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GAME THEORY AND FINANCIAL COMPONENTS FOR DETERMINING THE BUDGET PLACES OPTIMAL DISTRIBUTION IN THE HIGHER EDUCATION SYSTEM OF UKRAINE

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ABSTRACT

The complexity and interdependence of management and decision-making problems in the system of higher education require new ideas and approaches, which necessitates the search for new management solutions using modern approaches and methods of economic and mathematical modeling. The article is devoted to the problem of optimal allocation of budget places for higher education institutions by specialty. The conducted research shows that the priorities of the state, labor market and consumers do not coincide. In this situation, the university, as a provider of educational services, must balance the demand of the consumer (applicants, students and their parents) with the offers of the customer (the state, entrepreneurs, the labor market), taking into account the forecast of demand in the labor market. The purpose of the study is to determine the optimal allocation of budget places for higher education institutions considering financial constituents, system analysis and the game theory method. A solution to the problem is offered by building an economic-mathematical model using game theory techniques and methods of analyzing hierarchies, which have a powerful apparatus for considering many different models, approaches and concepts for solving the same problem. The presented mathematical model allows to obtain a balanced optimal distribution of budget places by university specialties, which harmonizes the demands of applicants and employers. The budgetary expenditures for higher education are an effective regulator of direct action on the training of specialists with higher education and an instrument of state regulation of the number of state-ordered students. Based on the results of the study, the model of distribution of the institution's budget expenditures for decision-making management is proposed, which allows redistributing funds to expenditure items that are included in the development expenditures of higher education institutions. Further development of the described model in the direction of researching the impact on existing restrictions on the market of educational services will allow offering powerful mechanisms and technologies for managing the process of forming optimal strategies for the development of higher education institutions.

Keywords: higher education institution, game theory, modeling, budget, mathematical model, system analysis, management, demand, supply

JEL Classification: I22, I23, I28

INTRODUCTION

Nowadays, the educational services market is being separated from the labor market. In the training of personnel, educational institutions focus on the requests of applicants and their parents, not employers. The discrepancy between the popularity rating of specialties and the distribution of guaranteed employment leads to the fact that applicants when choosing an educational institution, do not take into account the factor of their further employment. Due to the lack of scientifically based predictive assessments of the needs of specialists for the future, the demand for specialists in specific specialties is uncertain. In this case, a situation of supply and demand imbalance appears in the labor market: an oversupply of some professions and a shortage of others. In these conditions, it is the institution of higher education that is interested in the development and implementation of an optimal strategy that would contribute to the satisfaction of

demand on the labor market, and would meet the modern demands of the enterprise and the interests of students. The institution of higher education should become a connecting link between the labor market (enterprises, organizations) and students, entrants and balance consumer demand (entrants, students and their parents) with customer offers (state, entrepreneurs, labor market). Therefore, it is important to study changes in the volume of demand for educational services in order to adapt the higher education system to them using modern approaches of decision-making theory and methods of economic and mathematical modeling.

LITERATURE REVIEW

The results of a preliminary study of the forecasting of the mentioned problem are presented in the work [1], where the authors proposed an algorithm for the practical application of the theory of constraints of systems (TOC) and the apparatus of the theory of fuzzy sets for determining strategic management decisions regarding the balancing of supply and demand in the market of educational services. The application of economic-mathematical methods for solving economic problems is substantiated in works [2,3], which consider in detail the conditions of application of certain mathematical results, discuss the limits of their applicability, methods of setting economic and managerial problems, methods and technologies of their interpretation [4]. The analysis of scientific works makes it possible to assert that the purpose of using mathematical methods in the management of institutions of higher education is the desire to achieve consistency between the potential of institutions of higher education as producers of educational services and the needs of consumers in these services [5,6]. Article [7] is devoted to the construction of a model of the number of entrants depending on the number of graduates of 11th grade of secondary general educational institutions. Tendencies of increasing demand for higher education services due to awareness of its role in the accumulation of human capital as a factor in the development of the post-industrial economy have been identified. Lysytsia, N. et al, [8] consider a successful partnership between employers and universities, which will ensure the relative sustainable development of higher economic education, on the one hand, and, on the other hand, improve the image and reputation of enterprises, which means their sustainable development and competitiveness. This will confirm the importance and demand of the enterprise as a mandatory partner for improving the quality of higher education. The results support the assumption that the current generation of university students' studies to succeed in the future, but it has relatively high expectations about work and career that may reduce their employability if it does not have the appropriate work experience and social habits [9]. The methodological approach proposed by scientists [10] is aimed at forming an information space for simultaneous comparison and assessment of the level of institutional independence of higher education institutions and the indicators that affect it. The article [11] provides an analysis of scientific approaches to understanding organizational development in the field of management of educational institutions as a complex of successive educational changes, taking into account that little attention is paid to the issue of balancing the demand and supply of educational services. The effectiveness of the strategy implementation of higher education development depends to a large extent on the choice of strategic alternatives, the coordination of strategic priorities and goals, which necessitates the improvement of the methodological principles of strategic management [12, 13, 14]. As the results of the conducted research showed, the solution to the above theoretical and practical tasks is impossible without a scientifically based methodology for determining the future need of the state for specialists with a certain level of qualification; determination of the scope of their training in institutions of higher education; forecasting of the contingent of students. Scientific and research development of economic problems is impossible without the use of quite complex and at the same time accessible mathematical tools.

AIMS AND OBJECTIVES

The purpose of the study is to determine the optimal allocation of budget places for higher education institutions considering financial constituents, system analysis and the game theory method.

To realize this goal, the following tasks are set:

- to analyze the main trends in the development of the educational services market and the labor market;
- to make a rating of specialties;
- to determine the attractiveness coefficients for the areas of training, taking into account the labor market and the choice of applicants;
- to develop the model of distribution of the institution's budget expenditures for decision-making management in order to redistribute funds to expenditure items that are included in the development expenditures of higher education institutions;

- to build an economic-mathematical model using system analysis and game theory, which will allow to determine the optimal number of students of a certain specialty.

METHODS

The following methods were used in the research process: statistical - to process data on the dynamics of demand and supply in the market of educational services; sociological - in the study of factors affecting individual and socio-economic demand; survey - to collect primary data on consumer demand in the educational services market of the Dnipropetrovsk region. A mathematical model was built to determine strategic management decisions regarding the balancing of supply and demand in the market of educational services and the optimal allocation of budgetary places of higher education institutions using game theory methods (Table 1). The main goal of solving problems of this class is to develop recommendations for choosing the optimal strategies of the conflicting parties based on the application of methodological approaches of game theory.

Table 1. Mathematical model of the optimal allocation of budget seats by specialty using the apparatus of game theory.

Stages of building a mathematical model	Research indicators, research methods and tools
I STAGE. Collection and analysis of research data	
Labor market research	Rating of vacancies in the region, method of expert evaluations, a survey of employers, representatives of state and private enterprises of the region
Characteristics of the institution of higher education	Analysis of training programs and specialties for which specialists are trained; financial resources, material and technical base, information resources; educational and pedagogical and scientific potential
Study of demand among applicants	Questionnaires of applicants, students and their parents; statistical analysis of demand for specialties in previous years To collect primary data on consumer demand in the market of educational services of the Dnipropetrovsk region, a survey method was used, the main tool of which was a questionnaire. The target group of the population was covered by the survey - high school seniors, college graduates, first-year students and their parents. Consumers were divided into segments and samples were formed for the survey. The survey was conducted by the method of Internet questionnaires using Google forms, as well as questionnaires at student and parent meetings, during meetings at Open Door Days in higher educational institutions of the region. Generalization and processing of survey results were performed using Excel spreadsheets.
II STAGE. Data formalization and mathematical formulation of the problem	
Determination of ratings of the attractiveness of higher education specialties from the point of view of the consumer of educational services	Formalization of expert evaluations and results of questionnaires of applicants and parents, their statistical processing
Determination of ratings of the attractiveness of higher education specialties from the point of view of the labor market	Formalization of employment center data, surveys and questionnaires of regional employers, their statistical processing
III STAGE. Solving the problem by the method of game theory	
Determination of the distribution of player strategies and weighting coefficients	Calculation of the probability distribution of each player's strategies and the normalized matrix
Determining the optimal allocation of budgetary places for higher education institutions by specialty	According to the formula for calculating the combined weighting factor of the specialty, we determine the percentage distribution of budget places for the educational institution

RESULTS

The distribution mechanism in the market of educational services begins with an order from the state for qualified personnel who will replace positions at enterprises. Interacting, the labor market and the state act as customers in the market of educational services. On the basis of the received order, the institution of higher education, taking into account the requirements of the state and the labor market, carries out the recruitment of applicants and the organization of the educational process, which includes educational activities. In this case, the institution of higher education acts as a producer, which as a result of its activity produces specialists, satisfying the needs of customers, which turn into consumers. The paper proposes an analysis of the educational services market in terms of state procurement, the labor market, and

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consumer needs. The main stages of setting up and solving the problem of determining the optimal distribution of budgetary places by major in higher education institutions are proposed:

- I STAGE. Collection and analysis of research data;
- II STAGE. Data formalization and mathematical formulation of the problem;
- III STAGE. Solving the problem by the method of game theory.

An analysis of the development trends of higher education institutions in the market of educational services, an analysis of primary and secondary data on the example of the University of Customs and Finance (USF) was carried out [15]. Since the acute problem is the disproportion between the demand and the supply of the labor force by professional and qualification composition, let's analyze the situation on the labor market of the Dnipropetrovsk region. The greatest discrepancy between the demand for the labor force and its supply in terms of professional and qualifying was observed among legislators, leaders, and managers. (31 people for 1 free workplace), technical employees (29 people for one place), workers in trade and services (19 people), workers for maintenance, operation of equipment and machines (11 people), the simplest professions (10 people), specialists (10 people), qualified agricultural workers (10 people), etc. According to the data of the Dnipropetrovsk regional employment center, the situation in the labor market of the region is characterized by the indicators given in Tables 2 and 3.

Table 2. Structure of vacancies registered in the Dnipro employment center as of July 1, 2022. *(Source: [16])*

By types of economic activity	%	By professional groups	%
Processing industry	19.3	Professionals	20.0
Trade	13.7	Skilled workers with tools	17.0
Health care	12.4	Equipment and machine maintenance workers	15.7
The mining industry	8.3	The simplest professions and persons without a profession	13.6
Education	8.2	Specialists	13.2
Agriculture, forestry, fisheries	7.1	Trade and service workers	11.0
Transport	5.5	Legislators, employees and managers	5.5
Governance	4.6	Technical employees	2.4
Other species	4.2	Skilled agricultural workers	1.6
Supply of electricity, gas	3.7		
Water supply, sewerage	3.7		
Construction	3.7		
Administrative service	2.6		
Professional and scientific activity	1.9		
Art, sport	1.1		

Table 3. Professions with the largest number of vacancies as of July 1, 2022, by TOP-10 professional groups.

Leaders, managers	Professionals, experts
chief accountant	accountant
master	medical nurse (medical brother)
group leader	teacher of the general secondary education institution
manager	merchandiser
manager of a pharmacy (pharmacy establishment)	manager of a pharmacy (pharmacy establishment)
chief energy engineer	general practitioner-family doctor
production master	specialist
head of the station	master of industrial training
manager of the farm	economist
store manager	pharmacist

It is also expedient to analyze the demand of entrants for studies in the specialties for which the state has established the largest volumes of orders in Table 4.

Table 4. Comparison of the state order and the number of applicant applications in 2021. *(Source: [17])*

Specialty	State		Consumer	
	Number of seats	Place in the rating	Number of applications	Place in the rating
Secondary education	7900	1	2018	4
Law	3286	2	4358	2
Law enforcement activity	3100	3	986	6
Computer science and information technology	3066	4	2621	3
Electric power engineering, electrical engineering and electromechanics	2707	5	513	9
Construction and civil engineering	2510	6	752	7
Philology	2163	7	4402	1
Computer Engineering	1825	8	1079	5
Industrial engineering	1819	9	349	10
Automation and computer-integrated technologies	1725	10	687	8

Thus, applicants continue to choose prestigious professions, ignoring her priorities. Although representatives of middle and lower-level technical professions and technical specialties, in general, are in demand on the labor market, the corresponding study profile is weakly popularized and remains insufficiently attractive for young people, because it not only requires longer and more difficult training but also does not correspond to modern ideas about the prestige of work and comfortable living conditions.

This confirms the need for the development and application of a scientifically based methodology for the formation of state orders and expenditure volumes from the general fund of the budget, which will contribute to increasing the efficiency of the use of state budget funds aimed at training highly qualified personnel and providing the state with specialists with higher education in accordance with priority state needs.

Based on the results of the research, a model of the distribution of the institution's budget expenses is proposed for making management decisions by higher educational institutions, which allows redistributing funds to the items of expenses that are included in the expenses of the development of higher education institutions.

The income of the general fund (allocation plan) is determined as the sum of the cost of education under the state order for the *i*-th specialty according to the following formula:

$$GF = \sum_{i=1}^{n} \mathrm{K}_{GF\mathrm{i}} \cdot V_{\mathrm{Gi}} \quad (1)$$

where GF - is the sum of the cost of education under the state order, UAH; K_{GFi} - is the number of students studying under the state order in the i-th specialty, persons; V_{Gi} - the cost of training one student who studies under the state order in the i-th specialty, UAH. i=1, 2, …, n - the number of specialties in which students study according to the state order.

In the revenue part of the draft estimate, in addition to the planned amounts of allocations from the general fund of the budget, the amounts of revenues from the special fund, which are supposed to be directed to cover the relevant costs of the institution, are reflected. The income of the special fund of the higher education budget is formed based on the number of contract places for the training of specialists (licensed volume minus the state procurement plan) for each direction multiplied by the contract value. The amount of tuition under the contract is calculated:

$$SF = \sum_{i=1}^{m} \mathrm{K}_{SF\mathrm{i}} \cdot V_{\mathrm{Si}} \quad (2)$$

where SF is the amount of tuition under the contract, UAH; K_{SFi} - the number of students who study under the contract of the i-th specialty, persons; V_{Si} - the cost of training one student studying under a contract in the i-th specialty, UAH; i=1, 2, …, m - the number of specialties studied by students under a contract.

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Incomes from the general and special funds make up the income of the higher educational institution. Total income TI=GF+SF

$$TI = GF + SF = \sum_{i=1}^{n} K_{GFi} \cdot V_{\text{Gi}} + \sum_{i=1}^{m} K_{SFi} \cdot V_{\text{Si}} \quad (3)$$

The distribution of proven funds is carried out for each code of economic classification in proportion to the funds provided for in the budget proposal, taking into account the specified need for funds for one or another code of economic classification.

Thus, the amount of expenses under the general fund is:

$$AE_G = \sum_{i=1}^{\text{K}} AE_i, \quad (4)$$

AE_i – column matrix, the components of which are items of expenditures under the general fund, namely:

- $AE_1 = AE1110_G$ - wages for employees of budgetary institutions (total);
- $AE_2 = AE1120_G$ – payroll;
- $AE_3 = AE1342_G$ – studentship;
- $AE_4 = AE1160_G$ – payment of utility services and energy carriers;
- $AE_5 = AE1130_G$ – purchase of supplies and materials, payment for services and other expenses;
- $AE_6 = AE2100_G$ – acquisition of fixed capital;
- $AE_7 = AE1170_G$ – research and development, state programs.

The structure of each of the elements of the set of expenditure items is as follows:

$$AE_{G_i} = \{ae1,\ \text{ae2}\},\ i = 1,2,\dots,k, \quad (5)$$

where ae1 – name of article; ae2 - expenditure elements of the corresponding article.

The distribution of the special budget fund, first of all, provides for the allocation of revenues to finance the expenses of protected items (wages, payroll and utilities, and energy carriers) in proportion to the number of students studying under a state order and contract. The amount of expenses under the special fund is:

$$AE_S = \sum_{j=1}^{l} AE_j, \quad (6)$$

where AE_j – column matrix, the components of which are items of expenditures under the special fund, namely:

- $AE_1 = AE1110_S$ – wages for employees of budgetary institutions (total);
- $AE_2 = AE1120_S$ –payroll;
- $AE_3 = AE1160_S$ – payment of utility services and energy carriers;
- $AE_4 = AE1130_S$ – purchase of supplies and materials, payment for services and other expenses;
- $AE_5 = AE1140_S$ – travel expenses;
- $AE_6 = AE2100_G$ – acquisition of fixed capital;
- $AE_7 = AE1170_S$ – research and development, state programs;
- $AE_8 = AE2130_S$ – big repair.

The structure of each of the elements of the set of expenditure items is as follows:

$$AE_{S_j} = \{ae1,\ \text{ae2},\ \},\ j = 1,2,\dots,l., \quad (7)$$

where $ae1$ – name of article; ae2 - expenditure elements of the corresponding article.

The difference in funds between the amount of income of the special fund and expenses for financing protected articles can be directed to the maintenance of the educational institution and to the innovative and investment development of the higher educational institution:

$DSF=SF-AE_S$, (8)

where DSF – expenses for the development of a special fund, UAH; AEs – the amount of expenses under the special fund, UAH.

$$DSF = \sum_{i=1}^{m} К_{SFi} \cdot V_{Si} - \sum_{j=1}^{l} AE_j. \quad (9)$$

Expenses for the maintenance of the institution must ensure its smooth functioning, payment of mandatory taxes and payments, replenishment of non-current assets, current and capital repairs, expenses for the development of science.

This mathematical model, taking into account all the above requirements, reflects the optimal expenses of a higher educational institution for making management decisions, making forecasts and exercising control over the areas of activity of the institution, which allows redistributing funds to expenditure items included in the development expenses of higher education institutions. The amount of expenditure of financial resources, the level of income, the alternative of choosing investment projects, as well as the complexity, systematicity, structuredness of the content and organizational order of the educational process largely depend on the quality of the information used.

The analysis of trends in the development of higher education institutions in the market of educational services, including UMSF, and the analysis of primary and secondary data, the obtained rating of specialties gave the following estimates (in percentages) of the attractiveness of specialties among consumers of educational services (students, applicants) and from the point of view of demand specialists on the labor market, presented in Table 5.

The ratings of the attractiveness of specialties were determined as follows:

- assessment of the attractiveness of the *i*-th specialty from the point of view of the consumer of services (the applicant, his parents, etc.);

$$pr_{1i} = \frac{k_{1i}}{\sum_{i=1}^{n} k_{1i}} \cdot 100\% \quad (10)$$

where $k_{1i}, i = \overline{1,27}$ *- is a quantitative indicator of the attractiveness of the i-th specialty from the point of view of consumers;*

- assessment of the attractiveness of the *i*-th specialty according to the demand in the labor market;

$$pr_{2i} = \frac{k_{2i}}{\sum_{i=1}^{n} k_{2i}} \cdot 100\% \quad (11)$$

where $k_{2i}, i = \overline{1,27}$ *- is a quantitative indicator of the attractiveness of the i-th specialty from the point of view of employers.*

Table 5. Evaluation of the attractiveness of university specialties according to the results of the analysis of primary and secondary data.

№	Specialty	From the look consumers, %	From the point of view demand on the labor market, %
1	017 Physical culture and sports	1	1.4
2	022 Design	2	0.4
3	032 History and archaeology	1	0.05
4	034 Culturology	1	1.9
5	035 Philology	10	0.3
6	051 Economy	1	9.7
7	052 Political science	1	0.05
8	053 Psychology	3	2.2
9	061 Journalism	9	0.2
10	071 Accounting and taxation	1	30.2
11	072 Finance, banking and insurance	7	0.85
12	073 Management	14	20

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Table 5. *(continued)*

№	Specialty	From the look consumers, %	From the point of view demand on the labor market, %
13	075 Marketing	4	3.3
14	076 Entrepreneurship, trade and exchange activity	5	3.2
15	081 Law	6	2.7
16	121 Software engineering	8	1.3
17	122 Computer Science	7	0.7
18	125 Cyber security	3	0.05
19	232 Social security	1	9.4
20	241 Hotel and restaurant business	1	0.15
21	242 Tourism	1	0.05
22	262 Law enforcement activity	1	0.1
23	275 Transport technologies (on-road transport)	1	1.15
24	281 Public management and administration	1	10.5
25	291 International relations, public communications and regional studies	3	0.05
26	292 International economic relations	3	0.05
27	293 International law	4	0.05

Therefore, the analysis carried out indicates a certain discrepancy in the evaluations of the attractiveness of university specialties by consumers of educational services and the demand for relevant specialties in the labor market. In this situation, the university, as a provider of educational services, must balance the demand of the consumer (applicants, students and their parents) with the offers of the customer (the state, entrepreneurs, and the labor market). Under the conditions described above, it is advisable to apply the methods of game theory to find a solution to the given problem. The main goal of solving problems of this class is the development of recommendations for choosing the optimal strategies of the conflicting parties based on the application of methodological approaches of game theory [2, 18]. The characteristic features of a mathematical model of a game situation are the presence of several participants, called players, a description of the possible actions of each of the parties, called strategies, and the determined results of actions for each player, which are represented by payoff functions. The task of each player is to find the optimal strategy. As the first player, we will consider an applicant, a university student (player A), as the second player - an employer (player B). As the personal strategies of player A, we will choose the ratings of the attractiveness of the most rated specialties among university applicants, and as the strategies of player B, we will choose the ratings of the attractiveness of these specialties among employers, which were given in Table 1. The task was considered a repeated game, a normal form. Every game in normal form has a pure and mixed strategy Nash equilibrium. Since the task of the process of self-organization (self-organization) in socio-economic systems is considered, the Nash equilibrium is natural. Each player has a set of strategies, which is a set of probability distributions $p_i = (p_{i1},\ p_{i2},\ldots, p_{ik})$, where $0 \le p_{ik} \le 1,\ p_{i1} + p_{i2} + \ldots + p_{ik} = 1$ [2]. The probabilities were determined as statistical probabilities of choosing the relevant specialties of the university, obtained as a result of a survey of applicants and students and according to the vacancies of the employment center of Dnipro (January-July 2022). That is, the mixed strategy of each player is given by the distribution of probabilities that this player will play each of his strategies in a repeated game.

We determine the weighting factors using the method of analysis of hierarchies. Since we have 2 criteria at a given level of the hierarchy (criterion R – the attractiveness of the specialty among applicants and students, criterion L – the attractiveness of the specialty on the labor market), the corresponding procedure creates a matrix C of paired comparisons of dimension 2×2, which reflects judgments about the importance of various criteria from the university's point of view:

$$C = \begin{pmatrix} 1 & 2 \\ \frac{1}{2} & 1 \end{pmatrix}.$$

The relative weights of criteria R and L were determined by dividing the elements of each column by the sum of the elements of this column, the normalized matrix N was chosen:

$$N = \begin{pmatrix} 0{,}67 & 0{,}67 \\ 0{,}33 & 0{,}33 \end{pmatrix}.$$

The average values of the row elements are equal to WR=0,67, WL=0,33. The columns of matrix N are equal, which means that the correct consistency was found when determining matrix C. The combined weighting factors for each specialty were calculated using the formula:

$$Vk_i = W_R \cdot p_{1i} + W_L \cdot p_{2i}, \quad (12)$$

where p1i is the value of the i-th component in the probability distribution of player A's strategies, p2i is the value of the i-th component in the probability distribution of player B's strategies.

The values of the probability distribution of players and combined weighting coefficients are given in Table 6, and the scheme of their determination is shown in Figure 1.

Table 6. Distribution of player strategies and the value of combined weight coefficients by specialty.

№	Distribution of strategies player A (p_{1i})	Distribution of strategies player B (p_{2i})	Combined specialty weighting factor (Vki)
1	0.01	0.014	0.01132
2	0.02	0.004	0.01472
3	0.01	0.0005	0.006865
4	0.01	0.019	0.00769
5	0.1	0.003	0.09901
6	0.01	0.097	0.006865
7	0.01	0.0005	0.01396
8	0.03	0.022	0.02076
9	0.09	0.002	0.15996
10	0.01	0.302	0.009505
11	0.07	0.0085	0.1129
12	0.14	0.2	0.10469
13	0.04	0.033	0.03736
14	0.05	0.032	0.04241
15	0.06	0.027	0.04449
16	0.08	0.013	0.05591
17	0.07	0.007	0.047065
18	0.03	0.0005	0.05112
19	0.01	0.094	0.007195
20	0.01	0.0015	0.006865
21	0.01	0.0005	0.00703
22	0.01	0.001	0.010495
23	0.01	0.0115	0.04135
24	0.01	0.105	0.006865
25	0.03	0.0005	0.020265
26	0.03	0.0005	0.020265
27	0.04	0.0005	0.03307

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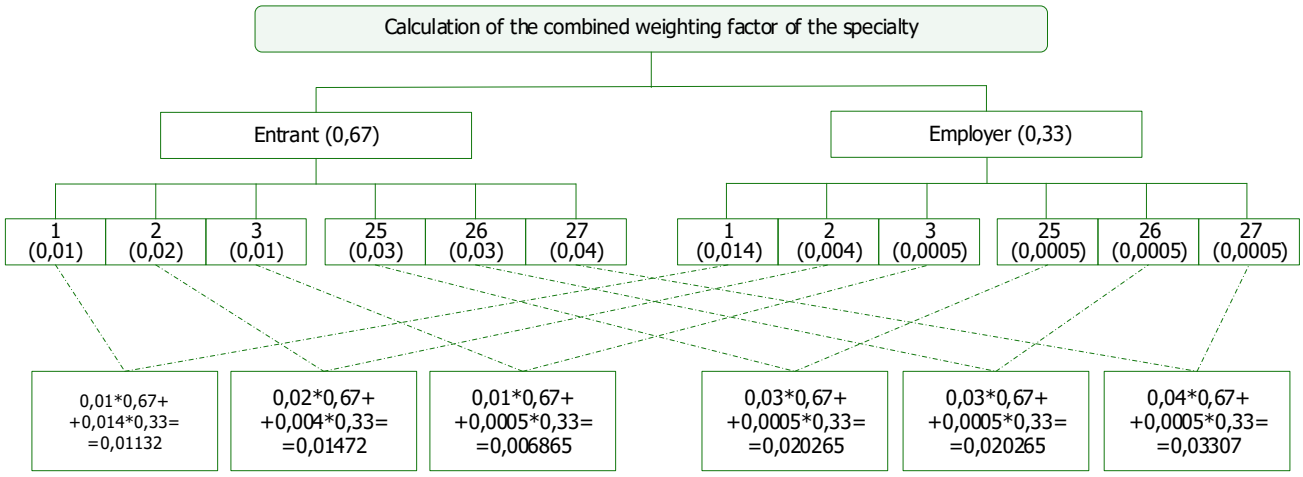

Figure 1. Scheme for calculating the combined specialty weighting factor.

DISCUSSION

Obviously, game theory is a theoretical framework for conceiving social situations among competing players. In some respects, game theory is the science of strategy, or at least the optimal decision-making of independent and competing actors in a strategic setting. It is present in almost every industry or field of research. Also, it can be pertained to many situations, making it a versatile and important theory to comprehend. We can highlight the following spheres and fields which are directly impacted by game theory:

- economics (Game theory brought a revolution in economics by addressing crucial problems in prior mathematical economic models).
- business (In business, game theory is beneficial for modeling competing behaviors between economic agents. Businesses often have several strategic choices that affect their ability to realize economic gain).
- consumer Product Pricing (The concept holds that if the company reduces prices, more consumers will buy more goods. The relationship between a consumer, a good, and the financial exchange to transfer ownership plays a major part in game theory as each consumer has a different set of expectations).
- project Management (Project management involves social aspects of game theory as different participants may have different influences).

As a result of the conducted research in order to solve the management problem, the necessity of using the game theory apparatus was substantiated and the stages of building a mathematical model and researched indicators, methods, and means of research were proposed. Thus, the theory of games is widely used today as a powerful apparatus for the study of socioeconomic processes. Its essence lies in the fact that it is used to achieve coordination of the interests of the parties, namely: the consumer (applicants, students, and their parents) with the offers of the customer (the state, entrepreneurs, the labor market), taking into account the forecast of demand in the labor market.

We note that the practical use of such methods requires special knowledge, which is explained by the requirement to use mathematical apparatus, in particular mathematical modeling methods. However, there are obvious advantages that organizations can get by applying these methods, namely the ability to develop and choose the most effective action algorithm based on a simulated situation.

Along with that, there is also a wide variety of methodological approaches to the analysis and forecasting of the state of the labor market [], determining the needs for personnel and/or qualifications, and assessing the level of unemployment. For the most part, relevant analytical centers combine various methods with the aim of obtaining optimal indicators regarding the state of the labor market and its real need, namely: the coefficient of variation method, the method of determining the ratio of the number of unemployed and employed, the Beveridge curve, the method of determining the mismatch by professions, the method of determining the payback of education and etc. But the issue of balancing the training of specialists by higher education institutions in accordance with the needs of the market is unresolved. Therefore, Ukraine faced the problem of the lack of an up-to-date statistical base for forecasting personnel needs in professional/qualification sections; groundlessness of the results of strategic planning of types of economic activity, etc. There is also no connection between specialties, educational standards and professional qualifications, etc.

CONCLUSIONS

The purpose of the article was to define the optimal allocation of budget places for higher education institutions considering financial constituents, system analysis and the game theory method. A solution to the problem is offered by building an economic-mathematical model using game theory techniques and methods of analyzing hierarchies, which have a powerful apparatus for considering many different models, approaches, and concepts for solving the same problem.

The paper proposed an assessment of the educational services market in terms of state procurement, the labor market, and consumer needs.

The analysis of consumer demand in the market of educational services revealed a conflict of interests between the consumer (applicants, students and their parents) and the customer (the state, entrepreneurs, the labor market). To balance the situation and determine the optimal strategy for solving the given problem, the game theory methodology was chosen, which is used to determine the choice of strategies in conflict situations.

Three stages of setting up and solving the problem of determining the optimal distribution of budgetary places by major in higher education institutions were proposed.

Based on the results of the research, a model of the distribution of the institution's budget expenses is proposed for making management decisions by higher educational institutions, which allows redistributing funds to the items of expenses that are included in the expenses of the development of higher education institutions.

In the future, in order to determine the optimal distribution of budgetary places in the educational institution, which takes into account not only the demand from applicants and vacancies on the labor market but also the state of the economy and the development prospects of the given region and the scientific and pedagogical potential of the higher education institution, it is necessary to solve this problem according to using the approaches of the theory of system constraints (TOC).

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ТЕОРІЯ ІГОР ТА ФІНАНСОВА СКЛАДОВА ВИЗНАЧЕННЯ ОПТИМАЛЬНОГО РОЗПОДІЛУ БЮДЖЕТНИХ МІСЦЬ У СИСТЕМІ ВИЩОЇ ОСВІТИ УКРАЇНИ

Складність і взаємозалежність управлінських проблем у системі вищої освіти потребують нових ідей і підходів, що зумовлює необхідність пошуку нових управлінських рішень за допомогою сучасних підходів і методів економіко-математичного моделювання. Статтю присвячено проблемі оптимального розподілу бюджетних місць для закладів вищої освіти за спеціальностями. Проведене дослідження показує, що пріоритети держави, ринку праці та споживачів не збігаються. У цій ситуації університет як постачальник освітніх послуг повинен збалансувати попит спожи-

вача (абітурієнтів, студентів та їхніх батьків) із пропозиціями замовника (держави, підприємців, ринку праці) з урахуванням прогнозу попиту на ринку праці. Метою роботи є визначення оптимального розподілу бюджетних місць для закладів вищої освіти з урахуванням фінансової складової за допомогою системного аналізу та методу теорії ігор. Запропоновано варіант вирішення задачі розподілу бюджетних місць для закладів вищої освіти при побудові економіко-математичної моделі із застосуванням методики теорії ігор, яка має потужний апарат для того, щоб для тієї самої задачі розглядати багато різних моделей, підходів та концепцій вирішення. Представлена математична модель дозволяє отримати збалансований оптимальний розподіл бюджетних місць за спеціальностями університету, що узгоджує попити абітурієнтів та роботодавців. Обсяг бюджетного фінансування на вищу освіту є ефективним регулятором прямої дії на підготовку фахівців із вищою освітою та інструментом державного регулювання кількості студентів, які навчаються за державним замовленням. На підставі результатів дослідження запропонована модель розподілу видатків бюджету установи для ухвалення управлінських рішень, яка дозволяє перерозподіляти кошти на статті видатків, включені до видатків розвитку закладів вищої освіти. Подальший розвиток описаної моделі в напрямі дослідження впливу на існуючі обмеження на ринку освітніх послуг дозволить запропонувати потужні механізми та технології для управління процесом формування оптимальних стратегій розвитку закладів вищої освіти.

Ключові слова: заклад вищої освіти, теорія ігор, моделювання, бюджет, математична модель, системний аналіз, управління, попит, пропозиція

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