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DEVISING AN INDIVIDUALLY ORIENTED METHOD FOR SELECTION OF SCIENTIFIC ACTIVITY SUBJECTS FOR IMPLEMENTING SCIENTIFIC PROJECTS BASED ON SCIENTOMETRIC ANALYSIS

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The main factors influencing the choice of individual subjects of the scientific activity or potential partners and executors for scientific and educational projects were analyzed. The specific features of choosing project executors of different categories were indicated. The functional responsibilities of project participants in accordance with the project structure were described.

The individually oriented method for choosing subjects of scientific activity as executors of scientific and educational projects was developed, taking into account the productivity of their scientific activities in the past and considering the structure of projects. To determine the merits of the subjects of scientific activity, which are included in the relevant scientific subject spaces, it is necessary to apply the procedure of their productivity assessment. In addition, it is necessary to predict a change in productivity in the future based on retrospective data for this subject. Next, it is required to solve the multi-criteria problem of the choice among the subjects of scientific activity who are quite productive in the opinion of the project manager. The use of the developed method reduces the subjective impact on making a decision regarding the choice of project executors. This is due to the fact that they are chosen by automated calculation of scientometric indicators of subjects, guided only by open sources of information.

The individually oriented method for the selection of subjects of scientific activity was verified on the example of the formation of three applications of research projects. As a result, the average percentage of scientists who meet the requirements of project managers for each scientific subject space was about 46.55 %. The percentage of those involved in the project from those who were selected is about 24.07 %. The probability of cooperation is higher among those who have an average H-index

Keywords: subject of scientific activity, scientometric analysis, scientific project, multicriterial problem of choice

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1. Introduction

The key prerequisite for ensuring scientific and technological progress is the creation of conditions for the functioning of the concept of open innovations [1]. This involves external partners, executors, experts, etc. in research and educational projects. The association of the best scientists, project managers, technical workers within the framework of an innovative project is the key to obtaining a high-quality result that can compete in the world of developments [2]. However, ensuring the concept of open innovations is hindered by the lack of the theoretical and practical basis for the formal selection of partners for a project in general, as well as for its components. Formal descriptions of the problem are insufficient. Often, partners and executors are chosen based on expediency and in accordance with the personal subjective preferences of a project manager [2]. Often, no scientifically substantiated conclusions on the expediency of choosing a particular executor are made or they are made in view of subjective assessments. It should be understood that in order to select partners, it is necessary to take into consideration their competencies, possible contribution to the implementation of the project stages, in particular, scientific, technical, legislative, administrative, etc. The choice of partners often takes into consideration new or basic knowledge that these partners possess. The relevant problem is to highlight the conditions that would specify the factors of selection of partners with different competencies for the implementation of different stages of a project and taking into consideration the level of knowledge. It is also necessary to highlight special types of project executors: individual subjects of scientific activity, that is, researchers and collective subjects of scientific activity (higher education institutions, research institutes, etc.). This is proved in paper [2], which proposed the concept of open innovations in science (OIS), which implies the application of open and joint practices during the process of creating and disseminating new scientific ideas.

A relevant task is to develop an individually oriented method for choosing subjects of the scientific activity or scientific partners, taking into account the project structure, considering their productivity in the project area in the past. This will make it possible to form scientifically based rational conclusions on the selection of a partner for the formation of project groups at different stages of a scientific or an educational project. The relevance of the development of this method is proved by the insufficient theoretical and practical basis for solving the problem of choosing partners, taking into consideration a complex structure of scientific projects in certain scientific subject space. In particular, paper [3] describes the system of selection of a scientist, taking into consideration scientometric indicators of the Scopus base using the weighed influence of a scientist in a particular field of knowledge. The use of scientometric indicators makes it possible to take into consideration the dynamics of scientists' productivity in specified subject space. The development of a scheme of interaction between project participants and the description of the factors that determine the choice of partners will ensure the possibility of choosing those scientific partners or subjects of scientific activity that will enhance the project effectiveness and quality in general.

2. Literature review and problem statement

The task of choosing partners for cooperation or project executors is well-known and relies mainly on the creation of matrices of advantages and competencies using multicriteria decision-making methods. In particular, paper [4] describes the mechanisms of development and erosion of competencies in an innovative project. The method of hierarchy analysis for selecting a project executor based on multicriterial solutions was proposed in research [5]. Specifically, paper [6] describes the process of choosing partners for the activities of companies. Paper [7] shows that the impact on the choice of partners for joint activities depends on factor analysis. The optimization model using the genetic algorithm for selecting partners is described in research [8]. The hybrid algorithm was developed in article [9] to optimize the problem of choosing a partner, which is more effective than the genetic algorithm by a numerical experiment. However, papers [5 9] do not take into consideration complex network relations between partners (competition, cooperation, etc.). Paper [10] describes the approaches to calculating the importance of a partner, which affects ensuring proper reputation and evaluation of the activities of companies. Research [11] describes how the network structure of relations between partners is taken into account. The structure of the network, self-organization, and growth of international cooperation in science are factors influencing the choice of a partner for cooperation, which are described in paper [12]. Article [13] describes the impact on the importance of a partner based on the existence of a network of hub connections. Paper [14] describes the PageRank approach to assess the importance of cooperation network nodes and, accordingly, the importance of a partner. The PageRank method with the use of topics is described in research [15]. However, in order to select subjects of scientific activity, in addition to taking into account the links between scientists in the form of a network of citation and cooperation, it is necessary to consider the dynamics of the productivity of scientific activity, which is not explored in papers [13–15]. Paper [16] considers performance estimates as a tool for selecting partners, but without taking dynamics into consideration.

The use of mathematical methods for selecting project executors relates mainly to fuzzy mathematics and fuzzy logical output [17]. The task of choosing partners for a virtual enterprise using fuzzy logic is described in study [18]. Paper [19] describes the fuzzy method for selecting scientific partners. Paper [20] proposes a model for choosing a scientific partner based on multifactor decision-making with the construction of an interval-valued intuitionistic fuzzy set. However, in studies [17–20], the structure of the project is not taken into consideration when choosing partners.

The choice of project executors aims to evaluate competencies that meet the project goals and satisfy a project manager who is responsible for achieving the right result. Research [21] describes the competencies and qualifications that a project executor must possess. Decision-making on the promotion of innovative projects is closely related to the competencies of the existing project team [22], determining which can be automated in the relevant information system, which is described in research [23]. Papers [21 23] examine the project management approaches to the choice of executors. However, the emphasis is not placed on the fact that project executors or partners have their own dynamic information space, and subjects of scientific activity have informational scientific space. The method for the formation of information space of subjects of scientific activity is described in research [24].

The dynamics of productivity of subjects of scientific activity is evaluated based on analysis of time series, the levels of which reflect performance estimates. Paper [25] points out that such series can be self-similar, and therefore fractal analysis can be used for their research and forecasting. The model of evaluation of executors based on the expert approach is described in paper [26]. Research [27] describes information technology, and article [28] deals with the development of methods for predicting time series, taking into consideration expert opinion with modifications taking into consideration the external impact on the time series.

The neural network apparatus is also used to find scientific partners. The system of efficiency indices for the scientific study of collective subjects of scientific activity based on neural networks is proposed in article [29]. The MATLAB software is used to build a neural network in article [30]. It was shown that the proposed method can solve the problem of selecting and evaluating a partner. Cooperation networks for the selection of partners are described in research [31], but the choice of partners when it comes to the structure of a project, for which this task should be solved, is not described. Paper [32] describes the approach of forming a project team, taking into consideration its structure. The formation of interdisciplinary scientific teams is described in article [33]. Paper [34] deals with the computational model of collecting a team in scientific fields. The results of the study show that cooperation probability is higher among those who have a longer tenure, a lower institutional level, a lower H-index, and a higher level of co-authorship and citation. The next step is to build an ecosystem of team interconnection for the common environment described in article [35]. Article [36] describes the comparison of the choice of scientists to carry out research projects according to five criteria. In general, articles pay little attention to the dynamics of performance of potential partners or project executors and do not reveal the complexity of the structure of scientific projects, on which the choice of performers depends. All this makes it possible to assert that it is advisable to conduct a study devoted to the development of an individually oriented method for choosing subjects of scientific activity for the implementation of scientific projects based on scientometric analysis.

3. The aim and objectives of the study

The purpose of this research is to develop an individually oriented method for selecting subjects of scientific activity based on evaluating the productivity of their research activity to form applications for the implementation of scientific and educational projects. This will make it possible to automate and reduce the subjectivity of the process of selecting competent potential project executors, which will improve the quality of project results in general.

To achieve the goal, the following tasks were set:

– to analyze the main factors that determine the choice of potential executors or individual subjects of scientific activity for research projects;

– to determine the significance of the project structure and dynamics of scientific productivity of subjects of scientific activity in the relevant subject spaces;

– to conduct experimental verification of the developed method.

4. Materials and methods of research

The choice of partners or executors for the implementation of a scientific or educational project is often based on the competencies of a potential partner, taking into consideration the structure of a project. This is especially true of technical specialists (programmers, system administrators), coaches/teachers (availability of certificates, professional development in the project module area, experience), administrative personnel (experience in conducting such projects, their final assessments after evaluation). For the executors who must perform scientific research work, the selection process is more complicated and should include the productivity of scientists in the field of a project or the working package of a project. Information about the performance of a potential partner can be represented by a discrete time series of scientometric indicators recorded at certain points of time (quarterly, annually, etc.). The scientist's productivity can be represented by a multidimensional time series for different indicators. In addition, all scientometric indicators of a scientist can aggregate, and then his productivity is displayed in a one-dimensional time series. Information about scientometric indicators is obtained by the method of scraping from Scopus, Web of Science, Google Scholar website, etc. To generate aggregated performance indicators, it is important to understand the relationship of citation between scientists. To do this, a citation network is constructed, the information for which is obtained from the portals of national libraries, sites that contain links to scientific publications and their citations. A network of scientific cooperation is also constructed, which is an important step for the establishment of scientific subject spaces. This is important because they must select potential executors not only by scientific rating but also by rating within the local scientific area, in which executors work. This area should match the scientific part of a project or its corresponding work packages. Scientific subject space is a totality of individual subjects of scientific activity, united according to the criterion of the joint direction of research activities.

An individually oriented method for choosing a potential partner or executor of a scientific project based on decision-making theory, the theory of evaluation and finding advantages, the graph and network theory, was offered. To form the networks of citation and scientific cooperation, a database with publication activity, which is collected from open sources (Google Scholar sites, National Libraries, etc.), is generated. The method is individually oriented because it focuses on the personal assessment of each potential partner or scientist. If a project or its working packages need to involve a collective subject of scientific activity, it is enough to aggregate the estimates of the performance of scientists or individual subjects of scientific activity working at this institution. Expert approach to the problem of choosing potential partners involves experts in evaluation and scientometry.

5. Results of devising the individually oriented method for selection of subjects of scientific activity

5. 1. Analysis of the factors influencing the choice of potential executors for scientific or educational projects

Let us assume that $G=\{G_1,G_2,...,G_n\}$ is the set of scientific and/or educational projects, n is the number of projects. The problem is choosing executors for these projects. Assume that $V=\{v_1,v_2,...,v_t\}$ is the set of potential partners that can be involved in implementing the projects from set G. We believe that potential partners are individual subjects of scientific activity who have articles in the journals indexed in scientometric bases and work at a scientific institution or institution of higher education. Higher education institutions and research institutes are collective subjects of scientific activity. In addition, the productivity of individual subjects of scientific activity, respectively, affects the productivity of collective subjects of scientific activity in general. This problem does not involve a possible subcontractor agreement that may be included in the project application to perform additional tasks by third parties or employees.

The structure of projects implies the availability of working packages $G_i=\left\{g_1^i,g_2^i,\dots g_{r_i}^i\right\}$, r_i is the number of working packages G_i, $i=\overline{1,n}.$ The execution of work packages has time limits and is linked to the Gantt chart of the entire project. Each work package is related to the results or complements other project packages and relates to a specific task or tasks (scientific, administrative, technical, educational, etc.). For each package, it is necessary to choose competent executors who will perform it at a high level. The overall assessment of the quality of the entire project depends on it. That is, the problem is to find a set of potential executors or subjects of scientific activity for each working package of each project:

$$\Theta\left(g_j^i\right)=\left\{v_d\in V\left|\left(v_d,g_j^i\right)\in Q^i\right.\right\},\ \ Q^i\subset V\times G_i,$$

$$j=\overline{1,r_i},\ \ i=\overline{1,n},\ \ d=\overline{1,t},$$

where $\Theta\left(g_j^i\right)$ is the set of executors of the j-th work package of i-th project.

The categories of executors are determined by the features and necessary project outcomes. However, for scientific and educational projects, it is possible to summarize them into the following five categories:

1. Project managers or managers. This category includes project leaders. Their functional duty is to control timely and effective completion of the project work packages, to choose project executors. A manager who performs the task of selecting potential partners is a decision-maker.

2. Administrative workers. This category includes the managerial staff or management of the collective subject of scientific activity. Functional responsibilities of this category include signing memorandums, ensuring document flow, and documentary coordination of cooperation between other collective subjects of scientific activity and stakeholder organizations. When choosing a collective subject of scientific activity for the project team, the administrative staff is appointed from experienced employees with experience in the implementation of such projects.

3. Technical specialists. This category includes programmers, system administrators, who should ensure the operation of servers, equipment, and special setups. This is determined by the tasks of a project. The criterion for the selection of such employees is the availability of appropriate competencies, certification, experience, etc.

4. Teachers and trainers. This category of employees primarily concerns educational projects and is formed from certified scientific and pedagogical staff of the collective subject of scientific activity. Selection to this category is carried out depending on the goals of a project and its work packages, the ability to use educational platforms, available qualification documents, etc.

5. Scientific research workers. The staff of the previous categories of executors can be formed relatively simply if there are appropriate competencies. The criteria for such selection are transparent and often do not require automation. In the case of the choice of research workers or individual subjects of scientific activity, it is not possible to do without assessing the productivity of their scientific activity. This directly affects the quality of the results of the entire project. Researchers play a key role in formal description, research, laboratory testing, and description of conclusions. The choice of scientists is determined by the tasks of each working package and must correspond to the scientific subject space, in which a potential executor works.

Thus, the choice of potential partners or executors of a scientific or educational project depends on the tasks of work packages, categories of executors to be involved, their competencies, performance, etc. In the case of choosing individual subjects of scientific activity, this problem is complex and multi-level. To solve it, the paper proposes the individually oriented method for choosing scientific partners (project executors), taking into account the project structure and considering the productivity of their scientific activities in the past, as well as the forecast for assessing productivity in the future.

5. 2. Establishment of the significance of the project structure and dynamics of scientific productivity in the relevant subject spaces for selection of subjects of scientific activity

Designate as $\varphi_k^j = \Phi\left(v_j, \tau_k\right)$ the estimate of productivity of an individual subject of scientific activity v_j at moment τ_k, $j=\overline{1,t}$, $k=\overline{1,T}$. A performance estimate is an aggregated indicator of the effectiveness of a subject of scientific activity, which may include the H-index in the relevant scientometric databases, the number of articles, the number of citations, etc.

Performance estimates of each individual subject of scientific activity are recorded at certain moments of time (monthly, quarterly, annually). Then performance is represented by discrete time series: $\left(\varphi_1^j, \varphi_2^j, \ldots \varphi_T^j\right)$, $j=\overline{1,t}$.

Assume that $P=\{P_1, P_2, ..., P_Z\}$ is the set of scientific subject spaces, Z is the number of spaces. Each project can be put in line with scientific subject space, $X:G \to P$. Besides, each work package can be put in line with a certain part of the scientific subject space, which corresponds to the subject matter of local problems of the package. Assume that $H=\{H_1, H_2, ..., H_Y\}$ is the set of collective subjects of scientific activity, in this case

$$\forall v \in V, \ \ \exists z \in [1, Z], \ \ v \in P_z,$$

$$\forall v \in V, \ \ \exists y \in [1, \mathrm{Y}], \ \ v \in H_y.$$

Then assume that

$$P^z = \left\{ j \middle| j \in [1, t], v_j \in P_z \right\},$$

$$H^y = \left\{ j \middle| j \in [1, \mathrm{t}], \mathrm{v}_j \in H_y \right\},$$

where P^z is the set of numbers of individual subjects of scientific activity that belong to the corresponding scientific subject space P_z. H^y is the set of numbers of individual subjects of scientific activity that belong to the corresponding collective subject of scientific activity H^y, $y=\overline{1,\mathrm{Y}}$, $z=\overline{1,\mathrm{Z}}$.

When selecting project executives, it is sometimes necessary to fix the region from which partners are selected. For example, in the projects of the Erasmus+ program, it is important that partner universities should not be represented by one region. It is important that the consortium of partners should include universities from different regions of the country. Given this and the corresponding scientific subject spaces, it is possible to generate the time series of productivity, which includes only the required individual subjects of scientific activity:

$$\left(\varphi_1^j, \varphi_2^j, \ldots \varphi_T^j\right), \ \ j \in P^z \cap H^y.$$

For fixed working place $z \in [1, Z]$ and $y \in [1, Y]$. If a working place of a potential executor is not important, $j \in P^z$.

Assessment of productivity of a subject of scientific activity, which was recorded recently should have more weight than the one that was recorded long ago. Accordingly, to calculate the quantitative estimates of productivity for each individual subject, it is proposed to apply a linearly weighed sliding mean from the following formula:

$$\hat{\varphi}_{T+1}^j = \left(\sum_{m=1}^{p} m\right)^{-1} \cdot \left(\sum_{d=1}^{p} (p-d+1) \cdot \varphi_{T-d+1}^j\right), \ \ j \in P^z \cap H^y, \quad (1)$$

$\hat{\varphi}_{T+1}^j$ is the productivity forecast with horizon 1 for the individual subject of scientific activity v_j, $j \in P^z \cap H^y$, p is the parameter that determines the pre-history period for forecast calculation.

Then the optimal individual subject of scientific activity j^* for project implementation in the area of scientific subject space P^z, which is a staff member of the collective subject of scientific activity H^y is determined from the following formula:

$$j^* = \underset{j \in P^z \cap H^y, \hat{\Delta}_{T+1}^j > 0}{\arg\max} \ \hat{\varphi}_{T+1}^j, \quad (2)$$

where $\hat{\Delta}_{T+1}^{j}=\hat{\varphi}_{T+1}^{j}-\varphi_{T}^{j}$ is the increment in productivity of the individual subject of scientific activity. The subjects, for which an increment is negative, are removed from consideration.

If a potential executor who has proved to be the leader by this criterion does not agree to join the team of executors, the participation offer goes to the potential executor who is the nest by rating. Thus, it is possible to make a sequence of individual subjects of scientific activity with advantages according to criterion (2): $v_{j_1}\succ v_{j_2}\succ\ldots\succ v_{j_r}$, $v_{j_q}\in V$, j_q={1, 2, ..., t}.

If it is necessary to involve a collective subject of scientific activity (university, institute, department, faculty, etc.) to execute a relevant work package, the potential executor is the subject in which v_j works.

If a project manager, in addition to the subjects' productivity of scientific activity, has an additional list of criteria for the selection of executors, it is necessary to solve the multi-critical problem of choice.

For each working package of each project, a list of criteria for the selection of potential executors is generated. The vector of estimates by criteria has the form of:

$$f^{ij}(v_d)=\left(f_1^{ij}(v_d),f_2^{ij}(v_d),\ldots,f_{N_{ij}}^{ij}(v_d)\right),$$

N_{ij} is the number of criteria of an estimation of potential executors of work packages g_j^i of projects G_i, $j=\overline{1,r_i}$, $i=\overline{1,n}$, $f^{ij}(v_d)$ is the vector of estimates for potential executor v_d, $d=\overline{1,t}$.

Maximize all criteria, then state the problem:

$$\sum_{k=1}^{N_{ij}}\alpha_k f_k^{ij}(v)\rightarrow\max,\quad \sum_{k=1}^{N_{ij}}\alpha_k=1,$$

$$V^{ij}=\left\{v\in V\middle|y_u^{ij}(v)\geq\rho_u^{ij},u=\overline{1,z_{ij}},j=\overline{1,r_i},i=\overline{1,n}\right\},$$

$$v\in V^{ij},\quad V^{ij}\subset V,$$

where z_{ij} is the number of threshold values for vector-function of restrictions $y_u^{ij}(v)$, α_k is the value of criterion $f_k^{ij}(v)$, $k=\overline{1,N_{ij}}$, $j=\overline{1,r_i}$, $i=\overline{1,n}$.

Use the method of expert evaluation. Assign the set of experts $E=\{E_1, E_2, \ldots, E_s\}$, s is the number of experts. Experts form the incomplete profile of advantages of potential executors based on the described criteria. Designate as $\xi_{c,b}^{ij}$ the average frequency of appearance of each advantage among potential project executors v_c and v_b, $c\neq b$, $v_c\in V$, $v_b\in V$. Then matrices of advantages Λ^{ij} take the form

$$\Lambda^{ij}=\left\{\xi_{q,w}^{ij}\right\}_{q,w=1}^{t},\quad j=\overline{1,r_i},\quad i=\overline{1,n}.$$

Based on the matrix of pair-wise comparisons Λ^{ij} for each package g_j^i of project G_i, we will generate a collective decision in the form of an orderly list of potential project executors. Using the method for the formation of collective decision, according to the matrix of pair-wise comparisons, it is possible to obtain an orderly list of potential executors for each package g_j^i of Project G_i: $v_{j_1}^{ij}\succ v_{j_2}^{ij}\succ\ldots\succ v_{j_t}^{ij}$, $j_q\in\{1,2,\ldots,t\}$, $v_{j_q}^{ij}\in V^{ij}$, $q=\overline{1,t}$. Next, a project manager selects specific executors and forms a working group for each working package. The project structure and dynamics of scientific productivity of executors in relevant subject spaces are an important aspect of the choice of subjects of scientific activity, which affects the project productivity in general.

5. 3. Experimental verification of the developed method

Verification of the study was carried out at Astana IT University on the example of the formation of applications for scientific research works for 2021. The module consisting of the spiders for scraping the information of international scientometric bases and websites of scientific periodical journals was created. Part of scientometric information was obtained freely to perform scientific research. The database contains information about more than 56 thousand individual subjects of scientific activity and 257 thousand scientific publications and is constantly updated. A set of scientific subject spaces was formed based on cluster analysis of publications of individual subjects of scientific activity and based on latent semantic analysis. Clustering is implemented based on establishing a metric distance between publications of subjects of scientific activity according to the citation graph and taking into consideration the proximity of annotations of scientific publications of subjects of scientific activity using the method of locally sensitive hashing. After clustering publications, the clusters were named and scientific subject spaces were constructed. A total of 211 scientific subject spaces were obtained. 4 scientific subject spaces were selected for three project applications (cluster 1 – Project Development, cluster 2 – Professional Competence, Cluster 3 – Educational Process, Cluster 4 – Scientific Activity). Table 1 shows quantitative indicators obtained as a result of the use of the devised method for selecting executors of three research projects. All actual project executors were included in the list of applicants.

Table 1

Quantitative indicators of application of the individually oriented method for selection of executors of scientific projects

Scientific subject areas	Cluster 1	Cluster 2	Cluster 3	Cluster 4
Number of publications	783	609	1140	505
Total number of scientists in the space	60	41	95	36
Number of scientists who meet selection criteria	30	17	39	22
Number of scientists involved in projects	3	4	10	9
Average position in the orderly list of executors who meet the selection criteria and are actual project executors	22.8	10.9	31.4	16.5
Average position in the orderly list of executors selected by the individually oriented method	19.3	12.5	21.4	13.0
Average position in the orderly list by the CB criterion [36]	18.1	11.2	20.8	13.9
Average position in the orderly list by the QA criterion [36]	19.9	13.6	23.0	13.2

For project applications, the actual project groups were compared with the project groups, which were proposed based on the individually oriented method for selecting the executors of scientific projects. They were compared based on the magnitude of the degree of a project executor belonging to the relevant scientific subject space (clusters 1–4). In accordance with the calculated magnitudes of belonging, a rating list of potential performers was formed.

The position in the orderly list of executors who meet the selection criteria and are involved in projects indicates that the executors with an average rating in clusters take part in projects. The average percentage of scientists who meet the requirements of project managers for each scientific subject space is 46.55 %. The percentage of those involved in a project from those who were selected is 24.07 %. The average position in the orderly list of executors who meet the selection criteria (Table 1) is higher than the value corresponding to randomly selected scientists from scientific subject spaces.

The proposed scientists were compared with actual executors according to the CB and QA criteria described in paper [36] and for which there are enough data. An orderly list of executors was constructed according to the specified criteria and based on the individually oriented method for selecting executors of scientific projects. The use of the developed method makes it possible to obtain a rational list of executors according to all criteria, compared to the projects, in which executors were chosen by another method.

6. Discussing the results of implementing the devised method

To determine the advantages of the subjects that are included in the scientific subject space, it is necessary to apply the procedure for assessing their performance. In addition, to understand the productivity of a subject of scientific activity, it is necessary to understand his place in the scientific subject space and predict a change in productivity in the future based on retrospective performance data for a given subject. Next, it is necessary to solve the multi-critical problem of choice among the subjects of scientific activity that are quite productive (all subjects whose productivity is less than some threshold value are excluded from consideration). The criteria will be the characteristics of the subjects required by a decision-maker. In this regard, a hierarchy and functional responsibilities of project participants are formed. It is important that the method makes it possible to include to a scientific subject area only those individual subjects of scientific activity, which are presented in scientometric databases. The productivity of scientists directly depends on the H-index, the number of articles, citations, etc. That is, some scientists who are not present in the informational scientific space are excluded from consideration.

Consider another limitation of the developed method. Calculation of productivity forecast for (1) is possible only in case of available prehistory of performance estimates for an individual subject of scientific activity at least for p periods. Although the p period may be chosen for (1) no more than 5–7, the individual subjects of scientific activity that have just begun to be published may not get in the list of potential executors. The calculation of productivity of subjects of scientific activity is described in studies [37, 38]. The specific features of management of scientific and educational environments, part of which is the calculation of performance estimates of scientists and higher education institutions, are described in more detail in paper [39].

The use of the devised method decreases subjectivism in choosing potential partners and rationally substantiates the choice based on the criteria that were laid in advance. The participation of experts in solving the problem is minimal, and it is not necessary in the case of using a single criterion of productivity of scientific activity.

It can be summarized that the devised method has advantages in the fact that it is based on an individual assessment of the scientist's performance as a potential project executor. When choosing a collective subject of scientific activity, a key role is played individually by a scientist as a staff member of the relevant establishment or institution, with its dynamics of scientific activity in the relevant scientific subject space. It should be noted that to justify the correctness of the choice of project executors, it is necessary to conduct a guided experiment based on the devised method with a sufficiently large sample of project applications. This must be done taking into consideration two control groups for the applications, in one of which the selection is carried out according to the developed method, and in the other, it is based on the choice of the manager. However, this is a difficult task from the financial and organizational point of view. It is difficult to conduct a comparative analysis with other studies of the selection of project executors due to a different set of projects that are unique, and it makes no sense to re-perform them.

7. Conclusions

1. The main factors that determine the choice of potential executors for scientific and educational projects were analyzed. The functional responsibilities of project participants were described in accordance with the project structure, based on which the problem of choosing scientific partners was solved. The specific features of the selection of project executors of different categories were emphasized. It was indicated that the selection of researchers is associated with difficulties, which should take into consideration the assessment of the productivity of scientific activity over a certain period.

2. The significance of the project structure and dynamics of scientific productivity in relevant subject spaces for the choice of subjects of scientific activity were established. The individually oriented method for choosing scientific partners was devised, taking into consideration the project structure: the choice of executors for each project package separately, in accordance with the estimates of the performance of executors in subject spaces that correspond to the area of the package. The use of the devised method allows reducing the subjective impact on making a decision to choose project executors, guided only by open sources of information with the performance of potential performers, their competence, etc. This approach is rational in terms of achieving maximum quality and effectiveness of the implemented scientific and educational project.

3. According to the results of experimental verification of the individually oriented method of selection of subjects of scientific activity, it was shown that the average percentage of scientists who meet the requirements of project managers for each scientific subject space is about 46.55 %. The percentage of those involved in the project among the selected ones is about 24.07 %. The probability of cooperation is higher among those who have an average H-index. The effectiveness of the selected participants in research projects can be discussed upon their completion or according to the results of reporting. The proposed scientists were compared with actual executors according to three criteria. The use of the devised method makes it possible to get a rational list of executors according to all criteria.

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