Modeling of the Processes of Formation and Effective Use of Financial Resources at Higher Education Institutions

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Abstract **– The problem of higher education funding has been urgent due to insufficient funds allocated by the state. The state is moving from the policy of comprehensive support for higher education as a public institute that provides educational, scientific and cultural development of the country to determining itself as a customer of educational services through educational establishments. Level of funding plays an important role in the system of factors affecting the effectiveness and competitiveness of educational services. The problem of optimal allocation and the use of state funds for education remain urgent. In order to ensure the efficient formation and use of financial resources, it is important to determine their predictions through modelling.**

Key words **– higher education institutions, mechanism for higher education institutions financing, monitoring the funding effectiveness, predictive model of the effectiveness within educational services.**

1. Introduction

The main purpose for any state is to create conditions for economic growth, which can be ensured by the introduction of the latest technologies, accumulation of human capital and its efficient use.

DOI: 10.18421/TEM91-39
https://doi.org/10.18421/TEM91-39

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Received: 22 August 2019.
Revised: 11 December 2019.
Accepted: 20 December 2019.
Published: 28 February 2020.

The quality of human capital is directly linked to professional education, a social institute, responsible for the imitation, accumulation and reproduction of professional competences. Modernization of the country's economy requires the formation of a new innovative educational model in line with the priorities in this field [1]. State policy should be aimed at ensuring the quality and affordability of higher education, improving the social status of higher education workers, integrating education and science, improving the efficiency of those financial resources that are invested in its development.

Improvement of economic mechanisms with respect to functioning of the national higher education is one of the main directions for the state educational policy, which is also defined by the strategic program including the development of education. This task could be reached through the introduction of modern financing models, the search for new sources of material and intellectual resources. This raises two problems at once: first, at the expense of which sources it is necessary to finance education; second, how to effectively leverage the resources involved to produce positive results and ensure high quality and accessible education for all [2].

In order to increase competitiveness level of the national economy and higher education of Ukraine, in particular, it is necessary to modernize higher education in a direction related to a closer and more rigid orientation to the demands of the labor market [3]. This requires, first and foremost, the improvement of the quality of highly qualified specialists training and the creation of jobs that would require such specialists, which requires the expansion and diversification of higher education funding resources.

Higher education institutions as market entities are forced to compete for access to financial resources, counteract negative factors of the external and internal environment, take measures to strengthen their own economic potential, improve the mechanisms of management decision-making and so on. As in other types of economic activity, in the

field of higher education there are negative consequences of the financial and economic crisis, which restrict the access of universities to financial resources. Therefore, the urgent and significant problem is the search for the newest financial instruments for the financial support regarding the development of the higher education system, taking into account the negative manifestations of the financial and economic crisis [4].

Ensuring the effectiveness of educational services, their competitiveness depends on a significant number of internal and external factors, in which funding level plays an important role. Determination of predictions is important to ensure its effective use. Typically, prediction process consists of a number of stages, each of which solves a specific problem [5]:

– definition of the task – the object of the prediction is specified, the goals and tasks are formed, the accuracy and the time of the prediction are determined;

– formation of the prediction object according to the task – the structure of the object is determined, the main factors are distinguished, their subordination, hierarchy, interconnection are found;

– collecting retrospective information about the object – identifying sources of information, developing a method of processing and submission of information, setting its volume;

– formalization of the task – methodology of formalized presentation of information is developed and the class of models of the description of the prediction object is selected;

– choice of methods and algorithm – among the known ones the most suitable method of prediction is selected, the corresponding algorithm is developed and the accuracy of the prediction is estimated;

– modeling based on retrospective information of model quality assessment;

– calculation of prediction.

In order to ensure the financial stability of institutions in the context of systemic organizational and legal and economic changes, it is necessary to use methods of complex evaluation for the effectiveness of activities in order to determine their competitiveness [6]. Based on economic information obtained, it is possible to improve the performance of higher educational institutions on the basis of targeted orientation and coordination of financial measures aimed at improving the mechanism of their financing.

Therefore, the development of a prediction model of the effectiveness of educational services, taking into account that financial factor is considered appropriate in terms of the need for its use in the process of analyzing the situation and assessing the prospects for the development of higher education institutions. For this purpose, it is proposed to build an economic and mathematical prediction model of higher education institutions performance.

2. Procedure for Construction of Economic and Mathematical Prediction Model of Higher Education Institutions Performance

The procedure for constructing such a model involves the sequential implementation of the following steps:

I. The stage in which the ultimate goals and objectives of the study are determined, as well as a list of factor and outcome variables.
II. Formation of the database according to the quantitative indicators defined in the previous stage.
III. Checking the adequacy of the sample.
IV. Building a prediction model.
V. Checking the quality of the resulting model and justifying the conclusions about the feasibility of its use.
VI. Calculation of predictions based on the use of econometric model [5].

2.1. The Essence of Economic and Mathematical Prediction Model of Higher Education Institutions Performance

To predict the quantitative values of social and economic indicators, the use of econometric modeling methods, in particular the construction of regression models, remains effective. Regression analysis is a statistical method of investigating the dependence of quantitative values of an economic indicator (the resulting variable) on a number of factors (explanatory variables) from the experimental data. To select the type of regression model, time series are analyzed, describing the dynamics of the studied indicators and they are the basis for analyzing the development of economic indicators and their modeling. This method has the greatest statistical significance when modeling systems with stable, strong development trends [7], [8].

Modeling cannot be done without defining the structure of the object being investigated, since it determines strong links between the elements. And the very nature of communication within the system is determined by the elements. Therefore, it is necessary to take into account the functioning peculiarities of a particular study object.

Econometric model is a logical (usually mathematical) description of what economic theory considers particularly important when investigating a particular problem. The model has the form of an equation or system of equations describing the correlation-regression relationship between economic

indicators, one or more of which is a dependent variable and the others are independent.

The equation in the econometric model is:

$$y = f(x1, x2, x3, \ldots, xm, u), \quad (1)$$

in which y is a dependent variable;
xi are independent variables;
u is a stochastic component that contains that part of the motion Y that is not explained by the variables x1, x2, x3, …, xm, and is random [9].

2.2. Methodology of Calculating the Performance of Higher Education Institutions

The preliminary analysis has led to the conclusion that the effectiveness of educational services is reflected by such indicators as the integrated assessment of higher education institutions activity and the evaluation of learning experience. These indicators are components of the annual university ranking of "Top-200 Ukraine 2018" [10]. As such, the integral indicator of higher education institution activity (first variant) and the evaluation of learning experience (second variant) are defined as a predictive indicator, which is the dependent variable of the prediction model.

It is worth noting that the methodology for calculating the "Top 200-Ukraine" is based on the use of data of direct measurements and expert opinions, which over the course of its existence have adapted to some extent changes in the higher education system of the country. A permanent basis of this methodology is a set of indicators for universities of different types, which allows comparing the results of their activities. The activity of each higher education institution under study is estimated using the integrated index – Із. This index contains three complex components: Із = Інп + Ін + Імв (Інп – index of quality of scientific and pedagogical potential, Ін – index of learning experience, Імв – index of international recognition).

The methodology was created in accordance with the Berlin University Ranking Principles. At present, 24 direct measurement indicators with the total weight of 80% are used to form these indices, as well as an indicator of information resources (quality and functional completeness of university websites) - 5% and expert evaluation with a weighting factor of 15%.

In order to evaluate international recognition of higher education institution in 2018, its participation in the European programs Horizon 2020, Seventh Framework Program, TEMPUS, Erasmus+ was additionally taken into account. Data on these indicators were selected from several independent sources (data from higher education institutions, data from the Ministry of Education and Science of Ukraine, data from the Committee on State Prizes of Ukraine and T. Shevchenko Prizes, data from international associations of universities, data on "Horizon 2020" international projects, Seventh Framework Program, TEMPUS, Erasmus +, other open data).

Expert evaluation was carried out on the following criteria:

– level of basic, general education of students;
– level of their professional training;
– level of practical knowledge of information technologies;
– demand of graduates of higher education institutions in the labor market.

2.3. Information Base for the Formation of Prediction Model

The research identified the factors that should be included in the prediction model, marking them as independent variables, which are financial cost of preparing higher educational establishment personnel and ensuring their performance without practice bases per student and the quality of their scientific and pedagogical potential.

The information base was formed using data from PA Center of International Projects "EuroEducation" and cost sheets of higher education institutions presented on their official websites. For the purpose of statistical sampling, all educational institutions that were included in the "Top-200 Ukraine 2018" rankings were divided into conditional 3 groups (high, middle and low) by the integral estimation. From each group, 10 higher education institutions were selected, the data of which were included in the statistical base of the study. The output for the model calculation was checked for lack of close relationships (linear dependence).

2.4. Building a Prediction Model of the Performance of Higher Education Institutions

According to the selection results of factors, two models were constructed and based on the selected group of factors (Table 1).

У1 – integral estimation of higher education institutions performance;
У2 – estimation of learning experience;
Х1 – quality of their scientific and pedagogical potential;
Х2 – financial expenditures for training specialists by higher education institutions and assurance of activity regarding their practice bases per student (thousand UAH).

Table 1. Regression models for predicting indicators of integral estimation of higher education institutions performance and learning experience

Indices	Integral estimation of higher education institutions performance (y1)	Estimation of learning experience (y2)
Model	y1 = 3,1623 + 1,9530x1+ 0,2793x2	y2 = 2,4898 + 0,4404x1+ 0,1148x2
Correlation coefficient	0,8695	0,8357
Determination coefficient	0,7560	0,6984
F-criterion	21,27	31,26
T- criterion	1,7	2,09
Test DW	1,29	1,16
Elasticity	E(X1)=0,7366 E(X2)=0,1604	E(X1)=0,5305 E(X2)=0,2105

2.5. Checking the Quality of the Obtained Models of Higher Education Institutions Performance

When assessing the quality of functioning and optimization of the use of financial resources at higher education institutions, there is a need to form a general indicator. As indicators do not always have the same significance, it is necessary to determine their weights and check the system for adequacy. The procedure for determining weights can be performed using subjective (expert) and objective (calculation) methods [11].

The models obtained were checked for adequacy. To test the adequacy of the multivariate regression model, Fisher's F-test is used [12]. For this purpose, the F-criterion is calculated and compared with Fкр, which is in the Fisher F-distribution tables with different degrees of freedom. The critical value of Fкр is with degrees of freedom k1 = m-1 and k2 = n-m and with a significance level of α (usually α=0,05). If the calculated value is > Fкр. (α, k1, k2), then with a given degree of reliability 1-α, we can assume that the model is adequate. F-statistic (Fisher test) is calculated by the formula:

$$F = \frac{\frac{R^2}{1}}{\frac{1-R^2}{n-2}} = 7{,}65 \qquad (2)$$

The critical value Fкр = 3,32. We see that for both models |F|≥Fкр, so the models are significant.

The quality of the obtained model is checked by determining the absence of autocorrelation, which may be due to the inertia and cyclicality of many economic processes. Incorrectly specified functional dependence in regression models and time lags in economic processes can provoke autocorrelation. The most well-known and common model test for residual correlation is the Darwin-Watson (DW) test. The quality of the obtained models was checked through the detection of autocorrelation by the DW method [12].

DW statistics are calculated by the formula:

$$DW = \frac{\sum_{i=2}^{n}(e_i - e_{i-1})^2}{\sum_{i=1}^{n} e_i^2} \qquad (3)$$

in which n is the number of observations;
e – value of residues.

The calculated and tabulated values of DW statistics on the models obtained are shown in Table 1, suggest that the autocorrelation of residues is absent. This is one of the arguments for confirming the high quality of the models.

The relatively high values of the multiple correlation and determination coefficients also confirm the satisfactory quality of the regressions. The correlation is considered strong if the value of multiple coefficient is higher than 0.7; if its value exceeds 0.9, then the correlation, and therefore the correlation between the factors, is considered very strong. In order to draw conclusions about the relationship between independent variables, the sample size should be taken into account: the larger the sample, the more reliable the value of the correlation coefficient obtained (in our case, a sample of 30 observations is used. Such observations are sufficient).

To assess the significance of the parameters of the multiple regression equation, Student's test is used. Significance of parameters means their difference from zero with high probability.

$$t = \frac{r\sqrt{n-m}}{\sqrt{1-r^2}}, \qquad (4)$$

in which t is the Student's test;
r is correlation coefficient;
r2 is coefficient of determination;
n is the number of observations;
m is the number of independent variables.

Since function and factors are evaluated in different units of measure, the coefficient of elasticity is determined to eliminate the dimensionality and to evaluate the relationship between each factor and the indicator, which is studied by means of relative values. The latter shows how many percent of the function will change with the change of a certain

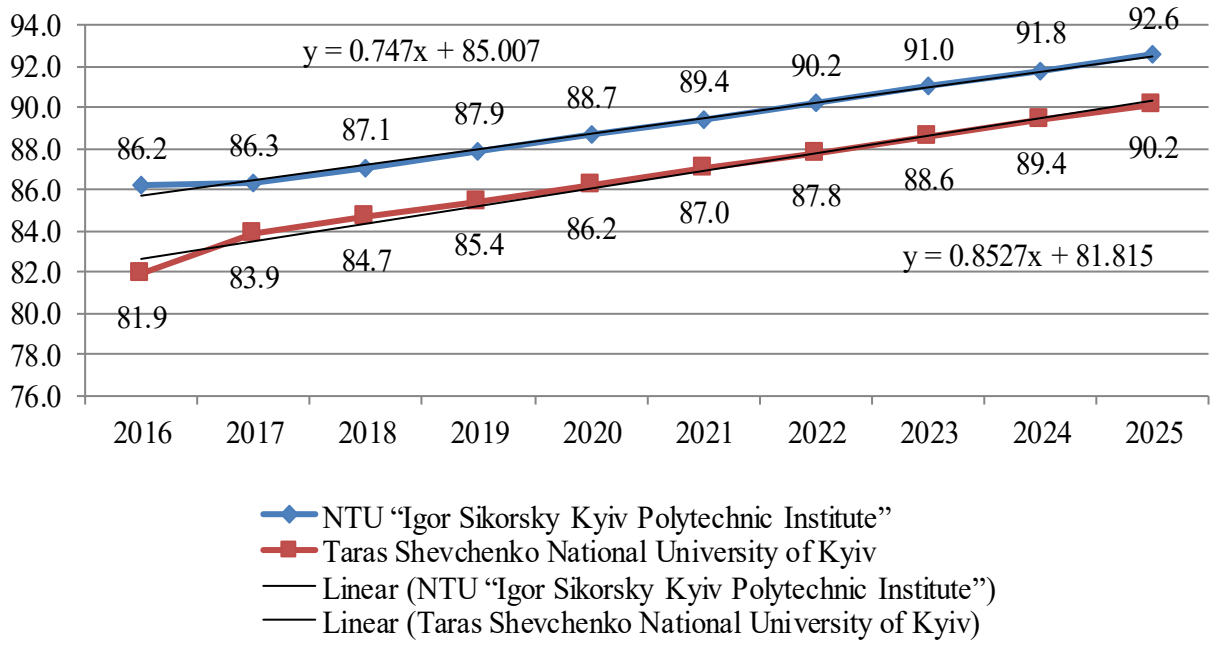

Figure 1. Prediction of the integral estimation of higher education institutions for the period 2019-2025.

factor by 1% with a fixed (average) value of other factors:

$$E = a_i \frac{Xcp_i}{Ycp} \quad (5)$$

in which E is the coefficient of elasticity;
ai – coefficient at unknown;
Xcp i – average value of the independent variable;
Ycp – average value of the dependent variable.

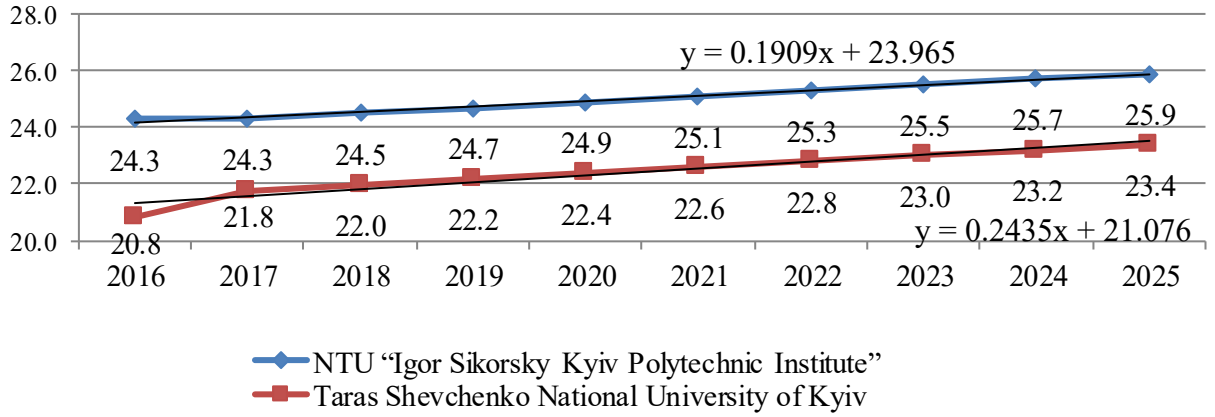

Figure 2. Prediction of the estimation of quality of learning experience in higher education institutions for the period 2019-2025

3. Approbation of the Obtained Prediction Models of Higher Education Institutions

The models obtained can be used to predict changes in the effectiveness of educational services, depending on changes in the level of financing of educational services and changes in the quality of scientific and pedagogical potential.

The models were tested according to National Technical University of Ukraine "Igor Sikorsky Kyiv Polytechnic Institute" and Taras Shevchenko National University of Kyiv, which are the leaders of "TOP-200 Ukraine" in recent years.

The prediction data and linear trends reflecting the overall direction of changes in the time series are shown in Fig. 1, 2.

Using a well-grounded methodology, let us analyze linear trends of integral estimation regarding the performance of NTU "Igor Sikorsky Kyiv Polytechnic Institute" and Taras Shevchenko National University of Kyiv. The results of the study show that during 2019–2025 there will be a gradual steady increase of this indicator.

Modeling predictive indicators of the quality of learning experience provides an opportunity to

evaluate the prospects and trends in the content and level of training of bachelors and masters of all specialties taught at universities. From Fig. 2 we realize that in both higher education institutions there will be an increase in the values of these indicators: in NTU "Igor Sikorsky Kyiv Polytechnic Institute" from 24.7 in 2019 to 25.9 in 2025; in Taras Shevchenko National University of Kyiv – 22.2 and 23.4 respectively.

4. Conclusion

The constructed mathematical models allowed us to estimate correlation-regression relationship between the factors and the resulting indicators, and the use of the extrapolation method made it possible to obtain the predicted values of these indicators. Therefore, the constructed methodology provides the basis for the implementation of better and more scientifically based prediction of educational services based on the appropriate level of financing concerning higher education institutions, which will ultimately help to optimize the mechanism of financing the higher education institutions.

In order to solve the statutory tasks and develop the market conditions at universities, there was a need for an objective analysis of its activities in the context of the functioning regarding the educational services market [13]. In a highly volatile environment, the challenge of ensuring the economic sustainability of higher education institutions is of particular importance. Therefore, the use of such tools is important to create and maintain an effective mechanism for the financial activities respecting the higher education institutions.

The efficiency of the financial mechanism is possible on the condition that a proper regulatory framework is created and functions effectively. The extent to which it will take into account objective economic laws and patterns of development of society and the state, its financial capacity and other factors will depend on the rate of socio-economic development [14].

In order to ensure financial stability of institutions in the context of systemic organizational and legal and economic changes, it is necessary to use the methods of complex evaluation on the effectiveness of activities in order to determine their competitiveness. Based on economic information obtained, it is possible to improve the performance of higher education institutions on the basis of targeted orientation and coordination of financial measures aimed at improving the mechanism of their financing.

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