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Marinko Skare[a,b,*], Beata Gavurova[c], Volodymyr Polishchuk[d]

[a]*Juraj Dobrila University of Pula, Faculty of Economics and Tourism Dr. Mijo Mirkovic, Zagrebacka 30, 52100, Pula, Croatia*

[b]*University of Economics and Human Sciences in Warsaw, Okopowa 59, 01-043, Warszawa, Poland*

[c]*Faculty of Management and Economics, Tomas Bata University in Zlin, Mostni 5139, 760 01, Zlin, Czech Republic*

[d]*Uzhhorod National University, Faculty of Information Technology, Zankovetska, 89a, 88000, Uzhgorod, Ukraine*

[*]*Corresponding author. Juraj Dobrila University of Pula, Faculty of Economics and Tourism Dr. Mijo Mirkovic, Zagrebacka 30, 52100, Pula, Croatia. E-mail addresses: mskare@unipu.hr (M. Skare), gavurova@utb.cz (B. Gavurova), volodymyr.polishchuk@uzhnu.edu.ua (V. Polishchuk).*

ABSTRACT

The main goal of this study is to develop a fuzzy multicriteria evaluation model of heterogeneous cross-border cooperation projects to ensure sustainable development of neighbouring regions, taking into account the goals of the announced competition and the possibility of avoiding the resource curse. The model allows you to compare projects of cross-border cooperation of different categories, takes into account expert linguistic conclusions on projects, considers the compliance of the challenge project, moves from expert conclusions to quantitative assessments. At the output of the model, we have an aggregated quantitative assessment of the project and a ranking of cross-border projects is built for their selection and financing. The results of the study can be useful for managers of cross-border project tenders, with the aim of improving the validity of supporting decision-making and sustainable development of neighbouring regions through the prism of the curse, both natural and human resources.

Keywords: Cross-border cooperation projects, resource curse, heterogeneous alternatives, fuzzy sets, sustainable development of regions

1. Introduction

Our research is aimed at increasing the level of validity of decisionmaking regarding the selection of the cross-border cooperation projects, based on an innovative fuzzy evaluation model, which takes into account the goals of the announced competition, the possibility of avoiding the resource curse and the sustainable development of regions.

In the recent years, many transformation and integration processes have been taking place in countries, related not only to the geopolitical situation, but also to ecological, epidemiological threats. Economic, business and social disparities are widening, not only between countries, but also within countries. Many processes have defined the dynamics as well as the character of socio-political, economic, social and sociocultural changes with a range of positive but also problematic impacts on society. The ongoing processes do not relate just one country, but are part of a spatial large-scale transformation with a national and international context (**Elías, 2021; Noferini et al., 2020**). Many transformation and integration processes were focused also on finding common, respectively coordinated policies and practices (**Bufon and Markelj, 2010**).

The Agenda 2030 plays a key role in the process of the sustainable development. Education will perform as the crucial point of the specific context related to the multidimensional aspects (**Shulla et al., 2020**). The cross-border collaboration is performed according to the procedures of the European Commission. The documents related to these activities cover many aspects of all the dimensions evaluation. Efficiency of the performed programmes is limited regarding the potential analytical gaps (**Tiganasu et al., 2020**). Environmental responsibility is formulated in each stage of the enterprise life cycle. A chain of inputs-pro-cesses-outputs is carried out through various dimensions. Mechanism of global environmental challenges is based on the responsibility management and it is a key point in every process in this field (**Kasych et al., 2020**).

The main goal of this study is to develop a fuzzy multicriteria evaluation model of heterogeneous projects of cross-border cooperation to ensure the sustainable development of neighbouring regions, taking into account the goals of the announced competition and the possibility of avoiding the resource curse. Another goal of our research will be to draw attention to the implementation of cross-border cooperation projects with the aim of sustainable development of neighbouring regions through the prism of the curse of both natural and human resources. The implementation of cross-border cooperation projects, focusing on access and security of resources of one neighbouring region in exchange for innovative practices of another region, will increase the economic, innovative and sustainable development of regions. In this way, to overcome the shortage of resources, the paradox of abundance and increase the security of their management.

In the multicriteria selection tasks, the set of alternatives, relative to the evaluation criteria, is currently classified as follows: comparative based on a common set of criteria; not comparable according to a common set of criteria; partially comparative according to a common set of criteria.

Solving the first class of problems is a classic problem of multicriteria selection of alternatives, where the evaluation criteria are clearly defined for the research objects. The second class of problems is solved by evaluating alternatives, for each of which its own set of criteria is selected, and at the output, standardized evaluations are obtained for their comparison. For example, funding for an investor in a grant social project or a classic investment project. The third class includes heterogeneous alternatives that have both a common set of criteria and their own. Evaluation based only on a common set of criteria does not provide comprehensive information and, accordingly, an assessment of the required quality. Here, for each alternative, it is also necessary to consider its own additional criteria, using them, a more adequate assessment of the research object is obtained. The various cross-border projects are combined into one set of cross-border cooperation programs, but each of them has its own characteristics.

Heterogeneous alternative solutions are alternative versions of solutions that are different in some content, and therefore it is not possible to evaluate them according to a common set of criteria. Such a set of heterogeneous alternatives is divided into groups based on some common characteristics - “categories of alternatives”, which are evaluated using common criteria.

We see the fuzzy multicriteria evaluation model of heterogeneous projects of cross-border cooperation as another innovative technological tool of intellectual analysis of data and knowledge, with the aim of creating a comprehensive knowledge system capable of avoiding the resource curse and maintaining the sustainability of neighbouring regions. New decision support systems are technologies that focus on data and knowledge analysis, including the UN’s Sustainable Development Goals.

Our research examines cross-border cooperation projects and programs that avoid the resource curse and support the sustainability of neighbouring regions.

As a result of the study, an initial quantitative assessment will be obtained and a ranking of the studied cross-border cooperation projects will be built, for their selection regarding financing in order to avoid the resource curse, increase international economic cooperation and support the sustainable development of neighbouring regions.

The scientific hypothesis of this study is formulated as follows. If a cross-border cooperation project, which has an existing high level of benefit of access to the resources of both parties to ensure the sustainable development of neighbouring regions, fully meets the goals of the program, is successfully implemented, then it is possible to claim a high estimate of the possibility of supporting such a project, which is obtained on the basis of the constructed vague multicriteria model of evaluation of heterogeneous cross-border cooperation projects.

2. Overview of domestic and foreign research studies

Cross-border cooperation is also one form of support for the development of the regions. Cross-border cooperation also results from the strategic behaviour of actors, within which are expected to have confidence, understanding and willingness to cooperate (**Sohn, 2014**). Durand and Decoville (2020) state that cross-border integration in Europe is a complex and multidimensional process and it has a contradictory impact on regions. Their different models are an example of the fact that there cannot be a single best cross-border cooperation strategy at EU level. **Scott** (**2015**) justifies the socio-political importance of borders within Europe, as well as outside. According to the author, the borderline perspective also expresses the boundaries between communities and groups through ideologies, political institutions, attitudes, agencies. Cross-border cooperation initiatives, institutional cooperation and political support are also important (**Scott, 2015; Wong Villanueva et al., 2022**). **Crescenzi and Iammarino** (**2018**) draws attention to the need to rethink current regional development processes and states that regional development is accompanied by a lot of concepts, empirical evidence and policy approaches that also influence decision-making processes. For a long time, regional development has been conceived as non-linear, interactive and socially anchored, but technological developments are changing its characteristics into an open and interdependent framework (**di Pietro et al., 2014; Medeiros, 2018**). This creates further opportunities for its development and study its potential benefits. The barriers to the development of cross-border cooperation are perceived in several dimensions. Internal barriers most strongly affect the social objectives of cooperation, and their elimination is possible through the policy of municipalities, mobilization of NGOs and entrepreneurs (**Kurowska-Pysz et al., 2018; Medeiros, 2018**). External barriers are characteristic for peripheral regions that are distant from national and regional decision-making centres. There are also a number of negatives associated with this. Cross-border cooperation can be an effective tool to overcome them. Exploring barriers of cross-border cooperation and quantifying their potential impacts on the sustainability of regions is absent from research studies.

An important component in regional development processes are natural resources. Regional development means a targeted use of resources as well as increasing the potential of the regions. In recent years, there have been many discussions about the effects of natural resources on the economic and business growth of countries. This issue creates extensive analytical dimensions within which economic, social and environmental variables and multidimensional causal relationships are studied. Many economic studies are intensively concerned with the issue of resource curse and they are looking for ways to eliminate them (**Brollo et al., 2013; Benigno and Fornaro, 2014; Ahmed et al., 2016; Cheng et al., 2021**). **Destek et al.** (**2022**) were looking for an optimal level of resource dependency that would eliminate the possibility of resource curse in 28 countries. The increased openness of the economy, according to the authors, supported economic growth, but at the same time harmed sustainable development. Many authors have conducted numerous researches to find suitable alternatives to mitigate the effects of the resource curse, however, the heterogeneity of these studies is strong, influenced by geographical and geopolitical aspects, as well as chosen methodologies of their quantification. The studies are dominated by regression analysis of various types from linear regression through panel regression to logarithmic regression, correspondence analysis, factorial analysis, principal component analysis, analysis of variance, methods based on fuzzy logic are used to a minimal extent (**Ziolo et al., 2022**). As a part of these researches, various macroeconomic factors have often been identified that need to be changed to eliminate the negative impacts of the resource curse: openness of trade (**Yang et al., 2019; Hassan et al., 2019; Erdogan et al., 2021**), human resources (**Aljarallah, 2020; Aljarallah and Angus, 2020**). **Sharma and Pal, 2021; Wu et al.,** (**2018**) and institutional factors (**Mehlum et al., 2006; Sarmidi et al., 2014; Collier and Hoeffler, 2016; Redmond a Nasir, 2020; Tandi a Mishra, 2020; Aljarallah and Angus, 2020**). Due to the strong heterogeneity of these studies, their results are difficult to compare. Many authors focus their research on finding the optimal boundary between resource dependency and economic growth. This research trajectory generates much more contrasting outputs and arouses critical discussions. While the positive impact of natural resource abundance on economic growth is declared by studies by **Wu et al.** (**2018**), **Erdogan et al.** (**2021**); **Nawaz et al.** (**2019**), opposing influences are reported by studies by **Kim and Lin** (**2018**), **Shahbazi et al.** (**2019), Cheng et al.** (**2020**) and others. Equally contrasting results were found when studying whether economic growth is positively influenced by resource dependency (**Tiba and Frikha, 2019; Topcu et al., 2020; Haseeb et al., 2021; Yasmeen et al., 2021; Rahim et al., 2021**). **Badeeb et al.** (**2017**) critically responds to contrasting results of studies examining the relationships between economic growth and resource dependency.

They argue that these outputs are the result of incorrect empirical specifications and that it is necessary to better deal with the endogeneity of dependency measurements, study longer time series and use a greater range of empirical methodologies. Moshiri and Hayati (2017) identified institutional qualities, government effectiveness, regulatory quality as significant factors for eliminating resource dependency. Boyce and Emery (2011) studied institutional and market failures caused by an overabundance of resources. They confirm that the amount of resources negatively correlates with the growth rate, but positively correlates with income levels. In this context, Sarmidi et al. (2014) point to the existence of a threshold effect In the relationship– natural resources and economic growth. According to the authors, the institutional factor is significant in the differences in the studied dependence of countries on natural resources. James and Aadland (2011) draws attention to the importance of taking into account sectoral differentiation in growth regressions between countries. In addition to the sectoral structures, it is important to study the role of stakeholders and institutions in managing the use of natural resources. Ahmadov and Guliyev (2016) consider them crucial in setting up resource management mechanisms and supporting regional development.

The results of these studies show strong efforts by the research and professional spheres to tackled the important macroeconomic and microeconomic determinants of regional development, and also highlight the issue of the resource curse in the context of the sustainable development of the regions. Despite the wide range of used methods in research studies, fuzzy logic-based methods, which deal with crossborder cooperation in order to sustainability development of the regions, are absent. The process of developing regions and ensuring sustainable development is closely linked to decision-making and evaluation mechanisms, both at different levels of management of the development of regions and institutional cooperation.

This is also typical for decision-making under support from various financial schemes, where knowledge of many regional aspects and contexts is necessary. Methods based on the principle of fuzzy logic provide many advantages and strong analytical support for quality decision-making processes at any level of management (Kilic and Kaya, 2015; Sir and Çalıs¸kan, 2019). For the successful development of the regions, it will be necessary to develop innovative tools and knowledge systems that would support the sustainability of the regions. These innovative instruments are also desirable during periods of intensive support from EU funds, as well as from other grant schemes and financial mechanisms, when many criteria enter into the decision-making processes on the allocation of financial resources, which makes it significantly difficult comparation and evaluation of the projects (Mosadeghi et al., 2015).

Projects aimed at cross-border cooperation represent a special type of regional development project that can also eliminate the resource curse and support the development of sustainable regions. At the same time, they will help develop the necessary adaptation and security strategies at local, regional and global level.

3. Materials and methods

3.1. Formal formulation of the evaluation problem

Let us denote cross-border cooperation projects as a set of heterogeneous alternatives $P = \{P_1;P_2;P_n\}$. Projects are presented as project applications, which are subject to competitive selection for their financing and implementation. Management entities participating in the evaluation of project applications will be denoted by $E = \{e_1;\ e_2;\ .;\ e_m\}$, which represents a set of experts. Each cross-border cooperation project application is evaluated by experts based on K_{CB} - the information model of cross-border cooperation project evaluation criteria. The set of heterogeneous alternatives $P = \{P_1;\ P_1;\ .;\ P_m\}$ is divided into categories $A = \{A_1, A_2,..., A_\alpha\}$ by common characteristics, $A_i = \{P_1^i, P_2^i ,...\}, i = \overline{1, a}$, where A_i — is the i-th category of alternatives (**Polishchuk, 2018**). All alternative projects are evaluated according to groups of common efficiency criteria $\{G_1, G_2,..., G_{p-1}\}$, and each category of alternatives, in turn, is evaluated according to a group of its own set of criteria $G_p = \{K_1, K_2,..., K_{m'}\}$.

For the researched task, we have the following management subjects: experts are persons entrusted with the functional responsibilities of evaluating cross-border cooperation projects based on the project application submitted within the competition; a system analyst is a person who adjusts all evaluation processes regarding the announced challenge or competition, selects sets of common and own evaluation criteria relative to categories of alternatives; decision-making (DM) are persons who make further management decisions regarding the selection of cross-border cooperation projects for their financing.

The task of multicriteria selection of heterogeneous projects of crossborder cooperation to ensure sustainable development of neighbouring regions can be formulated as follows: build a ranking series of projects and select the best alternatives from the set P, when the evaluations of the criteria obtained separately by experts are known on this set $E = \{ e_1 ; e_2 ; . ; e_m\}$.

A fuzzy multicriteria evaluation model of heterogeneous crossborder cooperation projects to ensure sustainable development of neighbouring regions is formally presented in the following form:

$$\sigma(P, E, K_{CB}) \rightarrow f(P). \quad (1)$$

σ is the operator matching the set of initial estimates $f\ (P)$, with the input variables P,E,K_{CB}. Based on the initial estimates of $f(P)$ a ranking series of projects is constructed. The problem model can be presented in the form of **Table 1**.

Here O_{get} is the evaluation of the t-th alternative according to the e-th criterion in the group g, $g = \overline{1,p}$, $e = \overline{1,m_g}$, $t = \overline{1,n}$. Each column of the table characterizes an alternative, and each row is a criterion. O_{p1}, O_{p2},..., O_{pn} — aggregated evaluations of alternatives, which are obtained according to the set of criteria of the corresponding category $A_i = \{P_1^i, P_2^i, ...\}$, $i = \overline{1,\alpha}$.

The solution of the formulated multicriteria selection problem is divided into three stages.

Table 1 Input criterion evaluations by some expert E

G	K	P_1	P_2	...	P_n
G_1	K_{11}	O_{111}	O_{112}	...	O_{11n}
	K_{12}	O_{121}	O_{122}	...	O_{12n}
	...	...	...	...	...
G_2	K_{21}	O_{211}	O_{212}	...	O_{21n}
	K_{22}	O_{221}	O_{222}	...	O_{22n}
	...	...	...	...	...
G_{p-1}	$K_{(p-1)1}$	$O_{(p-1)11}$	$O_{(p-1)12}$	...	$O_{(p-1)1n}$
	$K_{(p-1)2}$	$O_{(p-1)21}$	$O_{(p-1)22}$	...	$O_{(p-1)2n}$
	...	...	...	...	...
G_p	K_p	O_{p1}	O_{p2}	...	O_{pn}

1. there are aggregated estimates O_{p1}, O_{p2},..., O_{pn} of alternatives, taking into account their category;
2. there are aggregated estimates of alternatives by groups of common efficiency criteria {G_1, G_2,..., G_{p-1}|;
3. initial estimates of cross-border cooperation projects are derived and their ranking is constructed.

We will offer the information model K_{CB} of criteria for evaluating cross-border cooperation projects.

An information model of evaluation criteria for cross-border cooperation projects has been developed for their selection regarding financing, to avoid the resource curse. The complexity of the assessment lies in the fact that cross-border projects are implemented by applicants and partners from different countries, their projects are aimed at the implementation of different problems and provide different goals within the announced competition. Therefore, such projects have both a common and their own set of evaluation criteria. In this case, alternative projects of cross-border cooperation in the multicriteria choice problem will be heterogeneous alternatives.

Having analyzed various programs, projects, and challenges of crossborder cooperation, we can summarize the evaluation indicators broken down depending on the project category. As a rule, the strategic goal of cross-border cooperation programs should be achieved within the framework of project financing and implementation, while highlighting specific thematic goals of the programs. There are three main types of projects: large infrastructure projects, regular projects and microprojects. Therefore, for our study, it is proposed to break down the categories of heterogeneous alternatives depending on the type of project. A set of criteria by which the proposed categories of alternatives can be evaluated, as well as common criteria for avoiding the resource curse, are summarized.

The first category of MP cross-border projects is micro-projects. Micro-projects of cross-border cooperation are projects with a small budget, which are aimed at development between communities through the implementation of soft measures, which involve non-investment activities and promote the development of interpersonal relations, cooperation, and exchange of experience. All criteria are offered in the form of questions to which the applicant of the project application gives a descriptive answer. The expert analyzes the project application and assigns a corresponding score from the interval [1; 10] regarding the level of quality of the project application description. In this case, the following criteria are proposed (**Cross-border Cooperation Programme Poland-Belarus-Ukraine, 2014-2020, 2022**):

MPK_1 - what is the level of justification of the need in the project?

MPK_2 - what value will cooperation bring during project implementation?

MPK_3 - what is the level of quality of the partners regarding the declared project?

MPK_4 - to what extent are the management structures and procedures appropriate to the size, duration and needs of the project?

MPK_5 - to what extent are the communication activities appropriate and capable of reaching the relevant target groups and stakeholders?

MPK_6 - how realistic, consistent and coherent is the work plan?

The second category of cross-border RP projects is regular projects.

Regular projects are the most common cross-border cooperation projects, which may involve infrastructure, soft and investment measures. Similarly, all criteria are offered in the form of questions to which the applicant of the project application gives a descriptive answer. In the same way, the expert analyzes the project application regarding the level of quality and assigns a corresponding score from the interval [1; 10]. In this case, the own criteria are divided into four groups (**The Hungary-Slovakia-Romania-Ukraine ENI CBC Programme, 2014-2020, 2022**).

Group RPK_1 - financial and operational capacity.

RPK_{11} - the presence of sufficient experience in project management, which is confirmed by management skills?

RPK_{12} - availability of the required amount of technical knowledge and management skills?

RPK_{13} - availability of sufficient sources of funding for day-to-day financial activities?

RPK_{14} - availability of sufficient and rational planned sources to ensure project implementation?

Group RPK_2 - cross-border approach.

RPK_{21} - does the project have a pronounced cross-border impact, which will bring a strong positive effect?

RPK_{22} - additional cross-border value that benefits all participants on different sides of the border, the project cannot be implemented without the cooperation of a foreign partner who shares its experience, methods, models, data, ideas, knowledge, etc.

RPK_{23} - quality level of partners who will be involved in project implementation.

RPK_{24} - availability of real benefit from project implementation for all its partners.

Group RPK_3 - stability.

RPK_{31} - the project is predicted to have a long-term impact on its target audience and the results can be used after the project is completed.

RPK_{32} - the project is predicted to have multiplier effects in terms of its replication and expansion of its results.

RPK_{33} - expected results will be sustainable regarding: financial sustainability, environmental sustainability and institutional level (transfer of project results to local disposal).

Group RPK_4 - action plan and communication.

RPK_{41} - project plans are clear, logical, and practical.

RPK_{42} - the proposed activities and intermediate results of the project are appropriate, practical, corresponding to the goals and expected results.

RPK_{43} - the project communication plan corresponds to the achievement of project goals.

RPK_{44} - adequate time plan of activities.

The third category of cross-border IP projects is large infrastructure projects.

Large infrastructure projects are cross-border cooperation projects that are of strategic importance for the development of regions. The minimum budget is on average 25 times higher than for regular projects. Large infrastructure projects are evaluated according to similar indicators as regular projects. Their peculiarity is that they are not selected in a competitive selection, but are determined by the DM of the corresponding program (announced competition) with the approval of the European Commission. Therefore, without reducing the generality, for our study, we will use the evaluation indicators, as for regular projects.

A set of common criteria for all projects.

The improvement and deepening of cross-border cooperation opens up new opportunities for the activation of economic activity in the peripheral territories of the regions and the mobilization of natural resource potential. As a common set of criteria for our study, three groups of indicators are considered:

G_1 - project budget.

G_2 - compliance with the challenge project, programs, and goals.

G_3 - indicators aimed at avoiding the resource curse.

All common criteria are expertly evaluated using one of the terms, the next proposed term-set of linguistic variables $L = \{L; BA; A; AA; H\}$, which characterizes the level of the indicator, where: L - “low”; BA - “below average”; A - “average”; AA - “above average”; H is “high".

The following indicators are proposed for the first group of criteria G_1 - project budget:

K_{11} - the project budget is adequate in terms of the ratio of costs and expected results.

K_{12} - realistic and balanced budgets of partners corresponding to their actual participation.

K_{13} - the budget is transparent and adequately corresponds to the planned activities that are declared.

K_{14} - the financial plan is realistic and effective.

The criteria group G_2 - compliance with the challenge project, programs, and goals include the following indicators:

K_{21} - clearly stated and presented problems and needs of the project.

K_{22} - the project objectives correspond to and are determined by the analysis of needs, they are covered by the corresponding main objective of the presented program or challenge.

K_{23} - the project includes a comprehensive, appropriate and detailed analysis of risks, as well as a plan for their elimination.

K_{24} - all activities in the project ensure the implementation of its tasks aimed at achieving the main goal of the project.

K_{25} - there is a real need for the project, defined by clear needs for the general public.

K_{26} - the project meets cross-cutting priorities.

K_{27} - the project demonstrates added value in the implementation of both program/challenge strategies and regional or national level strategies.

For the group of criteria G_3 - indicators aimed at avoiding the resource curse, it is not possible to unequivocally generalize the criteria. By removing restrictions on their own resources, project applicants will be able to open up wider opportunities for the implementation of various ideas. When looking for partners, the possibilities of resource provision of the partner region for cross-border cooperation will be taken into account. On the other hand, improper management of natural resources can cause natural disasters in neighbouring regions across the border. For example, deforestation in the mountains leads to floods and flooding, not only within the borders of one country. Or environmental pollution affects the quality of drinking water in the neighbours as well. For example, general such indicators are offered:

K_{31} - level of activation of human resources, competences, experience, best practices and knowledge of partner parties.

K_{32} - the project allows allocation, exchange, and use of natural resources of the partner party.

K_{33} - the level of activation of management and rational use of natural resources, which will ensure ecological balance and guarantee environmental protection. For example, the project is aimed at managing water resources, developing flood protection, improving air quality, improving water quality, creating a system for forecasting and warning of emergency situations, etc.

K_{34} - the implementation of the project contributes to improving the controllability of processes in the waste management system, supports the principles of recycling, etc.

K_{35} - ensuring the development of technical progress of partners.

K_{36} - ensuring the development of the tourist and recreational economy in the context of green infrastructure to improve the quality of health of partner regions.

Also, experts assign a quantitative value to each estimate, which characterizes his confidence in issuing the estimate - μ-(O_{get}), g $= \overline{1,p}$, $e \ = \overline{1, m_g}$, $t \ = \overline{1,n}$ from the interval [1; 100].

This set of criteria cannot reveal all aspects of cross-border cooperation within various programs and challenges, therefore it is open, and depending on the program and its goals, the DM specifies the necessary indicators.

A fuzzy multicriteria evaluation model of heterogeneous crossborder cooperation projects to ensure sustainable development of neighbouring regions.

Next, a mathematical fuzzy multicriteria model is presented, the solution of which is proposed according to the three stages.

At the first stage, there are aggregated estimates O_{p1}, O_{p2},..., O_{pn} of alternatives, taking into account their category.

Let in this problem we have several alternative projects of crossborder cooperation in one category A_i $= \{P_1^i$, P_2^i,.... $P_k^i\}$, $k \ < \ n$, which are evaluated according to their evaluation criteria $\{K_1^i$, K_2^i, ..., K_{mi}^i.$\}$, where i — category of alternatives, $i \ = \overline{1, \alpha}$. The input data for evaluations of alternatives can be presented in the form of a decision matrix:

$$Z^i = \left(O^i_{dt}\right), d = \overline{1, m_i}; t = \overline{1, k}; i = \overline{1, \alpha}, \qquad (2)$$

where O_{dt}^i - is the evaluation of the t-th alternative according to the d-th criterion for the i-th category of alternatives.

The number of decision matrices will be determined by the number of alternative categories. On the basis of decision matrices, it is necessary to obtain vectors of estimates of cross-border projects V_1, V_2,..., V_α, which will contain all the sought estimates O_{p1} , O_{p2} , ..., O_{pn}, for the K_p criterion. This problem is a problem of multicriteria choice, so we can find the vectors of estimates of alternatives V_1, V_2,..., V_α using one of the approaches (**Polishchuk, 2018**).

Since for each question, experts assign a score from the interval [1; 10] regarding the level of quality of the project application, then at the first step it is necessary to standardize the evaluations of alternatives according to the criteria. For this purpose, normalization is proposed in the form of the application of membership functions. For example, let's use the triangular membership function, where the numerical parameters are 1, 8 and 9:

$$\mu(O^i_{dt}) = \begin{cases} 0, & O^i_{dt} \leq 1; \\ \frac{O^i_{dt} - 1}{7}, & 1 < O^i_{dt} < 8; \\ 9 - O^i_{dt}, & 8 \leq O^i_{dt} < 9; \\ 0, & O^i_{dt} \geq 9. \end{cases} \quad (3)$$

$d = \overline{1, m_\iota}$,; $t = \overline{1, k}$; $i = \overline{1, \alpha}$. The selection of these numerical parameters will be determined by the fact that inflated estimates of project experts will not be taken into consideration. Parameters 1 and 9 characterize the base of the triangle, and parameter 8 - its apex.

Thus, there is a transition from quantitative unstandardized point estimates to a decision matrix of standardized estimates:

$$\overline{Z^i} = (\mu(O^i_{dt})), d = \overline{1, m_i}; t = \overline{1, k}; i = \overline{1, \alpha}, \quad (4)$$

where $\mu(O^i_{dt})$ is the normalized evaluation of the t-th alternative according to the d-th criterion for the i-th category of alternatives.

In the second step, let for each criterion $\{K^i_1, K^i_2, ..., K^i_m\}$ the DM needs to set weight coefficients $\{p^i_1, p^i_2, ..., p^i_{m}\}$ from some interval [1; a]. For further calculations, it is necessary to determine normalized weighting coefficients for each criterion for different categories of alternatives:

$$\overline{p^i_d} = \frac{p^i_d}{\sum_{d=1}^{m_i} p^i_d}, d = \overline{1, m_i};\ \overline{p^i_d} \in [0; 1]; \quad (5)$$

which meet the condition $\sum_{d=1}^{im} \overline{1, p^i_d} = 1$.

If there is no need for the DM to enter weighting factors, then the weights of the criteria are considered balanced.

In the next step, which is the final for the first stage, the evaluations are aggregated taking into account the category of cross-border projects. The convolution approach is used here. For example, the most common of the convolutions is used - the average weighted convolution:

$$O_{pt} = \sum_{d=1}^{m_i} \overline{p^i_d} \cdot \mu(O^i_{dt}), i = \overline{1, \alpha}; t = \overline{1, n}. \quad (6)$$

We denote $O_{pt} = O_{4t}$. In this way, aggregated evaluations of alternatives are obtained according to the set of criteria of the i-th category, which completes the first stage of solving the given problem.

At the second stage of solving the problem, there are aggregated evaluations of alternatives by groups of common performance criteria $\{G_1, G_2, ..., G_{p-1}\}$.

In the proposed information system, we have three groups of criteria G_1 - the project budget, G_2 - compliance of the project with the challenge, programs, and goals, G_3 - indicators aimed at avoiding the resource curse. Therefore, without reducing the generality, the calculation will be illustrated in three groups of criteria.

The evaluations of the alternatives for each group of criteria can be considered as separate decision matrices for which the aggregated evaluations of the other options for the criteria should be calculated.

Each criterion is evaluated by an expert using one of the terms of the following term-set of linguistic variables $L = \{ L;\ BA;\ A;\ AA;\ H \}$. Also, experts put a quantitative value from the interval [1; 100], which characterizes the expert's confidence in his assessment - $\mu(O -_{get})$, $\bar{g} = \{1,2,3\}$, $e\ = \overline{1, m_g}$, $t\ = \overline{1, n}$.

Then the input is a set of scores $O -_{get} = \{L -_{get}; \mu(O -_{get})\}$. For visual interpretation, the input data according to the common criteria are presented in the form of a table as follows, **Table 2**.

To be able to compare the data, it is necessary to fuzzification the fuzzy linguistic reasoning of experts. The following approach is proposed. For each linguistic variable, a value from the interval [0; 1] is set: $L\ -\ [\alpha_1;\ \alpha_2\ ],\ BA\ -\ [\alpha_3;\ \alpha_4\ ],\ A\ -\ [\alpha_5;\ \alpha_6\ ],\ AA\ -\ \ [\alpha_7;\ \alpha_8\ ],\ H\ -\ [\alpha_9;\ \alpha_{10}\ ]$. Example: $L\ -\ [0;\ 0{,}2], BA\ -\ [0{,}2;\ 0{,}4], A\ -\ [0{,}4;\ 0{,}6], AA\ -\ [0{,}6;\ 0{,}8], H\ -[0{,}8;\ 1]$.

Next, one normalized assessment is calculated based on the linguistic variable and the confidence of the expert' s reasoning regarding their assignment, according to the following formula:

$$Z_{\bar{g}et} = a_r + \frac{1}{100} \cdot \mu\left(L_{\bar{g}et}\right) \cdot (a_{r+1} - a_r), \tag{7}$$

Where α_r is the interval value for the linguistic variable $L -_{get}$, get, $r — \overline{1, 9}$, $Z -_{get}$get is the normalized numerical value of the evaluation criterion adjusted for the confidence of the expert's judgment $\bar{g}$ ={1,2,3}, $e = \overline{1, m_g}$, $t = \overline{1, n}$.

Then there is one aggregated assessment within three common groups of criteria G_1, G_2, G_3. In this case, for each criterion in the group $\bar{g} = \{1, 2, 3\ \}$ the DM is offered to set the weighting coefficients $\{v_{\overline{g1}}, v_{\overline{g2}}, ..., v_{\overline{gm}}\}$ from the interval [1; a]. Similarly, normalized weighting coefficients are determined for each criterion within one group $\bar{g} = \{1, 2, 3\}$:

$$\overline{v_{\bar{g}e}} = \frac{v_{\bar{g}e}}{\sum_{e=1}^{m_{\bar{g}}} v_{\bar{g}e}},\ e = \overline{1, m_{\bar{g}}},\ \overline{v_{\bar{g}e}} \in [0;\ 1]. \tag{8}$$

After that, one aggregated score is calculated within the group of common criteria, using a weighted average convolution:

$$O_{\overline{g}t} = \sum_{e=1}^{m_{\overline{g}}} \overline{v_{\overline{g}e}} \cdot Z_{\overline{g}et}, \overline{g} = \{1, 2, 3\}; t = \overline{1, n}. \quad (9)$$

If there is no need in the DM to distinguish the importance of indicators in groups of common criteria, then the criteria will be considered balanced, and the aggregated score is calculated according to the formula:

$$O_{\overline{g}t} = \frac{1}{m_{\overline{g}}} \sum_{e=1}^{m_{\overline{g}}} Z_{\overline{g}et}, \overline{g} = \{1, 2, 3\}; t = \overline{1, n}. \quad (10)$$

Table 2 Linguistic assessment inputs for the project t

A group of common criteria	Criteria	Linguistic variable	Confidence of the expert's
$G_{\overline{g}}$	$K_{\overline{g}1}$	$L_{\overline{g}1t}$	$\mu(L_{\overline{g}1t})$
	$K_{\overline{g}2}$	$L_{\overline{g}2t}$	$\mu(L_{\overline{g}2t})$
	...	...	...
	$K_{\overline{g}m_{\overline{g}}}$	$L_{\overline{g}m_{\overline{g}}t}$	$\mu(L_{\overline{g}m_{\overline{g}}t})$

Here, $m -_g$ is the number of criteria in the corresponding group G.

Thus, at the end of the second stage, we have normalized aggregated evaluations of alternatives by some expert E according to groups of common criteria and own set of criteria obtained according to the categories of cross-border cooperation projects, **Table 3**.

The decision matrix of normalized aggregated evaluations of alternatives for the fuzzy multicriteria evaluation model of heterogeneous projects of cross-border cooperation is presented in the following form:

$$O(E) = (O_{\overline{p}t}), \overline{p} = \{1, 2, 3, 4\}; t = \overline{1, n}. \quad (11)$$

Where $O -_{pt}$ is the aggregated estimate of the t-th cross-border cooperation project. The number of received decision matrices will depend on the number of experts $E = \{e_3; e_2;...; e_m\}$.

At the third stage of solving the problem, based on decision matrices (ii), the initial estimates of cross-border cooperation projects are derived, and their ranking is constructed.

For this, the DM sets the weighting coefficients $\{w_1, w_2, w_3, w_4\}$ for each group of criteria G_1, G_2, G_3 and its own evaluation criterion K_p relative to the category of cross-border cooperation projects from the interval [i; a]. Normalized weighting factors are determined similarly:

$$\overline{w_{\overline{p}}} = \frac{w_{\overline{p}}}{\sum_{\overline{p}=1}^{4} w_{\overline{p}}}, \overline{p} = \{1, 2, 3, 4\}, \overline{w_{\overline{p}}} \in [0; 1]. \quad (12)$$

After that, one quantitative evaluation of the researched cross-border cooperation projects is calculated separately by experts $E = \{e_1; e_2;...; e_m\}$, for their selection regarding financing in order to avoid the resource curse, increase international economic cooperation and support the sustainable development of neighbouring regions, using weighted average convolution:

$$Y(P_t) = \overline{w_1} \cdot O_{1t} + \overline{w_2} \cdot O_{2t} + \overline{w_3} \cdot O_{3t} + \overline{w_4} \cdot O_{4t}. \quad t = \overline{1,n}. \tag{13}$$

Since not one expert participates in project evaluation, but a set of experts $E = \{e_1; e_2;...; e_m\}$, then the evaluation procedure is repeated m times. At the output of each project P_t ,$t = \overline{1,n}$, m estimates are obtained: $Y_j = (P_t), j = \overline{1,m}$.

After that, it becomes necessary to derive one aggregated estimate for the cross-border cooperation project, taking into account the opinions of all experts. Naturally, the content of our evaluation is as follows: when the values of the project evaluations are the maximum values, then the result of the aggregate evaluation should go to 1. For this purpose, it is suggested to use the multidimensional cone-shaped membership function in the m-dimensional evaluation space [0; 1], where the scaling by coordinates is (2; 2; . ; 2), the center of the base is a unit vector (1; 1; . ; 1):

$$f(P_t) = \begin{cases} 1 - \frac{1}{2}\sqrt{\sum_{j=1}^{m} (Y_j(P_t) - 1)^2}, \ if \ \sqrt{\sum_{j=1}^{m} (Y_j(P_t) - 1)^2} < 1, t = \overline{1,n}. \\ 0, \ otherwise. \end{cases} \tag{14}$$

Thus, an aggregate assessment of the cross-border cooperation project is obtained, taking into account the opinions of all experts $f\ (P_t) \in [0; 1]$, which makes it possible to eliminate the subjectivity of individual experts during evaluation.

Table 3 Normalized aggregated ratings by some expert E

	P_1	P_2	...	P_n
G_1	O_{11}	O_{12}	...	O_{1n}
G_2	O_{21}	O_{22}	...	O_{2n}
G_3	O_{31}	O_{32}	...	O_{3n}
K_p	O_{41}	O_{42}	...	O_{4n}

On the basis of $f(P_t)$ values, a ranking series of heterogeneous researched projects of cross-border cooperation is built:

$$A = (A_1, A_2, ..., A_n) \tag{15}$$

Therefore, a vague multicriteria model for evaluating heterogeneous projects is given, taking into account the goals of the announced competition, sustainable development of regions, and avoiding the resource curse. The model allows you to eliminate the subjectivity of experts in the evaluation procedure since projects with maximum and minimum expert evaluations will have equally low initial evaluations.

4. Results

We will test the results of the research on 5 cross-border cooperation projects that applied for the competition for their selection and financing $P = \{P_1, P_2,., P_5\}$. A fuzzy multicriteria model for evaluating heterogeneous projects, taking into account the goals of the announced competition, the possibility of avoiding the resource curse, and the sustainable development of regions, was tested and verified, both on real and test data. Real data was obtained from various organizations implementing cross-border cooperation projects, for example, the Agency for Regional Development and Cross-Border Cooperation of Transcarpathia (Ukraine). 5 experts, who are the authors of the article and representatives of the agency, were involved in the project evaluation. The projects were of two categories: $A_1 = \{P_1, P_2\}$ - microprojects, $A_2 = \{P_3, P_{4,} P_{5,}\}$ - regular projects, namely:

P_1— The oil legacy of the activities of Ignatius Lukasevich (PBU2/ 0787/18).

P_2— Carpathian Academy of Winemaking Heritage (PBU2/0854/ 18).

P_3 — The world of Carpathian rosettes - measures to preserve the uniqueness of the cultural Carpathians (PBU/0365).

P_4— Joint measures to prevent natural disasters in the transboundary basin of the Uzh River (HUSKROUA/1702/8.1/0005).

P_5— Strengthening cross-border security through joint measures aimed at preventing floods and inundation by inland waters in the confluence of the Tisza and Tours rivers (HUSKROUA/1701/LIP/003).

Each of the experts conducted research on cross-border cooperation projects according to their own set of criteria, taking into account the category of projects, and according to a common set of criteria. On the basis of the research, he assigned ball and linguistic evaluations. Input data from expert e_1 on projects are given in **Table 4—6**. The rest of the input data received from experts e_2 and e_5 are presented in the table (**Inputs data and calculations, 2022**).

After receiving evaluations from project experts, calculations are performed according to the developed fuzzy multicriteria evaluation model of heterogeneous projects of cross-border cooperation. We will illustrate the detailed calculation of all stages on the example of data from an expert e_1.

Table 4 Input criterion evaluations based on a set of common criteria obtained by the expert e_1

Groups of criteria	Criteria	P_1		P_2		P_3		P_4		P_5	
G_1	K_{11}	AA	80	A	90	H	90	AA	80	H	90
	K_{12}	A	90	H	70	AA	80	A	70	AA	90
	K_{13}	H	70	H	80	A	90	A	90	H	80
	K_{14}	BA	90	H	90	H	90	AA	60	AA	90
G_2	K_{21}	A	90	H	70	AA	70	AA	80	H	80
	K_{22}	A	90	H	90	A	90	H	90	AA	90
	K_{23}	H	80	H	80	H	80	AA	70	H	80
	K_{24}	H	90	H	80	A	80	H	70	H	90
	K_{25}	H	90	H	70	AA	70	H	70	H	90
	K_{26}	H	70	H	70	H	70	AA	70	AA	70
	K_{27}	BA	90	AA	80	AA	80	A	80	AA	90
G_3	K_{31}	H	80	H	70	H	90	H	70	AA	70
	K_{32}	AA	80	H	80	A	80	H	80	H	90
	K_{33}	A	80	A	70	A	70	H	90	H	90
	K_{34}	AA	80	AA	90	A	70	AA	80	AA	70
	K_{35}	H	60	H	90	H	80	H	80	H	80
	K_{36}	A	80	H	80	H	90	AA	80	AA	90

Table 5 Input evaluations of the criteria for the category of micro-projects received by the expert e_1

Criteria	P_1	P_2
MPK_1	7	8
MPK_2	8	8
MPK_3	6	9
MPK_4	6	8
MPK_5	6	7
MPK_6	5	8

Table 6 Input evaluations of criteria by category of regular projects received by the expert e_1

Groups of criteria	Criteria	P_3	P_4	P_5
RPK_1	RPK_{11}	7	8	8
	RPK_{12}	9	8	9
	RPK_{13}	8	7	8
	RPK_{14}	6	7	7
RPK_2	RPK_{21}	7	7	7
	RPK_{22}	8	8	8
	RPK_{23}	6	7	8
	RPK_{24}	5	6	7
RPK_3	RPK_{31}	7	6	5
	RPK_{32}	5	5	4
	RPK_{33}	6	7	8
RPK_4	RPK_{41}	8	8	8
	RPK_{42}	7	6	5
	RPK_{43}	8	7	6
	RPK_{44}	8	9	9

The first stage.

In the first stage, there are aggregated assessments of projects, taking into account their category.

In the first step, all project evaluations are normalized according to criteria according to the triangular function of belongingness, **formula (3)**.

In the second step, for each criterion, the DM expressed its reasoning regarding the weighting coefficients p from the interval [1; 10], then the normalized weight coefficients p are determined according to **formula (5)**. The calculation results are presented in the table separately for project categories A_1 and A_2, **Tables 7 and 8**.

In the next step, which is the final first stage, the evaluations are aggregated taking into account the category of cross-border projects according to **formula (6)**: $O_{p1} = 0{,}77$; $O_{p2} = 0{,}769$; $O_{p3} = 0{,}775$; $O_{p4} = 0{,}805$; $O_{p5} = 0{,}738$.

Table 7 Standardization of evaluations of alternatives according to criteria and weighting factors for micro-projects.

Criteria	Weight p	Normalized weight $\overline{p}$	$\mu(P_1)$	$\mu(P_2)$
MPK_1	10	0.204	0.86	1.00
MPK_2	8	0.163	1.00	1.00
MPK_3	9	0.184	0.71	0.00
MPK_4	8	0.163	0.71	1.00
MPK_5	7	0.143	0.71	0.86
MPK_6	7	0.143	0.57	1.00

Table 8 Normalization of evaluations of alternatives according to criteria and weighting factors for regular projects.

Groups of criteria	Criteria	Weight p	Normalized weight $\overline{p}$	$\mu(P_3)$	$\mu(P_4)$	$\mu(P_5)$
RPK_1	RPK_{11}	10	0.078	0.86	1.00	1.00
	RPK_{12}	9	0.070	0.00	1.00	0.00
	RPK_{13}	8	0.062	1.00	0.86	1.00
	RPK_{14}	9	0.070	0.71	0.86	0.86
RPK_2	RPK_{21}	9	0.070	0.86	0.86	0.86
	RPK_{22}	10	0.078	1.00	1.00	1.00
	RPK_{23}	9	0.070	0.71	0.86	1.00
	RPK_{24}	9	0.070	0.57	0.71	0.86
RPK_3	RPK_{31}	8	0.062	0.86	0.71	0.57
	RPK_{32}	8	0.062	0.57	0.57	0.43
	RPK_{33}	9	0.070	0.71	0.86	1.00
RPK_4	RPK_{41}	7	0.054	1.00	1.00	1.00
	RPK_{42}	8	0.062	0.86	0.71	0.57
	RPK_{43}	9	0.070	1.00	0.86	0.71
	RPK_{44}	7	0.054	1.00	0.00	0.00

The second stage.

At the second stage of solving the problem, there are aggregated evaluations of alternatives by groups of common performance criteria $\{G_1, G_2, G_3\}$.

One normalized assessment is calculated based on the linguistic variable and the confidence of the expert's reasoning regarding their assignment according to **formula (7)**. Also, the DM determined the weighting coefficients v from the interval [1; 10], after which the normalized weighting factors are determined $\bar{v}$ for each criterion within one group according to **formula (8)**, **Table 9**.

After that, one aggregated score within the group of common criteria is calculated using the weighted average convolution according to **formula (9)**. Thus, at the end of the second stage, we have normalized aggregated evaluations of alternatives by expert e_1 by groups of common criteria and own set of criteria, **Table 10**.

Table 9 Normalization of input data according to a set of common criteria.

Groups of criteria	K	v	$\bar{v}$	P_1	P_2	P_3	P_4	P_5
G_1	K_{11}	9	0.250	0.76	0.58	0.98	0.76	0.98
	K_{12}	8	0.222	0.58	0.94	0.76	0.54	0.78
	K_{13}	10	0.278	0.94	0.96	0.58	0.58	0.96
	K_{14}	9	0.250	0.38	0.98	0.98	0.72	0.78
G_2	K_{21}	8	0.143	0.58	0.94	0.74	0.76	0.96
	K_{22}	9	0.161	0.58	0.98	0.58	0.98	0.78
	K_{23}	9	0.161	0.96	0.96	0.96	0.74	0.96
	K_{24}	8	0.143	0.98	0.96	0.56	0.94	0.98
	K_{25}	7	0.125	0.98	0.94	0.74	0.94	0.98
	K_{26}	7	0.125	0.94	0.94	0.94	0.74	0.74
	K_{27}	8	0.143	0.38	0.76	0.76	0.56	0.78
G_3	K_{31}	10	0.182	0.96	0.94	0.98	0.94	0.74
	K_{32}	9	0.164	0.76	0.96	0.56	0.96	0.98
	K_{33}	8	0.145	0.56	0.54	0.54	0.98	0.98
	K_{34}	10	0.182	0.76	0.78	0.54	0.76	0.74
	K_{35}	9	0.164	0.92	0.98	0.96	0.96	0.96
	K_{36}	9	0.164	0.56	0.96	0.98	0.76	0.78

The third stage.

At the third stage of solving the problem, based on **Table 10**, one quantitative assessment is calculated to build a ranking series of the studied cross-border cooperation projects.

For this, the DM sets the weighting coefficients {10; 8; 9;10} for each group G_1, G_2, G_3 for each group K_p relative to the category of crossborder cooperation projects from the interval [1; 10]. The normalized weighting coefficients are determined similarly (12): $\overline{w_1} = 0{,}27$; $\overline{w_2} = 0{,}216$; $\overline{w_3} = 0{,}244$; $\overline{w_4} = 0{,}27$.

After that, one quantitative assessment is calculated according to **formula (13)**:

$Y_1(P_1)$ =0,741; Y_1 (P_2) =0,86; Y_1 (P_3) =0,78; Y_1 (P_4) =0,785; $Y_1(P_5)$ =0,837.

Other experts e_2 and e5 calculate similarly. Detailed calculations are given in (**Inputs data and calculations, 2022**). Thus, at the output for each project P_1, P_2,..., P_5 estimates are obtained for the remaining two experts:

$Y_2(P_1)$ =0,692; $Y_2(P_2)$ =0,774; $Y_2(P_3)$ =0,812; $Y_2(P_4)$ =0,791; Y_2 (P_5) =0,81.

$Y_3(P_1)$ =0,714; $Y_3(P_2)$ =0,85; $Y_3(P_3)$ =0,789; Y_3 (P_4) =0,815; $Y_3(P_5)$ =0,77.

$Y_4(P_1)$ =0,724; Y_4 (P_2) =0,84; $Y_4(P_3)$ =0,777; $Y_4(P_4)$ =0,804; $Y_4(P_5)$ =0,762.

$Y_5(P_1)$ =0,726; $Y_5(P_2)$ =0,864; $Y_5(P_3)$ =0,782; $Y_5(P_4)$ =0,799; $Y_5(P_5)$ =0,769.

After that, one aggregated estimate for projects is derived, taking into account the opinions of all experts, according to **formula (14)**: $f\ (P_1)\ = 0{,}6858$; $f\ (P_2)\ = 0{,}814\ 7$; $f\ (P_3)\ = 0{,}7626$; $f\ (P_4)\ = 0{,}7748$; $f\ (P_5) = 0{,}7625$.

On the basis of the obtained values, a ranking series of heterogeneous researched projects of cross-border cooperation is constructed: P_2, P_4, P_3, P_5, P_1.

5. Discussion

The work develops a fuzzy multicriteria evaluation model of heterogeneous projects of cross-border cooperation to ensure sustainable development of neighbouring regions, taking into account the goals of the announced competition and the possibility of avoiding the resource curse. For this purpose: an information model of criteria for evaluating cross-border cooperation projects was developed in relation to three categories of projects: micro-projects, regular and large investment projects; a fuzzy mathematical multicriteria evaluation model of heterogeneous cross-border cooperation projects was developed; the model was verified and tested on real and test data, as well as a test example of the calculation of five real cross-border cooperation projects by three experts was given.

The research uses an adequate apparatus of fuzzy sets, onedimensional and multidimensional functions of belonging, multicriteria decision-making support, and intellectual analysis of experts' opinions, which makes it possible to increase the objectivity of expert evaluation, take into account the goals of the announced competition, the possibilities of avoiding the resource curse, sustainable development of regions and increase the degree the validity of management decisions.

Table 10 Standardized aggregated estimates of projects from an expert e_2

	P_1	P_2	P_3	P_4	P_5
G_1	0.675	0.866	0.820	0.651	0.880
G_2	0.765	0.927	0.752	0.809	0.883
G_3	0.761	0.866	0.764	0.890	0.857
K_p	0.770	0.796	0.775	0.805	0.738

The peculiarity of the study is that it allows comparing projects of crossborder cooperation of different categories, takes into account expert linguistic conclusions on projects, considers the relevance of the project to the challenge, programs, and goals, and also takes into account the main goal of the study - indicators aimed at avoiding the resource curse. At the same time, all the parameters of the membership functions are obtained by verifying the model on real and test data; one aggregated assessment of the cross-border cooperation project is obtained, taking into account the opinions of many experts. As a result of the fuzzy multicriteria evaluation model, a ranking series of heterogeneous researched cross-border cooperation projects is built for their future financing and implementation, focusing on access and security of resources, innovative practices, increasing the economic, innovative and sustainable development of regions.

Input data is processed by a fuzzy multicriteria evaluation model of heterogeneous cross-border cooperation projects, intellectual analysis of experts' opinions, and aggregation of the results of different experts using a multidimensional membership function, which is based on an information model of evaluation criteria for cross-border cooperation projects, taking into account the possibilities of avoiding the resource curse and sustainable development of regions. Adjusting the values of the one-dimensional and multidimensional function of membership and openness of groups of common sets of criteria and own criteria, taking into account the categories of alternatives, allows for improving the quality of the evaluation process. At the output of the model, we have an aggregated quantitative assessment obtained based on the assessments of various experts. Taking into account the value of these assessments, a ranking of cross-border projects is built for their selection and financing.

The advantages of the fuzzy multicriteria evaluation model of heterogeneous cross-border cooperation projects are as follows: it increases the objectivity of expert evaluations in the evaluation of cross-border cooperation projects, using the input linguistic variables and the confidence of the expert' s reasoning regarding their assignment; combines opinions by categories of criteria into a final assessment, based on a constructed three-stage fuzzy mathematical model of obtaining a general aggregated assessment of projects; increases the objectivity of evaluation and the reliability of expert evaluations, reveals uncertainty in the input data, aggregates the evaluation of projects taking into account their category, considers the compliance of the project with the challenge, programs and goals, and also takes into account the main goal of the study - indicators aimed at avoiding the resource curse.

A limitation of our study was the selection of groups of common criteria and own criteria for evaluating cross-border cooperation projects, as well as the use of different types of membership functions and data fuzzification approaches, as well as convolution to obtain aggregated estimates. Another limitation is related to the geography of the study and the sample of cross-border cooperation projects, which is important to replicate in other groups of countries in order to be able to compare the original data. Such limitations may lead to ambiguity of the final results, but at the same time the adequacy of the developed mathematical model has been proven and confirmed.

The rationality of the obtained initial results proves the advantages of the developed model and the importance of drawing attention to the implementation of cross-border cooperation projects for the purpose of sustainable development of neighbouring regions through the prism of the curse of both natural and human resources. The reliability of the obtained results is ensured by the justified use of the mathematical theory of multicriteria decision support, which is confirmed by the results of research and its verification on real and test data.

6. Conclusions

The issue of cross-border cooperation is strongly linked to the overall development of cooperation and the integration processes in Europe. The main objective of cross-border cooperation is to solve economic, social and environmental problems, not only at regional and local level, but it is also a means for the development of international cooperation between several countries. Cross-border cooperation requires the adoption of administrative, technical, economic, social and cultural measures to govern the interrelationships between the cooperating entities within the concluded agreements.

The main goal of the conducted research is to develop a fuzzy multicriteria evaluation model of heterogeneous projects of cross-border cooperation, with the aim of sustainable development of neighbouring regions through the prism of the curse of both natural and human resources, while the following results were obtained.

Firstly, an information model of criteria for evaluating cross-border cooperation projects was developed for the first time. For this purpose, it is proposed to break down the categories of heterogeneous alternatives depending on the type of project: large infrastructure projects, regular projects and micro-projects. A separate set of six evaluation criteria is proposed for micro-projects. For regular and large infrastructure projects, four groups of criteria with a total number of 15 are recommended. As a common set of criteria, three groups of indicators are considered: the project budget (4 criteria), compliance of the challenge project with programs and goals (7 criteria), indicators aimed at avoiding resource depletion curse (6 criteria). The set of criteria is open, therefore, depending on the program and its goals, DM clarifies the necessary indicators.

Secondly, a fuzzy multicriteria evaluation model of heterogeneous cross-border cooperation projects were developed to ensure the sustainable development of neighbouring regions. The model consists of three stages: there are aggregated estimates of alternative projects, taking into account their category; there are aggregated evaluations of alternatives by groups of common performance criteria; initial estimates of cross-border cooperation projects are derived, taking into account the opinions of all experts, and their ranking is constructed. The model takes into account the goals of the announced competition, the sustainable development of regions and the avoidance of the resource curse, allows moving from expert conclusions to quantitative assessments, based on which the subjectivity of experts in the assessment procedure is eliminated and the degree of validity of the decisions is increased.

Thirdly, verified, tested, and adjusted the model, both on real and test data. An approbation example of the calculation of five real crossborder cooperation projects by three experts is given. The adequacy of the mathematical model developed in the work was experimentally confirmed and proven.

The obtained results demonstrate the scientific and applied value of the conducted research, as well as absolutely prove the formulated scientific hypothesis.

Further research of the problem can be seen in the development of web-oriented software based on the developed mathematical and informational tools. The software will be useful for tender managers of cross-border projects, in order to improve the validity of supporting decision-making and sustainable development of neighbouring regions through the lens of curses, both natural and human resources.

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