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Scientific and Methodical Bases of Formations of Indicator System of Innovative Potential Assessment of Higher Educational Institutions

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Abstract: Scientific and methodical bases of innovative assessment potentiality of a higher educational institution are indicated. The assessment of innovative potentiality is closely linked to commercialization issues of scientific and technical results activities of Russian higher education institutions. The transfer development of knowledge and technologies, commercialisation results of scientific and technical activities of higher educational institutions and scientific organizations, the degree of their discoveries and utilisations not only do not satisfy, but also don't correspond to the current state of Russian national economy.

Key words: Innovative potential · Higher institution · Results of scientific and technical activities of higher educational institutions · Commercialization · Transfer · Knowledge and technologies markets

INTRODUCTION

One of the main strategic directions of development of the higher educational institution of Russia is the formation and development of innovative potentials based on activisation of innovative activities of higher educational institutions in various spheres. The increase of innovative activities of higher educational institutions is linked to a number of tendencies and challenges of the last decades concerning Russian education as a social significant element of the national economy. This includes the modernisation and economic diversification; increased competitiveness among higher educational institutions in the knowledge and technologies markets; understanding of the new role of higher educational institutions not only as centers of advanced science and education, but also as the most important subjects of innovative activities capable of self-development and focused on the commercialisation of scientific and technical results activities by means of introduction into the markets of the scientifically based competitive production [1, p.4-5].

Under these conditions, the accumulated innovative potentials by higher educational institutions in the last decades require restructuring; the strategic analysis and expeditious monitoring for priority innovative management solutions of the following by the higher educational institution:

- Identification and structuring of resource management which includes: innovations in educational, research, administrative and managerial fields of activities of higher the educational institution; innovative programs and projects; resource provision to innovative activities; results of scientific and technical activities (RSTA) of the higher educational institution.
- The creation of criteria system of indicators of innovative potential, assessment indicators and ways of their determination as bases of information acquisition for rational decision making in the field of innovative policy and development strategy of the higher educational institution.

For the assessment of such complex, multidimensional phenomenon as innovative potentiality of higher educational institution (IPHEI) it is necessary to introduce aggregate indicators into the activities, necessary for full research, development and utilisation. Such indicators are divided into three groups: statistical

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(calculation), analytical (assessment and estimation) and rating (expert) according to innovative productivity activity, knowledge and ideas generation, management and provision [2, p.63].

Methodology (Technique)

1st stage: There is a financial resources sufficiency assessment of the higher educational institution for effective innovative activity provision on the basis of technique adaptation of assessment of financial stability of the organization [3, p.27-28], which characterises the economic ability of the subject to provide financial resources to the innovative process. The indicators characterizing ability of higher education institution to provide innovative process by own current assets or own current assets and the long-term credits, or own current assets, the long-term and short-term credits are analyzed. In determining the IPHEI, it is possible to use also a three-dimensional (three-component) indicator [4, p.60 - 62]:

$$S = \{Sl(xl), S2(x2). S3(x3)j. <\text{where } xl = \pm Mc, x2 = \pm Md. x3 = \pm M_K., \quad (1)$$

where Mc, Md, M_K respectively are the sources of IPHEI formation depending on the availability of personal resources, turn-over assets, short-term and long-term loans; personal turn-over funds. The functional equation S (x): S (x) = I, if x>0; S (x) = 0, if x < 0

On the basis of analysis of indicators characterizing financial stability, it is possible to determine the IPHEI main types. Taking into account the defined functional equation of S (x), it is possible to determine four IPHEI main types – high (absolute), above average (normal), average (unstable), low (critical), which permit the possibility to answer the question: how effectively does the higher educational institution utilise financial resources for innovative development. If the level of innovative potentials of higher educational institution is high or average for financial security innovative activity and utilisation of innovative strategy development of higher educational institution, then the second analysis stage and assessment of innovative potentiality makes sense and can be carried out.

2nd stage: The integrated assessment of IPHEI based on the determination of an innovative component in all types and activities of higher education institution is carried out. Based on of the allocated areas-products, functional, resource, administrative and organizational, the system of the aggregated indicators on components of innovative potentiality of the higher educational institution, characterizing the potential of each area and direction [5, p.189-192] is formed. All indicators depict the nonlinear dynamic model of IPHEI on the corresponding subsystems.

In our opinion, the list of indicators of IPHEI assessment in practice can change, be supplemented depending on the purposes of the analysis and the availability of necessary information as specified by the most effective directions of innovative activity, revealing the internal potentials and lapses (Table 1).

The integral level of innovative potentials of higher education institution is described in this formula:

$$\text{IPHEI}_{\text{IPV}} = (PTN_{\text{Prod.sec}} + PTN_{\text{Res..sect.}} + PTN_{Funct.sect.} + PTN_{\text{manag..sect.}} + PTN_{\text{Org.sect.}}) \times M \quad (2),$$

where $PTN_{\text{Prod.sec}}$ is the production potential section;
$PTN_{\text{Res..sect}}$ – resource is the resource potential section;
$PTN_{Funct.sect}$ – function is the functional potential section;
$PTN_{\text{manag..sect.}}$ – management is the administrative potential ection;
$PTN_{\text{Org.sect}}$ – organisation is the organizational potential section;

M is the synergetic multiplicator effect from the innovative assets unification of the innovative infrastructure of the higher educational institution. All the indexes are calculated using the following formulae:

$$J_R = \frac{\sum_{i=1}^{k} a_i R_i}{k} \quad (3)$$

where a_i – weight i- indicator; R_i – assessment i-indicator; k – quantity of indicator assessment.

Similarly all the block elements of innovative potentiality of higher educational institution are calculated. The aggregate local components are made in a linear form. To ensure compatibility and harmony of local components there is a maximum balancing of a set of compared values of the higher educational institutions.

The characteristics of product and functional spheres act as a basic assessment for the higher educational institution which affords the evaluation of scientific and technical product (services) levels etc. The analysis of other spheres is necessary in case there could be some favourable opportunities for environment (competition organisation of projects, grants, investments, tax benefits, etc.) or there are negative

Table 1: Complex system of indicators of assessment innovative potentials of higher educational institution

No	Assessment directions	indexes	indicators
	Nutritious sphere (potential)	$PTN_{\text{Prod.sect}}$	
1.	Innovative activities	J_I	30
2.	Educational activities	J_O	11
3.	Scientific and Research -(SaROKR) activities	$J_{N\,I}$	14
4.	Production activities	J_{PR}	16
5.	Training of specialists for the innovative economy	J_C	10
	Resources sphere (potential)	$PTN_{\text{Res.sect.}}$	
6.	Innovative activities personnel	J_{PER}	12
7.	Material and technical resources/logistics	J_{MT}	14
8.	Finance (investment, budget)	J_F	38
9.	Information base of innovative activities.	J_{IB}	12
	Functional sphere (potential)	$PTN_{\text{func. block}}$	
10.	Objects of intellectual property	J_{OIS}	19
11.	Marketing provision of innovative activities.	J_M	27
12.	Tax mechanism of innovative activities.	J_N	16
13.	Legal mechanism of innovative activities	J_P	11
	Management sphere (potential)	$PTN_{\text{Manag.block}}$	
14.	Administrative activities	J_A	13
15.	Management activities	J_U	12
16.	Social Support	J_S	16
	Organisational sphere (potential)	$PTN_{\text{org. block}}$	
17.	Organisational structure	J_{ORG}	8
18.	Innovative infrastructure (of institution and region)	J_{InInf}	13
		$J_{N,}$	292

indications processes, for example, throughout a period of years practically when there is no new production or the level is very minimal.

The production sphere shows how far the higher educational institution "is accustomed" to upradings and changes and whether the innovative activities are purposeful and systematic in character.

The functional sphere determines the innovative marketing opportunities, research and development and production, their interaction efficiency in the higher educational institution. It is possible to note some value characteristics of this sphere: readiness level and radical degree, preliminary result assessment, positive result probability, etc.

The resource sphere determines the availability of various resources for creation and utilisation of innovations.

The administrative sphere determines the efficiency activity of heads of all management level processes of the creation and utilisation of innovations. The criterion of administrative sphere efficiency of innovative potential corresponds to its strategic importance reflected in the planning systems of the higher educational institution management and also the possibility of its utilisation regardless of time span of the development plans, i.e. the possibility of amendments to the adopted and/or functioning plans for the purpose of innovation utilisations.

The organizational sphere is characterized by complying with the organizational structure of the innovative purposes, tasks, strategy. The favourable precondition for the development character of innovative activities and the manifestation of the organizational structures of the enterprise is its flexibility. In fact the innovative requirements to the higher educational institution organizational structure are:

- The possibility of organising temporary weak structured innovative teams (including staff of various divisions of higher educational institution) at the early development stage of an innovation;
- The availability of organizational mechanism within the firm "institutionalization" of innovative teams in case of successful achievement of the early stage development by them;
- The availability of special research divisions of innovative activities defines the organizational status;
- The availability of effective motivation and stimulation mechanism corresponding to the innovative activities and divisions and staff support of higher educational institution.

Thus, the importance of the organisational and administrative spheres of innovative potentiality consists not only in the elimination internal of organisational

bureaucratic obstacles in the development and utilisation of innovations, but also in the organisational stimulation and development conditions of innovative processes.

In the evaluation of IPHEI, the assessment should, besides personnel, educational, research, administrative and managerial, financial, information, material, intellectual; include also production, marketing, investment, tax, financial and legal, infrastructure, social and regional components.

For more profound assessment of productive, resource and administrative spheres coordinating among them financial and non-financial parameters, it is possible to apply one the system methods [6, p.71-79] - System of Balanced Indicators (SBI-Balanced ScoreCard, BSC). Using the SBI in respect to higher educational institution it is necessary to consider it not only as operational evaluative system, but more as the instrument of strategic management of IPHEI during the formation and utilisation of innovative strategy of the higher educational institution.

Each of the components given in the table is estimated by group of indicators from ten to thirty indicators. Therefore the complete assessment of IPHEI consists of 292 indicators which can be described by the corresponding imitation model. All the 292 indicators describe the IPHEI non-linear dynamic model in the resource provision, operation, controlled, scientific and productive subsystems.

3rdstage: The expert assessment of innovative potentiality is carried out by means of decomposition methods of the analysis of hierarchies. This method of hierarchical representation of a problem to a greater extent meets the requirements of universality, a multi-criteria assessment of choice under uncertainty conditions from a discrete or a set of continuous variety of alternatives and also the preparation simplicity and processing of expert information which rather contains a large number of uncertainties when there is qualitative information on the preferences and quantity about consequences. The decomposition hierarchy of assessment of innovative potentiality of the higher educational institution is formed on the basis of the description of dynamic judgements of experts in the innovative potentiality of the higher educational institution in the form of functions. These functions reflect intuitive feelings of the person making decisions on change in the trend: constant, linear, logarithmic and exponential, increasing to maximum and decreasing to minimum and increasing, fluctuation and finally, allowing catastrophic changes.

In practice, all issues concerning the assessment of IPHEI quantitatively (drastically) and transitively (serially) are uniformly (coherently) broken since human feelings can't be expressed in a concrete formula. Hierarchical synthesis is used for personal balanced vectors of matrices of comparisons of alternatives through criteria (elements) which are available in hierarchy and also for sum evaluation of all corresponding components of personal vectors of underlying hierarchical level [7, p.112]. Further the uniform evaluation has to done of all hierarchies by summing up indicators of all uniform levels through "comparison" to the first hierarchical level. The number of steps of algorithm is determined by the uniform calculation of concrete hierarchy. To solve the problem of comparison and assessment of alternatives in the indicated situations, the alternative comparison method of standards is the most useful. The standard establishes the criterion for quality object level.

4thstage: At this stage, the assessment of innovative potentials of higher educational institution is carried out by a private assessment of the capability of the higher educational institution to implement a new innovative project and integrated assessment into the current conditions of the higher educational institution involving all or a group of on-going innovative projects. In traditional sense the feasibility of the innovative project is its major priority which underlines the possibility of the most effective solution to complex financial, scientific and technical, design, production and technological and organizational and administrative tasks in ensuring the creation of new production or provision of services requiring scientific and technical quality, volume and terms and conditions of limited resource and the forecast period of project implementation.

One of the most widespread methods of multiple-factor assessment is the method of mathematical statistics, particularly the method of multiple correlation meant for the solution of qualitative measurement problems of diverse criteria and the combination of all data into one generalised indicator which involves the cluster analysis method of mathematical theory of image recognition [8].

The assessment of innovative project feasibility is carried out taking into account the prospects and dynamics of its development. Meanwhile it is necessary to consider the existing restricted limitations: for example, scarce raw materials and resources, qualified personnel, minimum production development cycle. The degree of

difference between them or the degree of strictness in the performance of financial policy of the innovative project is determined by subjective and objective factors.

5thstage: At the final stage the evaluation and assessment of an integral index of development of IPHEI as a whole are carried out which allows the possibility to investigate its resource provision condition and dynamics.

The main requirements of the creation of integrated criterion of assessment of IPHEI are so formulated.

- The integral criterion of IPHEI has to provide the assessment of the end results of the innovative processes efficiency in the higher educational institution.
- The integral criterion of IPHEI has to "develop" its local criteria hierarchy (pyramid), leaving to the acquisition of final complete system of criteria of innovation of the higher educational institution.
- The integral criterion of IPHEI has to define the directions (sector) of its growth through the impact of structural elements in the equation formula.
- The structure of integral criterion of IPHEI has to be varied, "through", involving at the same time different levels: high school, regional and as well as the higher school.

The integral level (index) of the innovative potential of the higher educational institution is defined this formula:

$$J = J_R \cdot J_H \cdot J_M \cdot J_F \cdot J \cdot J_N \cdot J_S \ \ldots\ldots J_{N,} \qquad (4)$$

where J_R – regional innovative infrastructure index;
J_H – index of personnel provision of innovative activities; scientific and technical equipment quality of the organisation;
J_M – index of material and technical provision of innovative activities;
J_F – Financial provision of innovative activities index;
$J_{A\dot{O}}$ – Administrative management activities index;
J_N – Scientific - Research) activities index;
J_S – index of social support of innovative activities etc.

All evaluation indexes formulae:

$$J_R = \frac{\sum_{i=1}^{k} a_i R_i}{k}, \qquad (5)$$

where a_i – weight i- criterion; R_i – assessment i- criterion; k – quantitative criterion assessment

In this way all the component factors of innovative potentials of the higher educational institution are calculated. The local components aggregation is made in a linear form. To ensure the compatibility and harmony of the local components maximum values of the indicators of the higher educational institution have been provided. Further the adoptive comparison of the importance of the criteria values within each private set of various structures has been carried out.

The integral index of innovative potential of the higher educational institution is determined by the basic mode importance. The list of the innovative potential indicators for analysis and assessment of the higher educational institution in practice can be change, amended depending on the purpose of analysis, availability of necessary information, type of higher educational institution, etc. The analysis of innovative potentials specifies the most effective directions of innovative activity and determine the optimum innovative strategy.

CONCLUSION

In essence, the assessment of innovative potentials gives not only the statistics (fixed) characteristics of innovative activities of the higher educational institution, but also affords the opportunities for detailed strategic innovative analysis and perspective goal achievements. The ideas of innovative potentials in accordance with the achieved innovative activity results is the reasonable basis of choice and definition of innovative strategy of the higher educational institution. Thus, the assessment of innovative potentials of the higher educational institution is the relevance and major task in modern conditions due to the necessary formation of innovative strategy of the higher educational institution and determination of its market prospect.

The presented integral approach can be used for the assessment of the accumulated innovative potentials at all levels. In this case, it is necessary to predict as the determined innovative projects will affect IPHEI change as a whole. Thus, based on the assessment of innovative potentials, as a matter of fact, it is necessary to estimate (to forecast) the level of future gain of innovation in the economy. The methodical tools for evaluation can as well be used in the same way as for the levels assessment. The formal description of the given methods allows the automation procedures and calculations for the assessment of the defined innovative project on the basis

of MATLAB system using the Fuzzy Logic Toolbox approach package[9] and to conduct multiple researches of various resource levels of IPHEI within optimal period.

It should be noted that for further study of technique of assessment of IPHEI there are still unresolved problems. Until recently, the higher educational institutions didn't focus their attention on obtaining income from innovative activities therefore the allocation of innovative component in the results of educational, research and financial and economic activities of the higher educational institution was a complex challenge. In statistical data and the common standard report reflecting the economic development, the innovative component of the higher educational institutions hasn't been defined. This fact created an important problem since it is impossible to operate without a defined object. The essence of innovative activity not meant to obtain applied scientific and technical results. The result of innovative processes is the product, service or technology, that brings income on constant basis in the form of sales, commercialisation of objects of intellectual property, management of portfolio securities of the innovative enterprises, attraction of investments venture and other activities consisting the innovative business. Therefore the higher educational institutions seek to diversify the innovative activities [10, p.33-35].

CONCLUSIONS

- The innovative potentials of the higher educational institution is part of its all other potentials, accumulating (mobilizing) the most modern, new and creative qualities of the potentialities of various spheres and kinds of activities. It is important in the definition of innovative potentials concept of the higher educational institution, its proportion and ratio compared with other potentials. Each of them has a wider innovative potential concept of the higher educational institution.
- The detailed analysis and assessment of innovative potential of the higher educational institution requires the application of non-linear dynamic model representing the whole scientific, management and operational multi layered complex subsystems.
- A block and modular structure of innovative potential and its relevant indicators system of assessment have been offered. Based on the allocated blocks - products, functional, resources, managerial and organisational are the system of integral indicators of the innovative potential components of the higher educational institution, characterising the potentials of its each element. All the indicators describe non-linear dynamic model of innovative potential of the higher educational institution provided by scientific, managerial and operational subsystems.
- The methodical approaches and practical recommendations about modelling of innovative potentials of the higher educational institution using neuronic methods and algorithms on the basis of multi indistinctive sets developed for decision-making support on management of innovative potential of the higher educational institution using the program Fuzzy Expert complex and a Fuzzy Logic Toolbox package in computerised module, developed on the basis of MATLAB system
- The presented integral approach can be used for the assessment of the accumulated innovative potentials at all levels. The author notes that the presented list of indicators is in-exhaustive, when necessary it will be possible to change their quantity and functional orientation.

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