rule of profit maximization;

2) reducing the price competitiveness of an enterprise, as funds, directed to social needs, increase the cost of the enterprise, and therefore, in order to maintain profits lead to higher prices, which reduces the competitive advantages of the enterprise in the market;

3) insufficient level of reporting on social actions;

4) lack of skills to solve social problems» [11].

A big problem for the country is the distrust of the population and entrepreneurs in particular to the government. Ukraine is characterized by distrust of enterprises of various areas of activity to the authorities, which leads to a phlegmatic attitude towards corrective functions of the state. Effective regulation of CSR in Ukraine is possible only if the state itself demonstrates a high level of social activity. Among Ukrainian scientists who pay a lot of attention to the study of corporate social responsibility, it should be noted O. Bilan [3], I. Buleev [5], O. Vorona [6], M. Rudenko [13], L. Selivestrova [14].

The analysis of scientific works by B. Bataeva allows us to cite the following «steps of the state elaboration of the CSR development program: team building, search for sponsors; analysis of the socio-economic situation in the country; analysis of companies, banks, business associations, public organizations, involved in the field of intersectoral cooperation in the framework of corporate social responsibility; motivation to understand responsible business; choice of priorities/discussion with public organizations and business community; goal-setting/adoption of a CSR strategy; development of methods of motivating a company by the authorities; dissemination among organizations, integration of CSR principles into the daily practice of companies; evaluation and control of results; encouragement of companies» [2].

M. Rudenko believes that «the implementation of the above ten steps requires the development of a theoretical basis for the formation of a mechanism for implementing CSR programs at the state level» [13]. O. Bilan proposes the development of a CSR program at the enterprise level and formulates the following «stages of development and implementation of a CSR program: formation of goals and objectives of the program, determination of program stakeholders, selection of program elements, program budget formation, selection of program responsible persons, program implementation, implementation of program measures, determination of the effectiveness of the program, development of measures to improve the effectiveness of the program [4]. L. Selivestrova insists that «the elaboration of a strategy for the development of CSR should include the implementation of measures, taking into account the external and internal environments of an enterprise» [14]. At the same time, it should be important to take into account the purposeful establishment and development of relationships with the main groups of stakeholders.

There is no consensus on the stages and directions of elaborating a program for the development of corporate social responsibility. The previously described methods do not fully suggest the measures, required by different groups of stakeholders at all levels of CSR implementation at road management and road transport enterprises.

9.2 ELABORATION OF A PROGRAM FOR THE DEVELOPMENT OF CORPORATE SOCIAL RESPONSIBILITY OF AN ENTERPRISE

The article by N. Bocharova and A. Shchepylina «Integral assessment of the level of corporate social responsibility of an enterprise» [16] substantiated the need to divide corporate social responsibility into external and internal, as well as in the areas: organizational and economic, legal, technical and technological, environmental and philanthropic.

The scheme of the algorithm of the methodology of integrated assessment of the level of CSR was provided, the last stage of which was to determine the development of the level of corporate social responsibility at an enterprise and the implementation of measures to improve this level. The main emphasis in the development of measures was placed on stakeholders. The following program of development of corporate social responsibility at an enterprise is offered (**Fig. 9.1**).

The choice of CSR goals will depend on the strategy, chosen by a company. They can be different: stability and sustainable development of the enterprise in the long run; preservation of social stability in society; improving the image of the enterprise, the growth of its business reputation; enterprise staff development; increase of labor productivity at the enterprise; promotion of goods and services of the enterprise; coverage of information about the company's activities in the media; the possibility of attracting investment capital; entering the international market, etc. Depending on the chosen goals, the programs can be directed either inside an enterprise (internal CSR program) or outside it (external CSR program). CSR programs of an enterprise can be conditionally classified by types: own programs of the enterprise; partnership programs with local, regional and public administration bodies; programs of cooperation with public and professional associations; information cooperation programs with the media [3]. When determining stakeholders, the division into internal and external stakeholders is also used (**Fig. 9.2**).

Basic recommendations and specific measures are developed for each group of stakeholders.

Thus, business owners and employees are offered the following recommendations:

– gradual increase in the value of an enterprise;

– timely provision of wages to employees, which is proportional to working conditions, productivity, seniority, education;

– compliance with the law;

– documentary employment, payment by the enterprise of the social contribution, holidays, sick leave, observance of the work schedule;

– use of a single server of the enterprise, to which all employees have remote access and where all the necessary information is stored;

– gradual introduction of energy-saving technologies;
– application of energy management;
– support for the preservation of historical experience, the development of cultural initiatives;
– support of corporate spirit and culture, common values;
– participation of staff and owners of the enterprise in charitable and volunteer activities.

For consumers of an enterprise we recommend the introduction of the following measures: continuous and fastest provision of customers with high quality finished products, legal registration of relationships, the ability to receive feedback from consumers by phone and on the official website, organization of environmentally friendly disposal of expired products, polite and attentive attitude to each client, individual approach, free excursions for consumers to the enterprise.

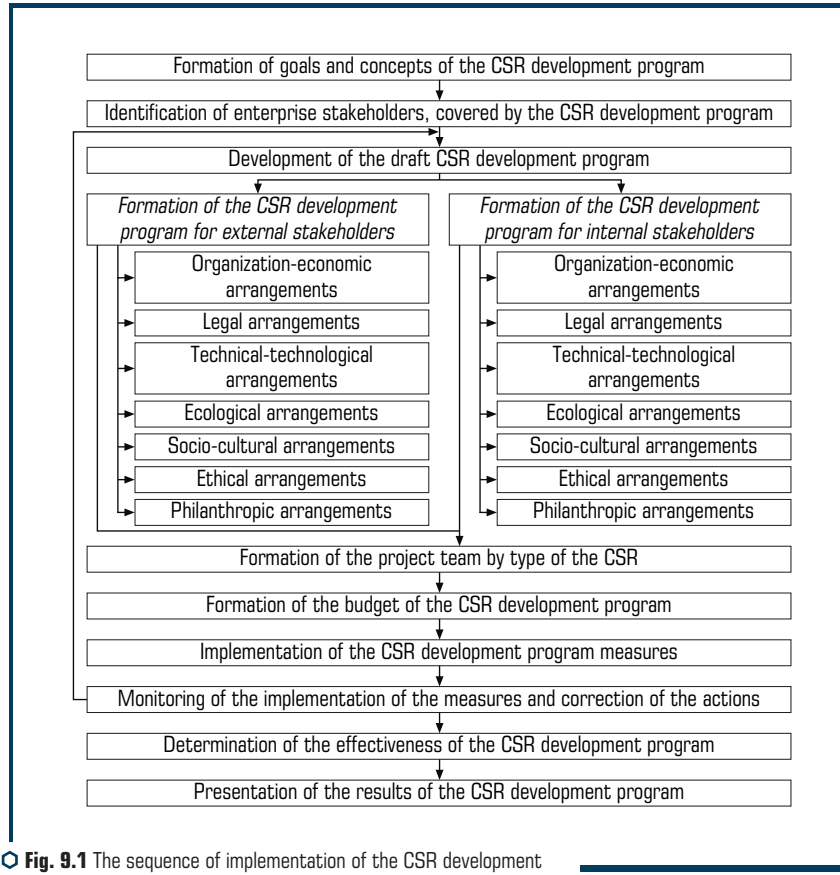

Fig. 9.1 The sequence of implementation of the CSR development program of an enterprise

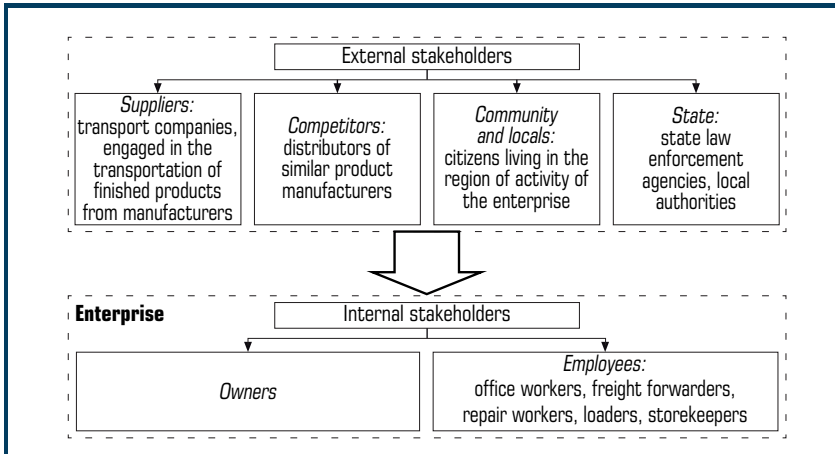

Fig. 9.2 Internal and external stakeholders of an enterprise

With regard to establishing work with suppliers, it is recommended to employees of road management and road transport enterprises to implement the following measures: maintaining constant contact with suppliers, documenting relationships with suppliers, establishing a convenient road to the company, concluding contracts only with those suppliers who comply state environmental standards of activity, free excursions for suppliers to enterprises of road management and road transport.

To improve the image of a company among the community and local residents, it is recommended to implement the following measures: expanding opportunities for higher education students to undergo industrial and undergraduate internships with further employment, compliance with legislation, implementation of local community support projects, annual cleaning of parks, landscaping of the city, equipping the territory of the enterprise with containers for separate waste collection with subsequent recycling, lectures and other classes for higher education students of specialized higher education institutions, providing silence at night, free cultural events for local residents, free tours for schoolchildren and applicants for higher education to the enterprise.

Regarding the improvement of relations with public authorities, it is recommended: creation of jobs for citizens, contribution to the country's economy, compliance with legislation, transparency, responsible and timely payment of taxes, renting of leased or own property, gradual reduction of environmental pollution, lectures and other types of classes with applicants for higher education from all over the country, self-monitoring, compliance with ethical standards of doing business, implementation of volunteer initiatives, charitable assistance projects, free excursions for students and applicants to the company.

Next, a draft program for the development of corporate social responsibility for road management and road transport enterprises is developed, taking into account the peculiarities of the application of indicators for external and internal activities, as well as according to the directions of CSR. The main possible elements of a CSR program, proposed by researchers: «charity, social investment, grants, equivalent funding, corporate volunteering, socially significant marketing, socially responsible behavior» [2–6, 14–18].

The proposed method of integrated assessment of the level of CSR is presented in the form of an algorithm diagram in **Fig. 9.3**.

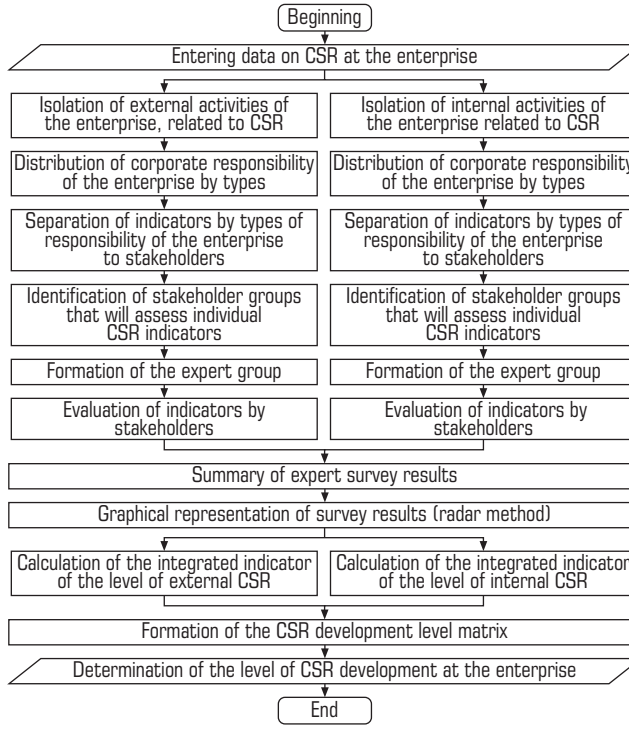

Fig. 9.3 The scheme of the algorithm of the methodology of integrated assessment of CSR level

At the stage of forming a project team, it is important to determine which staff will be used [19]. In fact, employees of the enterprise, who, if necessary, can undergo professional training in CSR design, or new employees who have already acquired the necessary skills and experience.

The implementation of specific measures of the program should involve employees from those departments that are listed in the content of the CSR program.

The stage of formation of the project budget acquires special importance. It is necessary to calculate alternative budget projects that take into account all the features of implementation and choose the best one in each case. All sources of project funding need to be identified. Each company can determine the total budget of the CSR program independently as a percentage of its net profit, which is allocated monthly for the implementation of corporate social responsibility programs.

Then the specific measures, identified within the budget, are implemented and included in the list of recommendations. Their implementation is closely monitored and corrective actions are taken in a timely manner. After the direct implementation of the program measures it is necessary to determine the effectiveness of the program and propose measures to increase its effectiveness. The assessment of the effectiveness of a corporate social responsibility program is based on the principle of comparing the effectiveness of the costs of activities and the expected results from their implementation. The efficiency of a CSR development program is determined by means of integrated assessment and construction of a CSR development matrix at an enterprise [16]. The following is a description of each type of corporate social responsibility of an enterprise in external and internal direction. Visually, it is presented in **Table 9.1**.

Each indicator is evaluated from the point of view of a stakeholder or a group of stakeholders of an enterprise (**Tables 9.2, 9.3**).

Indicators must be determined on a scale (low score – 0 points; satisfactory – 1 point; below average – 2 points; average – 3 points; above average – 4 points; high – 5 points) [17].

The coefficient of development (K) is the average score of the indicator ($\overline{x}_i$) on a scale from 0 to 1, for this purpose each average score of the indicator is divided by the maximum value 5.

For greater clarity, the results of surveys of stakeholders of the existing enterprise VITAL LLC are taken further.

The next step is to display the results of the evaluation of CSR indicators graphically.

To do this, the results of the calculation of the coefficient of the level of development, presented in **Table 9.4**, will be shown schematically using the radar method, where the value of the coefficient of the level of development in the center is taken as 0, and the final – for 1.

This was done on the basis that the current level of development of indicators tends to the highest value, thus providing a focus on the maximum level, ie to 1. Thus, **Fig. 9.4** schematically shows radars for internal and external activities.

Therefore, the area of the estimated circle is equal to: $S = 3.1416 \cdot 1^2 = 3.1416$ cm^2. However, since the construction of the radar method involves inscribing a polygon in a circle, it would be appropriate instead of the area of the circle, take the area of the polygon, which in this work in ideal conditions, when all indicators have a development factor of 1, is calculated as follows:

1) $s_p^{IN} = 3.097$ cm^2;
2) $s_p^{EX} = 3.087$ cm^2.

● **Table 9.1** The characteristics of CSR types

Responsibility type	Characteristic	
	External direction of CSR	**Internal direction of CSR**
Organization-economic responsibility	Satisfaction of the needs of consumers. Fair prices for goods or services, job creation, an organization's contribution to the country's economy. Timely and full settlement with suppliers	Profit-making (the main goal of any enterprise). Timely payment of fair salary to employees, taking into account employee satisfaction with the content of work
Legal responsibility	Compliance with the requirements and norms, contained in laws and other applicable regulations, timely and full payment of taxes. Reporting, transparency and informing the public about the company's activities	The need for management to respect the human rights of employees (documenting labor relations with staff, reflecting real working conditions, providing statutory leave, the opportunity to be on sick leave, etc.) and, in turn, the need for workers to comply with Ukrainian laws and perform their duties. Social guarantees (compulsory medical care, insurance, benefits)
Technical-technological responsibility	Commitment to invest in technologies that increase production efficiency. Production of quality goods. Development of innovation processes	Labor protection and safety. Development of the material and technical base. Industrial safety. Timely updating of equipment
Ecological responsibility	Protection of the environment and protection of the health of society members. Utilization of various types of waste of enterprise activity. Support for alternative fuel search programs. Compliance with national and international environmental standards and recommendations. Production of environmentally friendly products, elimination of expired products	Compliance with sanitary and hygienic standards in the workplace. Improving the social and living conditions of staff, environmental safety
Socio-cultural responsibility	Definition and satisfaction of the social requirements of the society in which an organization operates. Support for vulnerable groups, cultural education	Satisfaction of the needs of workers in personal recognition, recognition of their work achievements, social status and self-expression, providing opportunities for career growth and training. Formation of programs of rest for staff: financing of holiday vouchers, carrying out excursions. Social package (training at the expense of the enterprise, free travel or payment for gasoline, housing, free meals)
Ethical responsibility	Company's activities must meet the expectations of stakeholders in compliance with moral standards. Providing open and honest information about the activities of an enterprise and its products	Development of corporate culture, system of corporate ethics
Discretion responsibility (philantropic)	Activities, aimed at supporting and developing the welfare of society through voluntary participation in the implementation of social programs and other charitable activities	Volunteering of workers, voluntary participation of staff in charitable projects

Table 9.2 The indicators of internal activity of an enterprise

Responsibility type	Indicators (for the year of the activity)	Stakeholder who evaluates the indicator
1. Organization-economic responsibility	1.1 The growth rate of the organization's profit (R_G^P), %	Owners
	1.2 The staff turnover rate (K_{TURN}), %	Managers (HR department)
	1.3 The ratio of the average salary of workers at an enterprise to the average salary in the region ($\overline{S}$), %	Managers (accounting)
	1.4 Timeliness and completeness of salary payment (TC_s)	
	1.5 The level of corruption of an enterprise and the existence of a system to prevent corruption (L_K)	Owners, managers, employees
2. Legal responsibility	2.1 Observance of human rights by an enterprise (*HR*)	Managers, employees
	2.2 Availability of social guarantees at an enterprise (*SG*)	Managers, employees
	2.3 Compliance with the law by employees of an enterprise (CL^{EM})	Managers,
3. Technical-technological responsibility	3.1 The indicator of occupational injuries (*OI*)	Managers, employees
	3.2 The growth rate of material and technical base (R_G^{MTB}), %	Owners, managers
	3.3 R&D costs for the use of advanced technologies (from the amount of total costs) ($C_{R\&D}$), %	Managers (accounting)
4. Ecological responsibility	4.1 Fines, charged for violations of environmental legislation (F_{EL})	Owners, managers (accounting)
	4.2 Ensurance of the necessary standards of labor protection and hygiene (PH_t)	Managers, employees
5. Socio-cultural responsibility	5.1 The coefficient of education of workers (K_E)	Managers
	5.2 Timely definition and satisfaction of social requirements of employees of an organization (TR_{EM})	Managers, employees
	5.3 Recreation programs for staff (RP_S)	Managers, employees and their families
	5.4 Availability of a social package (*SP*)	Managers, employees and their families
6. Ethical responsibility	6.1 Corporate culture (*CC*)	Managers, employees
	6.2 The system of corporate ethics (*CE*)	Managers, employees
7. Philantropic responsibility	7.1 Volunteering of workers, voluntary participation of staff in charitable projects (V_{EM})	Managers, employees
	7.2 Volunteering of managers and owners of an enterprise, voluntary participation in charitable projects (V_{MO})	Owners, managers

Table 9.3 The indicators of external activity of an enterprise

Responsibility type	Indicators (for the year of the activity)	Stakeholder who evaluates the indicator
1. Organizational-economic responsibility	1.1 The growth rate of the number of jobs (R_G^J)	Community, locals, state
	1.2 The level of price impartiality (compared to competitors' prices) (CP)	Consumers
	1.3 Efficiency and completeness of settlements with suppliers (OC_S)	Suppliers
	1.4 Collection of customer feedback and response to them by the company (CF^{CL})	Consumers
	1.5 The level of compliance of products or services of an enterprise with international quality standards (L_Q)	Consumers, state
2. Legal responsibility	2.1 Level of compliance with current legislation (CL_L)	State
	2.2 Timeliness and completeness of taxes (TC_T)	State
	2.3 Availability of all permits and other state licenses and approvals, required for operation (PL)	State
3. Technical-technological responsibility	3.1 Costs for the development of innovation processes (from the amount of total costs) (C_{IP}), %	State
	3.2 Technical assistance to society when needed (A_T)	Community and locals
4. Ecological responsibility	4.1 Compliance with national and international environmental standards and recommendations (CES)	State, community and locals
	4.2 The waste recycling rate (K_{WR}), %	State, community and locals
	4.3 The level of natural resources consumption (L_C^{NR})	State, community and locals
5. Socio-cultural responsibility	5.1 Participation in social programs (SP)	State, community and locals
	5.2 Responding to concerns of the local population (L_C)	Community and locals
6. Ethical responsibility	6.1 The level of compliance with business ethics by an enterprise (L_{BE})	Suppliers, market infrastructure actors, influence groups
	6.2 The level of transparency and informing the public about the company's activities (L_{PI})	Consumers, influence groups, community and locals, market infrastructure actors
7. Philantropic responsibility	7.1 Participation of an enterprise in charitable events (P_{CE})	Community and locals, state, influence groups
	7.2 Costs of an enterprise on patronage, sponsorship, volunteering (from the sum of general expenses) (C_{PSV}), %	State, community and locals, influence groups

● **Table 9.4** The summary data on CSR indicators at the enterprise

Indicators of internal activities					**Indicators of external activities**				
Indicators	$\sum x_i^{IN}$	n	$\bar{x}_i^{IN}$	**Development coefficient (*K*)**	**Indicators**	$\sum x_i^{EX}$	n	$\bar{x}_i^{EX}$	**Development coefficient (*K*)**
Organization-economic responsibility									
1.1 R_G^P	12	3	4.00	0.800	1.1 R_G^J	58	13	4.46	0.892
1.2 K_{TURN}	4	1	4.00	0.800	1.2 CP	41	10	4.10	0.820
1.3 $\bar{S}$	4	1	4.00	0.800	1.3 OC_S	23	5	4.60	0.920
1.4 TC_s	5	1	5.00	1.000	1.4 CF^{CL}	41	10	4.10	0.820
1.5 L_K	103	26	3.96	0.792	1.5 L_G	65	14	4.64	0.929
Legal responsibility									
2.1 HR	107	24	4.46	0.892	2.1 CL_L	19	4	4.75	0.950
2.2 SG	108	24	4.50	0.900	2.2 TC_T	20	4	5.00	1.000
2.3 CL^{EM}	46	10	4.60	0.920	2.3 PL	19	4	4.75	0.950
Technical-technological responsibility									
3.1 OI	112	24	4.67	0.933	3.1 C_{IP}	15	4	3.75	0.750
3.2 R_G^{MTB}	48	12	4.00	0.800	3.2 A_T	42	9	4.67	0.933
3.3 $C_{R\&D}$	4	1	4.00	0.800					
Ecological responsibility									
4.1 F_{EL}	14	3	4.67	0.933	4.1 CES	49	13	3.77	0.754
4.2 PH_L	97	24	4.04	0.808	4.2 K_{WR}	56	13	4.31	0.862
					4.3 I_C^{NR}	59	13	4.54	0.908
Socio-cultural responsibility									
5.1 K_E	43	10	4.30	0.860	5.1 SP	60	13	4.62	0.923
5.2 TR_{EM}	105	24	4.38	0.875	5.2 L_C	35	9	3.89	0.778
5.3 RP_S	81	24	3.38	0.675					
5.4 SP	101	24	4.21	0.842					
Ethical responsibility									
6.1 CC	105	24	4.38	0.875	6.1 L_{BE}	43	10	4.30	0.860
6.2 CE	104	24	4.33	0.867	6.2 L_{PI}	97	24	4.04	0.808
Philantropic CSR									
7.1 V_{EM}	103	24	4.29	0.858	7.1 P_{CE}	48	15	3.20	0.640
7.2 V_{MO}	50	12	4.17	0.833	7.2 C_{PSV}	48	15	3.20	0.640

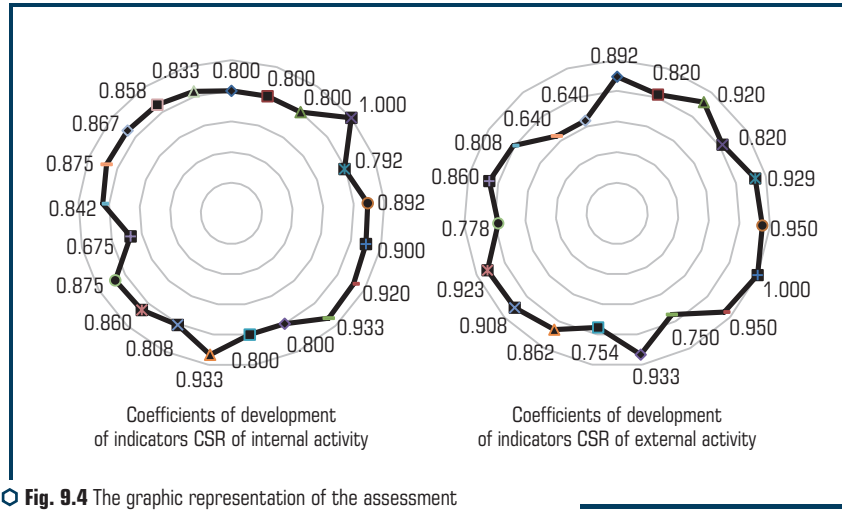

Fig. 9.4 The graphic representation of the assessment of corporate social responsibility by the radar method

Because the number of CSR indicators for internal activity $n=21$. Then, the angle α between the lines to be estimated, as well as the sine of this angle is equal to:

$\alpha=360°/21\approx17.14°$, $\sin=17.14\approx0.295°$.

Number of CSR indicators by external activity $n=19$. Then, the angle α between the lines to be estimated, as well as the sine of this angle are equal to:

$\alpha=360°/19\approx18.95°$, $\sin=18.95\approx0.325°$.

The area of the radar (S_p) in the direction of an enterprise is calculated in the same way:
– internal activity: $S_r^{IN}=2.239$ cm^2;
– external activity: $S_r^{EX}=2.234$ cm^2.

The next step is to calculate the integrated indicator of the level of development of CSR R by the formula:

$$R=S_r/S_p. \quad (9.1)$$

Indicator R for internal and external activities:

$R^{IN}=2.239/3.097=0.723$, $R^{EX}=0.724$.

According to the results of the calculation of integrated indicators, corporate social responsibility of an enterprise is characterized by the high indicator of its development.

At the last stage of the methodology it is proposed to give a qualitative assessment of the level of CSR of «VITAL» LLC. To do this, the results of the calculation of integrated indicators of the level of development of CSR are depicted on a two-dimensional matrix. The corresponding values of the integrated indicator for internal activity are shown on the x-axis; on external – on the *y*-axis (**Fig. 9.5**).

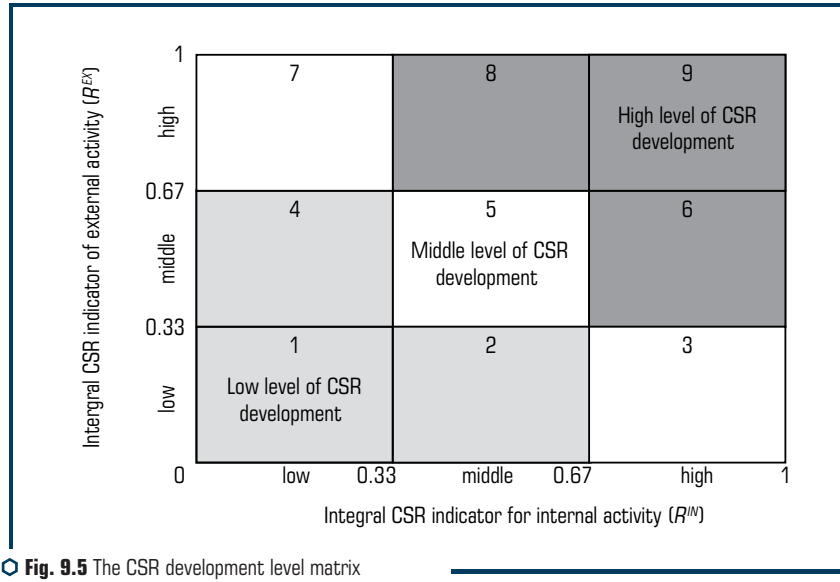

Fig. 9.5 The CSR development level matrix

The space of the matrix is divided into nine cells, as its factors form three levels: high, middle and low. Based on the fact that the values of the indicators vary from 0 to 1, the preliminary division of the axis of the matrix into three equal parts is conducted.

Integral indicators for internal and external activities of LLC are in the range from 0.67 to 1.

The characteristics of all sectors of the matrix by measurement ranges are described in **Table 9.5**.

According to the calculations, VITAL LLC falls into the 9th sector in terms of corporate social responsibility development at the enterprise, which corresponds to a high level of CSR development. At the last stage it is necessary to choose a way of representation of the received results.

It is very important to take into account the environmental aspect when developing a program for the development of CSR of road management and road transport enterprises. The activities of road management and road transport enterprises have a significant impact on the environment [19]. The development of measures to reduce the negative impact of enterprises should be

a daily issue that needs to be addressed. Therefore, environmental measures are developed and their effectiveness is evaluated [20].

Table 9.5 The characteristics of the matrix sectors

No. sector	Measurement range	Characteristics of the matrix sectors
1	R^{EX}=0–0.33 R^{IN}=0–0.33	Zone of low level of CSR development. Motivation – making a profit, obeying the law. The company assumes only the obligatory responsibility
2	R^{EX}=0–0.33 R^{IN}=0.33–0.66	The company began to implement one-time CSR measures to meet internal groups of stakeholders, which are spontaneous. Motivation – the pressure of the environment
3	R^{EX}=0–0.33 R^{IN}=0.66–1	The company focuses only on meeting the needs of internal stakeholder groups. Low staff turnover. High staff productivity. Uneven development of corporate social responsibility. Dissatisfaction with the needs of external groups of stakeholders deprives the company of reliable and mutually beneficial relationships with partners. The company's image is low, consumers do not recognize the company's brand
4	R^{EX}=0.33–0.66 R^{IN}=0–0.33	The company began to implement one-time CSR measures to meet external groups of stakeholders, which are spontaneous. Motivation – the pressure of the environment
5	R^{EX}=0.33–0.66 R^{IN}=0.33–0.66	Uniform development of corporate social responsibility. The company has a CSR strategy that needs to be refined
6	R^{EX}=0.33–0.66 R^{IN}=0.66–1	The company focuses more on the internal environment than on the external. The company has a CSR strategy. There is a need to have a separate CSR department. Low staff turnover. High staff productivity. If the company pays more attention to external stakeholders, it will quickly reach a high level of CSR development
7	R^{EX}=0.66–1 R^{IN}=0–0.33	Uneven development of corporate social responsibility. Low level of development of the internal direction of the enterprise with CSR at a high level of the external direction. This leads to high staff turnover and low staff productivity. The company is recognized by consumers. But due to the tense situation inside, the company will not achieve stable success
8	R^{EX}=0.66–1 R^{IN}=0.33–0.66	The company focuses more on the external environment than on the internal one. The company has a CSR strategy, aimed at external stakeholders. There is a need to have a separate CSR department. The company has a good image. Participates in philanthropic activities. If the company pays more attention to staff, it will quickly reach a high level of CSR development
9	R^{EX}=0.66–1 R^{IN}=0.66–1	The company has a developed CSR strategy. Pays equal attention to internal and external stakeholders. Motivation – own considerations. It has a special CSR department and a budget for its implementation. Preventive nature of activity. Rapid response to local concerns. Strong and trusting relationships with partners. Taking into account customer requirements. Attentive attitude to employees and their families

Thus, the CSR development program has been developed that takes into account the goals and activities of a company, recommends measures for different groups of stakeholders, proposes the formation of the project budget and project team, determines the control actions and effectiveness of the development program. The radar method for calculation of the integral indicator and the two-dimensional matrix has been used. The implementation of the proposed measures in the long run will significantly improve the level of CSR development in an enterprise. However, there are risks that may jeopardize the functioning of the entire road transport complex. It's about safety. No branch of the road transport complex will be able to function effectively without safety observance. The next and final section of this study will be devoted to the study of this issue.

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10 SAFETY OF THE EUROPEAN UNION TRANSPORT SYSTEM AS A MUST HAVE FOR UKRAINE

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ABSTRACT

The influence of the European Union (EU) on Ukraine can hardly be overestimated. Today, Ukraine's development directly depends on the country's integration into the EU and the adoption of European best practices. Of course, there are also imperfections in the EU. And where are they not? For countries like Ukraine (which are in their infancy), best practices are a chance for development. Such experience is invaluable. In order to adopt such a positive experience in the context of ensuring the safety of the transport system, it was decided to conduct additional research on this vector. The section discusses the main provisions for ensuring the safety of the EU transport system. A monographic review of research in the field of ensuring the safety of various modes of transport in the EU and in the world has been conducted. An assessment of safety indicators for different modes of transport in the EU has been realized. Impact indicators and safety measures for various modes of transport in the EU countries have been identified. Various safety management systems and EU programs, aimed at ensuring safety in rail, road, air and maritime transport have been described. New challenges to the security of the EU transport system through the COVID-19 pandemic and ensuring the competitiveness of different modes of transport, economic stability of market operators, compliance with environmental standards, etc. have been identified. The need to improve the infrastructure to ensure the safety of the transport system in the EU is pointed out. A combined safety management system for the EU transport system has been proposed and its key elements have been identified.

KEYWORDS

EU transport system, safety, rail transport, road transport, air transport, maritime transport, infrastructure, proactive safety management system, policy, strategy.

10.1 PROBLEMS OF ENSURING THE SAFETY OF THE TRANSPORT SYSTEM

The transport system is an important sector of the European Union (EU) economy and plays an important role in today's mobile society. The transport system and population mobility are central to the sustainable development of EU countries. EU transport policy promotes cleanliness, safety and efficiency by supporting the internal market for goods and the right of citizens to travel freely within the EU.

Ensuring the efficient functioning and safety of the EU transport system contributes to the overall well-being of the countries of the EU and socio-economic indicators. A well-balanced policy

for managing the EU's transport system, its resource potential and infrastructure achieves safety in various modes of transport and increases macroeconomic indicators, measures to combat climate change and draws human resources to other essential services, such as health and education.

The crisis, caused by the COVID-19 pandemic, has only exacerbated the need for and the importance of the EU transport system and identified new challenges for transport safety. During this period, the EU transport system played a significant role in attracting workers, sustaining the economy and launching the global distribution of vaccines. But the current situation has revealed vulnerabilities in the EU transport system, including the need to attract additional financial resources to cover losses from reduced traffic and ensure compliance with quarantine regulations, additional government support for operators due to loss of part of revenue, and so on.

Ensuring the safety of the transport system at different times is considered by a number of authors. In their works, researchers consider the theoretical foundations and methodology of ensuring the safety of the transport system, taking into account current trends, in particular the introduction of information technology and intelligent systems in road transport [1, 2]. Based on the perception data, the improvement of technology, management and institutions is proposed [3]. A reliable combination of vehicles is proposed through the introduction of ITS applications of the new generation of smart cities, the application of American and European ITS standards, elliptic curve cryptography algorithms to protect communication vehicles [4]. It is proposed to use ITS wireless communication technologies for the purpose of autonomous communication of vehicles with other transport nearby and road infrastructure and the use of a wide range of new opportunities for road safety and assistance [5–8]. Other authors propose the application of the process of analytical hierarchy in a combination of three areas: safety, environment and equipment performance [9]. To ensure the safety of land transport in the EU, the use of intelligent transport systems is proposed, which will increase the efficiency, comfort of transportation of people and goods, minimizing environmental damage and the contribution of transport to global warming [10]. Ensuring the safety of the EU transport system is seen in the context of its sustainable development; the role of European transport networks as integrated international ones *is considered* and the application of intermodal possibilities is evaluated [11]. The problems of introduction of intelligent transport systems and the need to develop a concept of integration of technologies into intelligent transport systems for different modes of transport are considered [12–14].

Important attention is focused on the management of international aviation safety, a comparative characterization of trends in the past and forecasting in the near future are realized, the current state of the aviation industry is studied [15, 16]. The practical safety measures, currently used in airports around the world, are studied, effective methods and basic principles for the development and implementation of the aviation safety system are studied [17]. The example of the United States addresses issues of transportation safety and risk minimization; the level of safety is determined depending on the type of transport [18].

The most urgent problems of the safety system of sea, land (rail and road transport), pipelines and air transportation are identified; the current legislation and institutions that provide regulation

and control of safety of each type of transport, the implementation of appropriate programs to improve the safety of a particular transport operation are analyzed [19–22]. Considerable attention is paid to ensuring the safety of maritime transport and ports in the field of comparative analysis of the main approaches and methods, used in the United States and the EU; emphasis is placed on raising safety standards, countering the terrorist threat, maximizing internal safety, strategies for balancing safety needs with protection of confidentiality and trade protection, etc. [23].

10.2 THE RESULTS OF THE STUDY OF THE SAFETY OF THE EUROPEAN UNION TRANSPORT SYSTEM

The EU transport system aims to promote environmentally friendly, safe and efficient travel, while supporting the rights of citizens, goods and services to free circulation within the single market. However, various circumstances can occur in transport, which can lead to harm to human health, crime and terrorism, damage to transport, disruption of transport infrastructure, etc., leading to serious socio-economic and environmental problems in the EU.

Ensuring the safety of the transport system in the EU is aimed at avoiding deaths and injuries in transport. Road safety depends on the driver's behavior, the quality of the transport infrastructure and the technical condition of a vehicle. Safety on railway transport is directly dependent on compliance with the rules of crossing the railway by pedestrians and road transport. Safety in maritime transport often depends on ship overload, design and the lack of appropriate safety measures; particular attention is paid to the safety of the transport of dangerous goods, as they pose serious risks to the general population, property and the environment. Aviation safety is aimed at eliminating mistakes of pilots, ensuring their high qualification through training, countering organized terrorist acts, providing proper infrastructure, etc.

In the spring of 2020, in the first months of the COVID-19 pandemic in the EU, virtually all EU Member States introduced containment and restriction measures for minor travel within a country and/or abroad, some partially or completely closed borders, thus enhancing safety. These restrictions were applied to almost all modes of transport, especially on passenger traffic. Commercial transport services, operated during the pandemic, implemented initiatives, aimed at protecting transport workers and travelers, as well as ensuring trade (especially essential goods) within and between EU Member States, as well as between the EU and non-EU countries.

In order to monitor events and policies for the development of further strategies for ensuring the safety of the EU transport system, the European Commission analyzes a number of statistics on different modes of transport. Eurostat statistics in this area describes the most important features of different modes of transport in terms of injuries and infrastructure indicators, as well as the contribution of transport services to the economy. Data collection is supported by a number of legal acts, requiring EU Member States to report statistics, as well as by voluntary agreements on the provision of additional data.

10.2.1 THE SAFETY OF EU RAIL TRANSPORT

Characterizing the number of railway accidents in the EU, it should be noted, that during the period 2015–2019 they decreased (**Fig. 10.1**). In 2019, the number of railway accidents in the EU decreased by 14 % compared to 2019 and by 9 % compared to 2018. During the study period, the EU implemented a number of projects and measures for safety in railway transport, which led to a reduction in the number of accidents, in particular, the introduction of innovative traffic technologies, the improvement of regional railway policy on the EU's participation in relations with neighboring countries.

Despite the reduction of railway accidents, their number has increased in some EU countries (**Table 10.1**). Thus, during the period 2015–2019, an increase in the number of railway accidents was observed in Spain, Norway, and Sweden.

The regional distribution of the EU's railway infrastructure is determined by historical and economic development, geographical characteristics of the regions. For example, several eastern EU member states have longer rail networks than their western neighbors, reflecting the legacy of the communist or Soviet era, when they were often more dependent on rail (compared to road) to transport passengers and goods [26].

Railway safety in the EU is achieved through high-quality track construction with the use of accident-free technology, improved technical characteristics and increased use of railways. The EU has rules and regulations on rail transport that are constantly being improved and aimed at the effective operation of the infrastructure management system, railway operators or service providers and contractors, operating on the railway.

Effective safety management is a prerequisite for maintaining and improving the safety of railway systems in the EU, especially for the technical, organizational and human factors that affect the internal functioning of railway systems. The railway safety management system in the EU identifies hazards, assesses risks and takes measures to reduce them, provides for ongoing inspections and timely detection of new hazards [27–29].

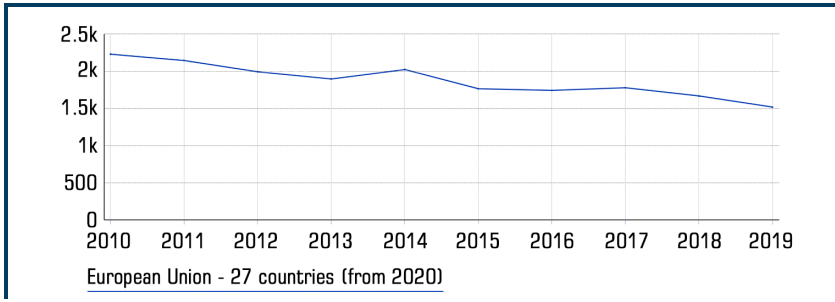

Fig. 10.1 Railway accidents in the EU, 2010–2019
Source: Eurostat [24]

Table 10.1 The number of railway accidents in some EU countries, 2010–2019

Country	2015	2016	2017	2018	2019
Belgium	21	22	33	31	27
Bulgaria	48	40	47	42	39
Czechia	94	87	97	89	91
Denmark	13	13	12	10	10
Germany	306	310	346	302	298
Estonia	12	15	19	21	5
Ireland	1	0	4	6	2
Greece	25	13	22	24	18
Spain	42	45	52	47	49
France	150	146	151	119	123
Croatia	27	23	33	25	28
Italy	97	99	104	109	76
Latvia	25	18	24	20	19
Lithuania	13	20	27	15	9
Luxembourg	0	2	1	2	0
Hungary	156	162	160	162	142
Netherlands	31	28	26	29	25
Austria	77	87	60	42	47
Poland	307	265	252	275	214
Portugal	23	38	29	37	51
Romania	141	184	145	132	112
Slovenia	14	11	11	14	10
Slovakia	87	60	65	63	62
Finland	13	18	17	15	14
Sweden	40	36	40	35	45
Channel Tunnel	1	0	0	5	0
Norway	19	16	16	25	27
Switzerland	33	37	47	39	35
United Kingdom	40	53	71	50	36

Source: [24, 25]

Rail accidents in the EU are rare compared to road accidents: monitoring even less serious consequences is an extremely important tool for a proactive safety management system. An example of such an approach is the EU's proactive rail safety monitoring system, where national safety authorities report general safety indicators to the European Railway Agency [30]. One such measure is the investigation and reporting of «accident precursors», indicators of incidents that, in other circumstances, ie if not monitored and mitigated, can lead to accidents. These indicators were determined by studying the causes of major incidents (derailment; train collisions; collisions with obstacles; accidents at the crossing; accidents with people, caused by rolling stock (excluding suicide); fires in rolling stock) [31].

The EU uses two methods of assessing and managing the risk of rail accidents:

1) use of historical data on accidents to determine the types of accidents with the highest risk or frequency on the railway;

2) modeling the study of potential causes or accidents [32].

10.2.2 THE SAFETY OF EU ROAD TRANSPORT

Roads in the EU are the most common mode of transport for passenger and domestic freight. The EU road safety policy includes a number of tasks related to:

– ensuring mobility in an increasingly busy road network;

– reduction of road deaths;

– reduction of air pollution (emissions of carbon dioxide and other pollutants);

– reducing dependence on the use of traditional fuels and promoting the use of electric vehicles;

– revision of working conditions of professional drivers [29].

European roads are the safest in the world, and road safety has improved significantly in recent decades. However, the number of deaths and injuries is still too high and progress has slowed (**Fig. 10.2**). In 2019, the number of fatalities in road accidents in the EU decreased by 7 % compared to 2019 and by 2 % compared to 2018.

Despite the decrease in the number of fatalities in road accidents, in some EU countries their number has increased (**Table 10.2**). Thus, during the period 2015–2019, an increase in the number of fatalities in road accidents took place in Belgium, Croatia, Portugal, Spain, Sweden and Switzerland.

Factors, influencing road accidents in EU countries, include:

– drunk driving;

– speeding;

– no use of seat belts and helmets;

– use of mobile phones while driving [25].

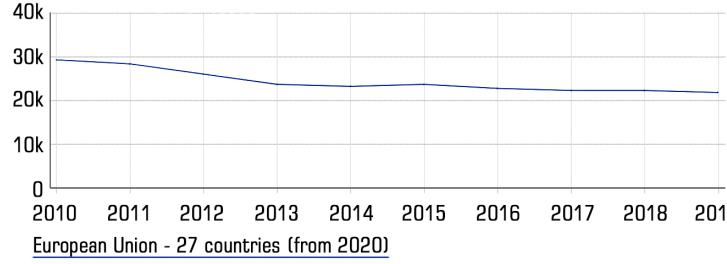

Fig. 10.2 The number of fatalities in road accidents in the EU, 2010–2019 (persons)
Source: Eurostat [24]

● **Table 10.2** The number of fatalities in road accidents in individual EU countries, 2010–2019 (persons)

Country	2015	2016	2017	2018	2019
Austria	77	87	60	42	47
Belgium	21	22	33	31	27
Bulgaria	48	40	47	42	39
Croatia	27	23	33	25	28
Czechia	94	87	97	89	91
Denmark	13	13	12	10	10
Estonia	12	15	19	21	5
Finland	13	18	17	15	14
France	150	146	151	119	123
Germany	306	310	346	302	298
Greece	25	13	22	24	18
Hungary	156	162	160	162	142
Ireland	1	0	4	6	2
Italy	97	99	104	109	76
Latvia	25	18	24	20	19
Lithuania	13	20	27	15	9
Luxembourg	0	2	1	2	0
Netherlands	31	28	26	29	25
Norway	19	16	16	25	27
Poland	307	265	252	275	214
Portugal	23	38	29	37	51
Romania	141	184	145	132	112
Slovakia	87	60	65	63	62
Slovenia	14	11	11	14	10
Spain	42	45	52	47	49
Sweden	40	36	40	35	45
Switzerland	33	37	47	39	35

Source: Eurostat [24]

To address road safety, the EU has adopted Vision Zero, which aims to reduce the number of deaths on EU roads to almost zero by 2050. Vision Zero provides a strategic plan and monitoring of key safety indicators, such as car safety, level of seat belts, speed or car care after an accident. The strategy set an initial goal of halving the number of deaths and serious injuries by 2030 [33].

The EU works closely with the authorities of its member states for road safety. It seeks to build on national initiatives, set targets and take into account all factors that play a role in road accidents (infrastructure, car safety, driver behavior, emergency response, etc.). This is achieved by passing laws, supporting education campaigns, helping member states and other road safety actors to share relevant experiences and providing appropriate funding [29].

In July 2020, the European Parliament and the Council adopted some important elements of the so-called «Mobility Package I» – a set of legislative proposals, presented by the European Commission in May 2017 to modernize and improve the legal framework, governing the European road transport market. The new rules provide for improved working conditions for drivers and fairer competition between carriers [33–37].

Road safety in EU countries poses new challenges, which include:

– ensuring the safety of road transport to reduce the number of fatalities and/or injuries on the roads due to the rapid growth of economic development and the level of motorization of individual EU countries;

– exacerbating the growing problem of motorcyclist safety, especially in developed EU countries, where the number of fatalities is growing;

– an increase in the number of electric vehicles and the use of bicycles increase the risk of accidents for the elderly and visually and/or hearing impaired;

– ensuring the safety of children on roads. Children are less experienced and often difficult to spot on the road, so they face an increased risk of accidents. Early learning of road safety rules, blind spots and the safety of cycling and walking habits are important to reduce such risks. Many accidents occur, in particular road sections («black spots») due to problems with road design/maintenance, such as sharp corners, reduced visibility, missing signs or other causes [38].

10.2.3 THE SAFETY OF EU AVIATION

Aviation is one of the safest and fastest growing modes of transport. The EU aviation safety policy ensures a high level of passenger safety by using cost-effective rules and facilitating the free movement of products, services and persons, involved in civil aviation.

Given the unprecedented growth of air transport and the significant number of market operators that have resulted from the successful implementation of the single aviation market, the EU has given priority to effective aviation safety standards. Therefore, in the period 2010–2019, there were a small number of casualties in plane crashes in the EU, with the exception of the terrorist attack in France in 2015, where the death toll was 150 people (**Fig. 10.3**).

Liberalization measures in recent years have led to an increase in airline budgets and the expansion of smaller regional airports in the EU, which tend to be less congested and charge lower fares than major international airports. Air transport has been particularly hard hit by the COVID-19 crisis: the direct impact of the crisis is not yet visible in regional air transport statistics due to the lack of data for 2020.

In 2004, the EU launched the Single European Sky initiative, which aimed to address the challenges of air congestion and increased load on airport and airspace capacity [39]. In 2009, as part of the second package of measures «Single European Sky II», the EU paid more attention to the environment and economic efficiency [40]. However, the pace of change was considered slow, and in June 2013 the European Commission made further proposals to accelerate the implementation

of the Single European Sky 2+, which includes further initiatives to improve safety and supervision, as well as greater consumer focus [41]. The ultimate goal of these initiatives is to improve the economic, financial and environmental performance of air navigation services, while eliminating the fragmentation of the European air traffic management system.

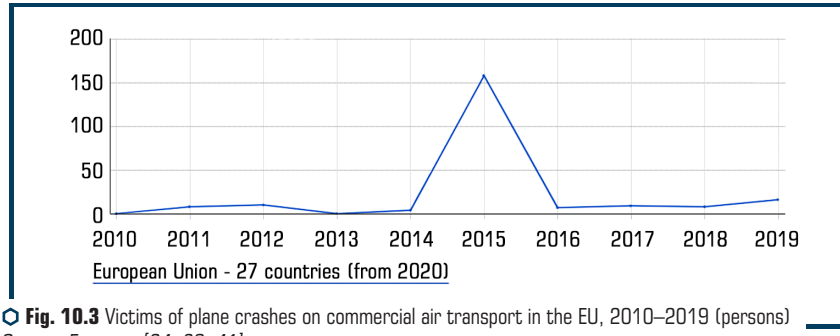

Fig. 10.3 Victims of plane crashes on commercial air transport in the EU, 2010–2019 (persons)
Source: Eurostat [24, 39–41]

In December 2015, the European Commission adopted an Aviation Strategy for Europe (COM (2015) 598) to ensure the competitiveness of the European aviation sector. The main priorities of this strategy include:

– engaging in emerging markets by improving services, market access and investment opportunities with non-EU countries, while ensuring a level playing field;

– overcoming growth constraints in air and on the ground by reducing capacity constraints and improving efficiency and communication;

– maintaining high EU safety standards by moving to the risk-based approach [42].

10.2.4 THE SAFETY EU MARITIME TRANSPORT

In maritime transport, the safety of both passenger and merchant ships is paramount in the EU. The EU maritime policy is about ensuring the competitiveness of maritime transport, implementing safety rules, reducing the risk of serious maritime accidents and the impact of maritime transport on the environment. The European Commission develops and implements various measures to protect citizens as users of maritime transport services, create safe and secure conditions, respect the rights of passengers, study the adequacy of civil transport connections and reduce the administrative burden by simplifying the procedure.

The level of safety of maritime transport in the EU is evidenced by the data in **Table 10.3**. During the period 2011–2019, the largest number of victims of maritime accidents was observed in the Mediterranean Sea (in 2012 – 35 people), the smallest – in the Black Sea. A positive trend

is the reduction or absence (Baltic, Black Sea, English Channel) of victims of maritime accidents in all types of regions of the seas, oceans, canals.

● **Table 10.3** Victims of maritime accidents by regions of occurrence and country of registration of vessels, 2011–2019 (persons)

Region	2011	2012	2013	2014	2015	2016	2017	2018	2019
Baltic Sea	2	2	2	3	1	4	2	1	0
North Sea	1	15	1	2	2	3	1	2	3
English Channel	0	2	0	2	1	0	2	0	0
Atlantic Ocean	3	7	7	22	10	6	1	6	3
Black Sea	:	0	0	0	0	0	0	1	0
Mediterranean Sea	2	35	15	13	12	4	3	3	3
Other sea basins	6	12	2	1	12	4	6	8	15

Source: Eurostat [24]

In order to ensure the safety of maritime transport, its development and competitiveness in the EU, the following programs have been adopted:

– Regulation (EU) 2017/352, which establishes the framework for the provision of port services and common rules on the financial transparency of ports. Its implementation contributes to the development of short sea shipping and strengthening the integration of maritime transport with rail, inland waterway and road transport [43];

– Regulation (EU) 2019/1239, which establishes a «European Single Window Environment at Sea» by August 2025, and then replaces the existing framework, provided for in Directive 2010/65/EU on reporting formalities for ships, arrivals and/or departures from EU ports. The main purpose of the new Regulation is to harmonize the various national single windows, operated by the EU Member States by adopting a common data set, harmonized interfaces and applying the «once only» principle through new data reuse mechanisms. The provision will help reduce the administrative burden on market operators, as well as increase the competitiveness and attractiveness of maritime transport and infrastructure [44];

– the new maritime initiative FuelEU, which promotes the adoption of sustainable alternative fuels and electrification in the maritime sector, continuing the approach, already promoted by the European strategy for low-emission mobility in 2016 [45].

The safety of the EU transport system is significantly influenced by its infrastructure. In 2013, the EU and the European Parliament agreed on a new framework for transport infrastructure, formulating guidelines for the development of the Trans-European Transport Network (TEN-T) and the Connecting Europe Facility. It is an ambitious package that aims to provide businesses and passengers with a fully functional transport network, combining different modes of transport through high-speed services, uniting Europe from north to south and from west to east, creating a network infrastructure that can serve as a basis for the development of economic growth. The TEN-T guide-

lines provide for the development of a multimodal and intelligent core transport network by 2030. In addition, by 2050, a comprehensive network should be developed to ensure the accessibility of all regions. TEN-T's strategic direction is nine core network corridors and two horizontal priorities, namely: the European Rail Traffic Management System and the Motorways of the Sea. TEN-T's policy is to develop a more efficient transport network, simplify cross-border transport operations for passengers and businesses, improve links between different modes of transport and contribute to the EU's climate change goals. For the period 2014–2020, the € 24 billion budget was allocated to the transport sector under the Connecting Europe Facility [46].

The conducted studies show that the safety [47] of the EU transport system is carried out through the formation of appropriate conditions for the operation of various modes of transport and infrastructure, the creation of a system for monitoring and preventing accidents, injuries and fatalities in transport, compliance with technical rules for passenger transport, cargo, transport services, greening of transport. The assessment of the safety indicators of the EU transport system for the period 2010–2019 in terms of modes of transport shows a decrease in the number of railway accidents, fatalities in road accidents, victims of plane crashes, victims of maritime accidents. For each mode of transport, a number of measures, procedures, policies and strategies are developed in EU regions to ensure the proper safety of the transport system. The new challenges, posed by the COVID-19 pandemic, require additional financial resources to ensure transport safety, manpower to control the movement of passengers and transport within the EU and abroad, regulation of procedural issues to support market operators, compliance with environmental standards and more. Rapid response to changes in the changing environment to ensure the safety of the EU transport system encourages the consolidation of efforts and directing resource potential to improve transport policy, introduction of innovative technologies and technical controls, modern financial instruments, implementation of EU transport legislation and increase competitiveness and development of operators market, including outside the EU. Given the above, in order to mitigate the negative impact of the external environment and ensure the safety of the transport system as a whole in order to implement it in Ukrainian realities, a combined safety management system «behavior + transport status + infrastructure + permanent monitoring + post-accident services» is proposed. The key elements of the management system should be:

– information environment of transport safety and its improvement;

– application of effective means of safety management of the transport system through strengthening the role of regional and general regulatory framework agreements and increasing funding for the transport safety program;

– construction of safe transport infrastructure;

– adaptation of traffic rules to the local environment;

– monitoring of technical condition of all types of transport, periodic maintenance;

– formation of statistical information on road safety in accordance with international standards;

– development of insurance coverage;

– improving medical care for injuries after an accident, etc.

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CONCLUSIONS

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According to the results of this work, it can be stated, that the road transport complex is a powerful living organism, the functioning of which is ensured by a huge number of its components. Of course, the components, considered in this paper, are not a complete interpretation of them, and are basic for ensuring the development of the road transport complex as a whole.

Based on the study, the following results can be distinguished:

1. In order to methodically ensure the selective financing of scientific and educational institutions through targeted investments, the introduction of targeted investments is proposed, in order to stimulate scientific and educational institutions to create innovative technologies. When calculating the proposed procedure, investments in fixed assets are taken into account. The model of effective cooperation between a capital donor and a scientific and educational institution that takes into account targeted investment is proposed.

2. In order to eliminate the regional imbalance in the country on the way to its innovative development, methodological tools are proposed to provide financial state support to the regions that have the worst values in terms of investment attractiveness and risk.

3. It is proposed to determine the rating of the best educational institutions in the region on the basis of mathematical modeling. Relevant clusters of educational institutions of the region have been established and systematized, taking into account their sectoral significance, form of ownership, efficiency of state funding and the amount of own revenues. It has been determined, that educational institutions that effectively use their innovative and scientific potential receive planned accumulations and a bonus for the appropriate rating, taking into account innovative and scientific investments. Educational institutions that do not meet the requirements of the task in the model are doomed to liquidation.

4. The main problems of quality of Ukrainian logistics have been considered. The basic principles of quality management have been substantiated: orientation on requirements, constant communication with consumers of logistic services; building mutually beneficial relationships with consumers and staff of an enterprise; flexibility of the system of transport and logistics customer service and others. Methodological support for quality management of transport and logistics services has been developed, which includes a certain procedure and a set of appropriate methods for implementing this activity based on the application of the scenario approach and algorithmization of procedures for obtaining possible states of operation of the modern transport and logistics sector.

5. It has been determined, that effective viability management requires the creation of an organizational structure in an enterprise that will function as a «living organism». The representation of the enterprise system in the form of a living organism has been considered. To form a holistic

system of an enterprise, the systems of the human body have been considered in more detail and the corresponding systems of the enterprise have been determined. A set of functional subsystems of an enterprise by analogy with the systems of a living organism, the activity of which is interdependent, which ensures the stability of the «living organism» of the enterprise to the influence of external conditions has been formed. It has been determined, that in order to fully maintain the viability of an enterprise, it is necessary to study not only the «physical body» of the enterprise as a set of functional subsystems, but also its «soul» – corporate culture, which must be developed on the basis of paradigms of sustainable development and social responsibility.

6. The theoretical and methodological foundations of CVP-analysis have been deepened and improved by ensuring their compliance with the principles of sustainable development of an enterprise, organization and feasibility of VUCA-solutions that act ahead. In the future, it is planned based on the principles of sustainable development of an enterprise and the essence of VUCA-solutions: to offer a mechanism of crisis management of an enterprise in the modern business environment; to determine a place of continuous CVP-analysis in it; to clarify the methodological basis for the implementation of continuous CVP-analysis and a list of its indicators that meet modern business requirements.

7. The process of determining and assessing the competencies of employees on the basis of the modern assessment technology «Assessment Center» has been formed, and the content of the necessary actions at each of its stages: preparatory, evaluation and processing of results has been detailed.

8. To specify the actions to assess the competencies of specialists, the block diagram of the determination and assessment of competencies of employees of an enterprise has been built, which, unlike existing, has a logical sequence of actions, based on the principles of the technology «Assessment center» for a set of methods (interview, «Brainstorming», «Business Game» and testing) and is based on bringing the level of existing competencies of employees to their reference values. The inclusion of assessment methods, such as interviews, brainstorming, business game and testing in the Assessment Center makes it possible to obtain comprehensive and complementary information on the results of the assessment to formulate the overall conclusion.

9. The program of development of corporate social responsibility at internal and external levels of implementation, taking into account features of various groups of stakeholders is offered. The implementation of such a program will allow road management and road transport companies to improve their business reputation and generally contribute to the development of the country's business.

10. In order to mitigate the negative impact of the external environment, ensure the safety of the EU transport system and to implement best practices in Ukrainian realities for each mode of transport, the combined safety management system «behavior + transport status + infrastructure + permanent monitoring + post-accident services» is proposed.

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PROBLEMS AND PROSPECTS OF DEVELOPMENT OF THE ROAD TRANSPORT COMPLEX: FINANCING, MANAGEMENT, INNOVATION, QUALITY, SAFETY – INTEGRATED APPROACH

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