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Predictive model of strategic development of a university

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Abstract

The paper presents an economic and mathematical model designed to forecast development of a university depending on social and economic changes in the country and the amount of public funding of education. The university's internal decisions how to distribute its budget among operational activities, development, supporting science, and improving educational services are assumed as endogenous variables. The development of the university is viewed as a phase space trajectory defined by the four characteristics: quality of educational services, level of development of R&D and consulting activities, image and financial performance of university.

The choice of parameters meets the major interests of the most important stakeholders: state and society, business and science, labour market, prospective students, and the university staff. The model describes relationships between: a) funds obtaining and spending; b) results of university development along various axes and the investments; c) finance obtained and the results of university development; d) results of the university development in adjacent time intervals. The strength of the model consists in its practical use confirmed by the first results of modelling.

Keywords: strategic development; university; economic and mathematical model; prognosis; Balance Scorecard System; recursive relations; quality of education, scientific activity of a university; financial situation of a university; image of a university;

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1. Introduction

Identifying and describing the major problems universities face became a matter of concern in the period of adaptation of the Russian system of higher education to market conditions. Such problems included lack of public funding, low standard of living, decreasing prestige of higher education, and obsolescence of infrastructure and facilities at universities; moreover, highly qualified staff left universities to work abroad or in business. To these is added low level of managerial knowledge and skill among the administrative personnel[1,2,3].

As rules of market economy were being adopted in Russia, universities became more and more exposed to the universal problems of higher education: fast changing environment, increased competition, globalization processes, changed stakeholders' requirements to higher education, etc. [4]. The pace and ways of universities' adaptation varied greatly due to significant differences in levels of earnings[5] and development of labour market sectors, as well as regional peculiarities. As the result, since 2000 the monitoring of the higher education system in general and of the strategic development of universities in particular, has been gaining popularity[6,7]. The monitoring was aimed at studying the existing situation dynamically, identifying the best managerial practices applied by universities, predicting the future changes in the higher education system, and, most importantly, developing relevant suggestions to the government to improve the state of things.

Approximately at the same time period, the growing pressure of competition forced Russian universities to create programmes of strategic development. The research into those revealed, however, that most of them were unreasonably unified and "made for show". They lacked situational approach, nor did they analyze the consequences of the decisions made[8]. Thus, it seems that developing quantitative prognoses of what consequences the choice of a strategy will have, is becoming more and more relevant in the modern conditions of tough competition in the market of educational services, increased qualification of Russian consumers, and rigorous demands that society and state make on universities, The main criterion of adequacy for such prognosticative model is its ability to consider specifics of universities as objects of strategic management.

2. University specificities considered in the economic and mathematical model

Universities are non-commercial organizations (NCOs) that are believed to emerge when consumer cannot pay the required price for certain goods or services; however, society on the whole or certain social groups are interested in these goods[9]. The major reasons for the state to use NCOs include lower costs, higher quality of service and flexibility when developing curricula, and the possibility to influence indirectly the process of service delivery in political terms.

Consequently, functioning of market mechanisms is somehow limited in the spheres of NCOs' activities. The role of the state in this case is to compensate for the fact that consumers only pay a proportion of the price of the acquired social benefits.

The suggested economic and mathematical model considers the following inherent features of universities and their specificities as NCOs:

1. Consumers do not often have enough expertise to assess the quality of the services provided by professionals: Service provider has more information about its quality and quantity. In the case of universities, such asymmetry of competence[10] escalates due to the complexity of services. One of the implications of this specific feature (included in the model) is that it is significantly stronger influenced by image than traditional commercial structures;
2. NCOs are dependent on external resources provision (resource dependence theory) [11]. Organizations have to adjust their activities to environment; moreover, they must constantly adjust to the changing requirements set by environment, and obtain new resources (which will be considered in the model);
3. When applied to NCOs, the stakeholder control theory[12,13] takes new dimension. Universities are less influenced by the end consumer compared to commercial organizations. Consumers provide only a proportion of financial resources and do not have the opportunity to check their quality and quantity. This is compensated by strong influence of other stakeholders, primarily, of the state;

4. Quantitative assessment of universities' efficiency and its prognosis are more complicated than in the case of other organizations; the accuracy of assessment and forecast is lower. This can be explained by the following factors:

- larger (compared to other types of organizations) number of performance objectives, gaining profit being only one of the many goals;
- the challenge to achieve common strategic goals through the efforts of many virtually autonomous divisions (faculties, departments, chairs, institutes, laboratories). As a rule, they are much less connected with each other than departments in a company, which may be caused by lack of cross-cutting technological processes in educational institutions which could unite their activities;
- relative independence of teaching staff and academic freedom may lead to opportunistic behavior of the collective and individuals when implementing the accepted development programme;

5. Strategies developed for universities are often characterized by long-term time-frames and inertia of all processes related to:

- long duration of education process makes time-frame planning at universities analogous to high-tech industries (shipbuilding, prototype production of aircrafts, medicinal drugs and technologies). Technological and industrial revolution, in particular, development of ICT leads to time-frames' further extension, as it is necessary to create and implement new educational programmes before the real demand from the labor market and prospective students appears;
- duality of governance (academic boards and administration) [14] and absence of clear hierarchy slow down the decision-making process;
- persisting perceptions of universities by the outside world caused by traditional privacy of such organizations as well as by the above-mentioned asymmetries of competence.

3. Building the model: general approach

The major challenge when building the economic and mathematical model of strategic development of a university is to quantitatively describe the strategy. This statement requires clarification.

Almost every definition of strategy and strategic management (for example definition of H. Ansoff, R. Declerk and R. Hayes[15]) emphasizes the goals of the process and factors considered when creating the programme of development.

Classic studies on strategic management of NCOs[16] are mainly focused on the "how" of strategy development and describe various approaches: integrated, which encompasses all goals and possible ways of development, and problem approach aimed at resolving the most important issues. Another widely discussed question is how to best develop the strategy: from "top to bottom" or "from bottom to top" which depends on dominance of initiatives coming from the central administration of the university or its departments. This defines analytical or empirical way of developing strategies[17]. Methods of strategy development are also a matter of academic concern. In this context should be mentioned the integrated model of strategic planning for Public and Nonprofit Organizations by J.M.Bryson[16], McLaughlin's Nonprofit Strategic Positioning[18], and the method based on product-consumer matrices (SCMs) [19]. It should be emphasized, however, that none of the approaches mentioned allows to assess the consequences of the chosen strategy.

Having researched more than sixty Russian universities and analyzed a voluminous corpus of publications on programmes of development of higher education institutions, it was revealed that the prognoses of results that the chosen strategies might have, are mostly done qualitatively, if at all[20]. In some cases the universities assessed economic effectiveness of individual managerial decisions.

Unexpectedly enough, the most suitable approach to assessing the results of the chosen strategy seems to be the Balanced Scorecard System (BSC) developed by R. S. Kaplan and D. P. Norton[21], although BSC is most often used for detailing a programme, in particular, harmonizing the goals at various levels of management and controlling the implementation of the strategy.

The appropriateness of R. S. Kaplan and D. P. Norton's approach may be explained as follows.

Firstly, BSC includes not only financial but also non-financial performance measures which demonstrate consumers' levels of satisfaction. This is rather suitable, as (previously mentioned) obtaining resources for universities as objects of strategic management depends largely on satisfaction of stakeholders with various aspects of their performance. The approach permits to take account of causal relationship between non-financial performance of higher education institutions provided by leading indicators and financial results viewed as "lagging indicators". The suggested economic and mathematical model also considers counter-causal relationships: how investing in certain areas of university activity impacts their performance results in the future periods.

An important idea of BSC which is used in the suggested model is that changes of values build in the phase space a trajectory of development of an object. Besides that, the model uses recursive relationships between values of each parameter in adjacent time intervals. However, due to the previously mentioned inertia of all processes taking place at universities, description of some dependences requires consideration of relations among several time frames.

An important point influencing the possibility of forecasting university development is the choice of metrics and parameters to describe the strategy and its outcomes. Taking into account the importance of accuracy of the information used in the practical implementation of the model, such complex of metrics must satisfy strict and largely controversial requirements:

- metrics must include all spheres of activity relevant for major categories of stakeholders and the university itself;
- for practical use of the suggested model it is required that the metrics be rather exactly definable, as for the model using recursive relation the accuracy of prognosis declines with each next iteration;
- the number of parameters should be relatively limited; it is caused by the non-linear increase of relationships that must be described within the model. The problem lies not in difficulty of describing them but in the inevitable decline of the model's accuracy caused by the large number of inter-dependences each bringing in its own error.

It should be noted that depending on specific social and economic conditions the set of parameters used to describe the strategy of the university and forecast its outcomes may vary. For instance, in the period of adaptation to market conditions the following parameters were used to describe ways of development characteristic of that time:

- scale of extensive growth of educational activity (adding new curricula, increase in the number of students and teachers);
- resources provision for academic process (potential opportunities to deliver high quality educational services);
- intensity of non-core (non-academic and non-research) activity;
- financial performance.

The correctness of choice of analyzable parameters for that period of the country's development was proven by a longitudinal study of strategies of Russian higher education institutions (approximately 300 objects within a time frame) conducted in 1998-2005[7,8,20]. The parameters mentioned were employed to develop a multi-dimensional classification. The data used were obtained from official statistics.

Analysis of monographic records from the most remarkable objects (approximately 60 universities throughout the whole period of study) justified the approach as well. However, in the middle of 2000s the number of managerial decisions based on those parameters began to decrease[20].. Non-core operations and extensive growth made less contribution to financial performance of the universities, whereas research and development, and consulting activities were gradually gaining more impact.

It is therefore suggested to use the following set of metrics at the present stage of development of the Russian system of higher education:

- "Quality of educational services" (K);
- "Level of development of R&D and consulting activities" (N);
- "Image" (I);
- "Financial performance of university" (F).

The first three parameters represent the main requirements of the major categories of stakeholders. Thus, high quality of educational services is relevant for the society on the whole, the state, labor market and prospective students. Due to asymmetry of competence between universities and consumers of their services, image replaces quality of teaching. Secondly, the rise of R&D and consulting activities is important not only for the society, entrepreneurs and business: this sphere gives universities unique competences which are significant for the labor and education market. All parameters including financial performance of university also represent the goals of higher education institutions and their staff.

The last issue to analyze when explaining general approaches to creating the model, seems to be description of structure and sources of data which allow to quantitatively assess the four above-mentioned parameters. This issue will be considered in detail in the next study, as it requires a thorough analysis of Russian legislation and specific research. The same is applied to the methods of calculation of all coefficients used within the model.

4. Predictive model of strategic development of a university

The assumptions, used to create the model shall be presented separately in modules.

4.1. Module 1. Obtaining financial resources

Assumption 1.1. In random year t the overall budget of the university F_t has 3 components: donations from the state budget $F_{m,t}$, tuition fees $F_{k,t}$ and income from research and consultancy $F_{n,t}$. Other sources of funding are not considered in the model.

This assumption rather adequately reflects the real situation. If necessary, it can be weakened by introducing throughout the modelling a free term to consider other undocumented contributions to the university budget.

$$F_t = F_{m,t} + F_{k,t} + F_{n,t} \tag{1}$$

For the first iteration of modeling, Ft is calculated from the base-year data.

Assumption 1.2. The year-to-year variation of the university budget is impacted not only by its performance but also by the changes of social and economic environment in the country. In the model is used the coefficient "c" characterizing economic increase or decrease: for example, in 2008-2009 the GDP growth rate was 7-8%, in 2010 – 4%, in 2011 – 3.7% .

Various scenarios can be suggested for modeling at the present stage: optimistic (5%), guardedly optimistic - 4%, realistic - 3%, guardedly pessimistic- 2%, and pessimistic - 1%. For modelling, the value of this coefficient can be either positive or negative and is divided by 100.

Assumption 1.3. Variations in the amount of state subsidies correspond to changes in GDP.

Assumption 1.4. National economic growth equally impacts all components of the university budget (state funding immediately reaches entities and individuals).

Assumption 1.5. Extensive growth does not take place.

Within these assumptions the forecast value of overall amount of university financial resources is given by the following recursive relation

$$F_{t+1} = F_t\left(1+c\right) + \left(F_{k,t+1} - F_{k,t}\right) + \left(F_{n,t+1} - F_{n,t}\right) \tag{2}$$

The first member of sum gives the value of state funding based on the economic changes in the country, without considering the university performance.

$F_{k,t+1}$ and $F_{n,t+1}$ are forecast values defined during modelling (see below).

The second and the third member of sum give annual variations (increase or decrease) of finance obtained by the university through delivering educational services on commercial basis, from R&D, and consulting.

The operations of substitution and reforming in formulae (1) and (2) give

$$F_{t+1} = F_{m,t}\left(1+c\right)+c(F_{k,t} - F_{n,t}) + F_{k,t+1} - F_{n,t+1} \quad (2')$$

4.2. Module 2. Use of finance (ongoing operations and development)

Assumption 2.1. All finance available in the current year is spent on ongoing operations $P_{const,t}$ and development $P_{var,t}$. The model does not consider carryovers, debt payments, etc.

$$P_{const,t} + P_{var,t} = F_t \quad \forall t \quad (3)$$

Then

$$P_{const,t} = bF_t \ , P_{var,t} = \left(1-b\right)F_t, \ 0 \le b \le 1 \quad (4)$$

The coefficient "*b*" is the first endogenous variable describing the operational - development funds ratio.

The equation (4) uses Assumption 2.2, which states that the ratio is constant through the whole modelling.

To design various scenarios of the university development the marginal and tentative values of the operational - development funds ratio may be defined by expertise basing on the current performance of the university. For instance, the coefficient "b" may be graded as follows:

- maintenance of the existing ratio;
- predominance of current expenses (the proportion of current expenses increases by 50% of the marginal value, the proportion of development funds decreases accordingly);
- dramatic predominance of current expenses (the proportion of current expenses reaches the marginal value);
- predominance of development interests;
- dramatic predominance of development interests.

4.3. Module 3. Distribution of finance among the most important development axes

Assumption 3.1. This assumption considers only the basic characteristics of the model: enhancing the quality of education and supporting the development of science. At the same time the assumption does not include the image parameter, as it is believed it can be neglected because the image is built on the quality of education and development of science. Besides, these expenses can be accounted for ongoing operations.

$$P_{var,t} = P_{k,t} + P_{n,t} \ , \qquad \forall t \ , \quad (5)$$

where

- $P_{k,t}$ - the finance spent on enhancing the quality of education (rewarding the best teachers, training, purchasing new equipment, information databases, courseware) in the year under consideration.
- $P_{n,t}$ - the finance spent on developing science in the year under consideration. For NRU HSE, it includes rewarding teachers for research, grants for research projects, scientific mobility.

The second endogenous variable is the ratio between these two segments of expenditure which is characterized by the "*a*" coefficient «*a*» ($0 \leqslant a \leqslant 1$).

For instance, in the Nizhny Novgorod campus of NRU HSE nearly 35% of the development budget is spent on science, and 65% on enhancing the quality of education, respectively. Similar to the previous case, several scenarios are possible: maintaining the existing ratio, predominant or dramatically predominant development of each axis. In the case of a scenario with "dramatically predominant" development trajectory it is possible to use the marginal value of "*a*" for calculation; in the case of a "predominant" one – its half.

$$P_{k,t} = a\,P_{var,t}$$
$$P_{n,t} = (1-a)\,P_{var,t} \tag{6}$$

4.4. Module 4. Dependence: results of university development along various axes and the investments.

Assumption 4.1. Scientific development and quality of education in the next year are linearly dependent on the analogous values in the previous year and investment:

$$N_{t+1} = eP_{n,t} + N_t \tag{7}$$

$$K_{t+1} = dP_{k,t} + K_t \tag{8}$$

where

- N – scientific development;
- K – quality of education;
- e and d – respective coefficients of growth of the parameters depending on the amount of investment.

To calculate "e", which characterizes the "scientific development" elasticity of investment, for a university it is suggested to average the ratio

$$\frac{scientific\ development\ in\ the\ year\ t}{(investment\ into\ scientific\ development\ in\ the\ year\ t-1)} \tag{9}$$

through the previous several years.

The same approach may be applied in the case of "d", which characterizes the "quality of education" elasticity of investment.

Assumption 4.2. The image of the university depends on its performance in the previous several years.

Assumption 4.3. Education being the core activity for the majority of universities, it may be suggested that the image of a university is defined by the quality of education.

Inaccuracies caused by using the Assumptions 4.2 and 4.3. may be partially compensated by introducing into the equation (10) a free term $\Delta 1$, with a constant value for the whole process of modelling. This quantity allows to consider the so-called "borrowed branding" built from collaboration with high status structures, world leading scholars and teachers.

$$I_{t+1} = \frac{f \bullet (K_t + K_{t-1} + K_{t-2})}{3} + \Delta 1 \tag{10}$$

where

I - image;

f – coefficient defining the impact of quality of education on the image of the university.

The equation (10) allows to consider the image – quality of education lag and the significant inertia of the university's image. Undoubtedly, the real period of building or destroying a university's image is considerably longer than 3 years used in the calculations. In the Soviet period it was considered that regardless of a university's success the opinion of prospective students did not change within a generation. Parents decided where their children should study or gave recommendations basing on the information from their young years. However, at present may be observed faster image change, due to higher openness of universities and dependence between planned career path and the choice of universities by students.

When modeling, in (10) is first used the data for one year, then for two years, and so on.

4.5. Module 5. Dependence: finance obtained from each sphere of activity and their performance

Assumption 5.1. The number of fee-paying students is linearly dependent on the image of the university in the previous year. Other factors influencing this parameter are characterized by a free term Δ2 with a constant value for the whole modelling.

Finance obtained from tuition fees consists of two parts: fees by the current and previous year enrollees:

$$F_{k,t+2} = S\left(gI_{t+1} + \Delta 2\right)0,25 + F_{k,t+1}\,0,75 \tag{11}$$

where

- S – average fee for one year;
- g – coefficient defining the impact of the university image on the number of fee-paying students.

The formula (11) is developed for 4-year bachelor's programmes. Multiplying the first and the second term by the coefficients 0,2 and 0,8 respectively, it is possible to calculate the approximate ratio between the finance obtained from new students and those who entered the university in the previous years. Extensive activities: introducing new educational programmes, increase in the number of state-funded students, change in tuition fees are not considered in the model. Besides, the formula (11) does not consider drop-out and transfer students.

In the case of 2-year master programmes, the inertia of finance obtained from tuition is significantly lower; both term coefficients equal 0,5.

When modelling, the ratio between finance obtained from tuition fees from "new" and "old" admissions can be deduced from analysis of the university's activity.

Assumption 5.2. Finance brought by R&D and consulting is linearly dependent on their intensity. Consequently, other factors including the quality of education and image are not considered.

$$F_{n,t+2} = h\left(N_{t+1} - N_t\right) + F_{n,t+1} \tag{12}$$

where

N_t – scale/intensity of R&D and consulting in the year t;

h – coefficient characterizing dependence of obtained finance from the intensity of R&D and consulting.

5. Conclusion

At the time of writing the present paper the methods of assessing the four basic parameters ("Quality of educational services", "Level of development of R&D and consulting activities", "Image", "Financial performance of university"). Moreover, in the campus of NRU HSE in Nizhny Novgorod were collected the data necessary to evaluate the values of parameters during the previous years. The methods of assessing the coefficients are being developed.

The model shall be verified as follows:

- the anticipated results obtained through the modelling process shall be compared with the real data from the HSE campus in Nizhniy Novgorod;
- calculating values of the coefficients used in the model;
- adjusting the character of time dependence for each of the four basic parameters of the model;
- adjusting the relationships between these parameters;

After the model is verified, it will be used to forecast the options of development for the campus in Nizhniy Novgorod. These options are supposed to be primarily impacted by such external factors as socio-economic changes and change in the amount of finance allocated to education. Other endogenuous factors to be considered are internal

decisions on how to distribute the budget between day-to-day activities and future development, or between research and education. The latter could help to identify the most appropriate strategy for the development of the country.

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