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Multi-Criteria Evaluation of the EU funds Long-Term Development Potential: Repercussions for Labour Market and Competitiveness

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ABSTRACT

This research was carried out to evaluate the effects of the long-term development potential that the Republic of Croatia had from the application of EU funds. To investigate this, Zadar County was selected as a case study, and with the assistance of specialists from the Zadar development agency ZADRA NOVA and Inovacije Zadar (Zadar Innovations), projects were evaluated within ten sectors, which were observed using eight criteria. This research adopted a neutrosophic set approach to implement the evaluations provided by these experts, which were expressed in linguistic values. This methodology allows for the determination of the degree of truth or falsehood, as well as the level of uncertainty associated with each evaluation. Consequently, the derived scores were scrutinized more rigorously, and by incorporating uncertainty into the decision-making process, the results yielded safer decision outcomes. The results of this research were obtained by applying the SWARA and CORASO methods, which showed that the criteria demographic effects (C2) and cooperation and partnership hold the highest significance for experts, and that the best effects were provided by projects aimed at enhancing entrepreneurship and research infrastructure. This research has provided essential information that can be leveraged for the future allocation of EU funds to further advance the Republic of Croatia in terms of competitiveness and the labour market.

1. Introduction

European funds serve as a crucial tool for the economic, social, and territorial development of the member states within the European Union (EU) [1]. Their significance is especially evident in countries that are undergoing a process of economic convergence towards the EU average, such as the Republic of Croatia. Since its accession to the Union, Croatia has achieved notable progress in utilizing European funds, with the absorption of these funds often viewed publicly as a measure of the effectiveness of national development policy [2]. However, this quantitative perspective, which

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emphasizes the amounts of contracted and disbursed funds, fails to provide a comprehensive understanding of the actual developmental impacts and the sustainability of project results.

The effectiveness of European fund utilization should not be evaluated solely through administrative and financial metrics, but rather through the tangible and enduring effects on the economy, society, and the environment [3]. While immediate effects, such as GDP growth, job creation, or investment, are relatively apparent [4,5], long-term effects, including the enhancement of innovation capacity, demographic stability, reduction of regional disparities, and strengthening of institutional resilience, require a more thorough analysis and a time delay for accurate evaluation.

This research introduces a novel and innovative model for assessing the effectiveness of EU funds, which transcends traditional macroeconomic evaluations and incorporates multi-criteria decision-making (MCDM) based on expert evaluations of various development dimensions. Rather than examining individual projects, the analysis emphasizes groups of projects within specific thematic areas, facilitating an assessment of the overall investment efficiency and the identification of criteria that most significantly contribute to long-term development.

In this way, the objective is to examine not only the efficiency of fund utilization but also its purpose and outcome. In this context, the goal is to determine whether the projects resulted in genuine innovations, enhanced social resilience, demographic stability, and sustainable growth [6,7]. The opportunities for withdrawing funds from existing resources for the Republic of Croatia are gradually diminishing, and a relatively lower availability of funds is anticipated in the future due to shifts in the Union's priorities and the transition to new policies. Consequently, it is feasible to scrutinize, or project, the actual long-term impacts of previous investments from this perspective.

The study is focused on Zadar county, serving as an example of a region that has experienced considerable investment momentum over the past decade, largely due to European Union funds. The analysis relies on evaluations of experts from the Zadar development agency ZADRA NOVA and Zadar Innovations, who possess extensive experience in the preparation and execution of EU projects, thereby facilitating a reliable and credible assessment of the effects. Based on this foundation, the aim of this research is to assess the effectiveness of EU funds across various sectors, using Zadar County as a case study, employing the MCDM method.

In alignment with this research objective, specific research questions are posed that this paper intends to address:

i. Which factors are most crucial for evaluating the development effects of EU funds in Zadar County?
ii. Which sectors experienced the biggest increase in regional competitiveness as a result of the projects?
iii. What influence do specific criteria have on the stability of the shift in the ranking of the impacts of EU funds for particular sectors?

In earlier studies that evaluated EU funds, the emphasis was placed on the short-term macroeconomic indicators associated with these funds, including the growth of the gross social product, employment, investment, and others. Research that applied the evaluation of EU funds including MCDM methods has focused on short-term macroeconomic effects or financial absorption rates without including multidimensional long-term development potential at the regional level. In addition, there are fewer papers that directly incorporate uncertainty into decision-making. To address this gap, this research introduces a framework that combines: a regional sectoral perspective on the impacts of EU funds, a neutrosophic set approach for modeling uncertainty in expert decision-

making, and an MCDM model to provide a more robust and realistic assessment of the impact of EU funds on competitiveness and the labor market.

Consequently, this research is characterized by examining EU funds through a decision-making model that prioritizes the evaluation of development at the regional level. The contribution of this paper lies in the creation of an innovative methodological framework for assessing the effectiveness of EU funds at the regional level, which could serve as a model for other EU member states or countries seeking accession. This approach facilitates the evaluation of the actual added value of projects, specifically their capacity to produce long-term economic, social, and environmental benefits. This introduces a new perspective on sustainable development propelled by European funds, emphasizing quality, efficiency, and the strategic targeting of public investments. Furthermore, the findings of this research will allow for the assessment of the sustainable impact of EU funds on the local economy and the development of recommendations for other EU member states and accession countries, thereby paving the way for a new avenue of research into the effectiveness of European development policies.

This study advances the literature by moving beyond conventional macroeconomic evaluations of EU funds and introducing a novel, uncertainty-aware MCDM framework that captures the multidimensional and long-term development potential of investments, thereby providing a more realistic and policy-relevant assessment of their structural impact.

2. Literature review

The European Union finances its cohesion and development policies through five main funds: the European Regional Development Fund (ERDF), the Cohesion Fund (CF), the European Social Fund Plus (ESF+), the European Agricultural Fund for Rural Development (EAFRD) and the European Maritime, Fisheries and Aquaculture Fund (EMFAF). In addition, complementary programmes such as Horizon Europe and the Recovery and Resilience Facility (RRF) further strengthen the research and innovation capacities of Member States [8].

According to a report by the European Commission [9], Croatia is among the most successful new Member States in using EU funds, and the effects are visible through a short-term increase in investment activity and economic growth rates. Analyses by Šelebaj and Bule [10] confirm that grants have had a positive impact on employment, income and productivity of Croatian companies, while aggregated data show GDP growth and an increase in investments from cohesion sources.

Such findings correspond to the broader European context. A research by Fidrmuc *et al.* [11] shows that EU funds have had a significant, but spatially differentiated, positive impact on economic growth in European regions, with pronounced spillover effects towards neighbouring areas. Similarly, Aparicio-Pérez *et al.* [12] in their counterfactual analysis of the Next Generation EU program in Spain confirm an increase in GDP per capita between 2022 and 2025 compared to the scenario without NGEU funds. The results show that the EU's coordinated fiscal response through the RRF has produced measurable short-term positive effects on macroeconomic indicators, especially in countries strongly affected by the crisis.

However, research that relies on regression models and short time series fails to capture the long-term and sustainable effects of funds. Győrffy, D. [13], in the analysis of the countries of Central and Eastern Europe in the period 2008-2015, does not find a significant connection between the rate of absorption of funds and GDP growth, concluding that funds generate results more slowly and in the longer term and that it is not possible to use them as a tool for rapid recovery of the economy. A similar conclusion is made by Vukašina [14], who confirmed that EU funds contribute to increasing the standard of living but also emphasized that a significantly longer time horizon is needed to assess real and sustainable development. This indicates the limitation of existing research, which in most

cases is focused on short-term macroeconomic indicators, while the structural dimensions of development remain out of focus.

A significant shortcoming of existing analyses is the neglect of demographic, innovation, environmental, resilience and institutional effects. Demographic effects, such as population retention, attracting young people and reducing depopulation, cannot be observed in a single financial perspective, but require observation over a longer period [14].

Foray [15] stated that innovation capacity is developed through strengthening research infrastructure and networks of cooperation between scientific institutions and entrepreneurs, and its impact is not measured solely by the number of start-ups, but by the ability of a region to create and retain knowledge. On the other hand, Lobo & Bande [16] state that environmental effects are often limited to physical indicators (e.g. the number of renovated buildings), while the long-term contribution to emission reduction and climate resilience can only be observed over several decades.

Similarly, the resilience of the economy and communities, although increasingly integrated into projects, is difficult to quantify due to the lack of standardized indicators [8]. Finally, the institutional quality, which includes transparency, accountability and the ability to manage projects, is key to the effectiveness of funds, but can also be strengthened by their application [17].

New approaches advocate a holistic and multi-criteria evaluation of the effects of funds, which includes economic, social, demographic, environmental and institutional dimensions [16]. In their work, Popescu, *et al.* [18] state that models linking projects to the Sustainable Development Goals (SDGs) or national sustainability strategies enable more systematic monitoring of the real effects of EU investments.

In addition, the European Commission [8] in the *Align, Act and Accelerate Report* emphasizes the need for an integrated approach to research, innovation and industrial policy through the ERC, EIC and MSCA programs, which aims to increase the long-term competitiveness and sustainability of the European economy.

Recent contributions in the field of business analytics and decision science further reinforce the importance of multi-criteria approaches in complex evaluation contexts. In this regard, Sarkar and Goswami [19] provide a comprehensive review of the application of MCDM methods in business analytics, emphasizing their growing role in addressing multidimensional decision problems characterized by conflicting criteria and uncertainty. Their findings highlight that traditional single-indicator approaches are increasingly insufficient for capturing the complexity of modern economic systems, thus justifying the use of advanced decision-support frameworks.

Similarly, Ullah *et al.* [20] demonstrate the application of advanced fuzzy-based MCDM models in stock market decision-making, combining CRITIC and WASPAS methods within a complex uncertainty environment. Their results confirm that incorporating uncertainty and expert-based evaluations leads to more robust and realistic decision outcomes. This is particularly relevant in contexts such as public investment evaluation, where precise quantitative data are often limited and subjective assessments play a significant role.

After reviewing the existing literature, it can be concluded that current empirical studies primarily concentrate on short-term economic impacts and fail to encompass a multidimensional perspective on development. This is precisely why the application of multi-criteria decision-making methods (MCDM) in the context of EU funds is considered an innovative approach, as it has not previously been utilized to evaluate long-term development potential at the level of an individual country.

3. Methodology

This research is carried out through certain phases that are connected to each other. These stages are:

- Preparatory phase of research,
- Conducting the research,
- Data processing,
- Conducting the analysis.

Any research based on the MCDM method begins with a preparatory phase in which alternatives and criteria are determined [1]. Due to the specificity of conducting this research, where the effects of EU funds on the development of infrastructure in the Republic of Croatia are observed, certain projects within individual sectors were observed when defining alternatives. In this way, ten alternatives were defined in this research. These alternatives are presented in Table 1. This study aimed to identify the areas where EU funding has had the most significant impact and what improvements have been made in the Republic of Croatia using the example of Zadar County.

Table 1
The impact of EU funding research alternatives.

Tags	Alternative	Range of alternatives
Alternative 1	Water and utility infrastructure	Drainage systems, treatment plants on islands and in the hinterland
Alternative 2	Traffic connectivity and safety	Ports, piers, road reconstruction, ITS system
Alternative 3	Digitalization of public services and schools	City administration e-services, smart mobility, e-schools
Alternative 4	Energy renovation of public buildings and RES (Renewable sources of energy)	Schools, kindergartens, health centres, solar panels
Alternative 5	Waste and water management	Recycling centres, green islands, reduction of water losses
Alternative 6	Culture and heritage	Rector's Palace, 'Zadar Heritage', interpretation centres
Alternative 7	Entrepreneurial and research infrastructure	Incubators, business zones, laboratories
Alternative 8	Protection against climate risks	STREAM project – floods and fire prevention measures
Alternative 9	Health and social services	Modernization of hospitals, equipment, social programs
Alternative 10	Tourism and recreational infrastructure	Bicycle paths, promenades, coastal restoration

In order to determine the effects of these alternatives, the criteria for this research were selected. A total of eight criteria were selected. These criteria were chosen in such a way that each alternative would be viewed equally. Consequently, an initiative was undertaken to ensure that these criteria remain neutral (refer to Table 2). For every chosen criterion, an assessment was conducted to identify the observations associated with those criteria that ought to enhance these alternatives, thereby improving their scores.

These alternatives and criteria were then subsequently used to create the questionnaire. By employing MCDM methods, the questionnaire was designed so that respondents initially needed to assess the significance of specific criteria for evaluating the effectiveness of EU funds, followed by an evaluation of how each alternative aligns with the established research criteria. To achieve this, linguistic value scales were implemented, spanning from very poor to very excellent across seven levels (see Table 3). The initial phase of this study was concluded with the development of the questionnaire.

Table 2
Criteria for observing the effects of EU funds

Criteria	Contributions of criteria
C1. Innovation and technological impacts	Strengthening research, development, digitalisation, smart specialisations and start-ups
C2. Demographic impacts	Contributing to population retention, attracting young people, preventing depopulation and the return of emigrants
C3. Tourism impacts	Improving the quality of the tourist offer, extending the season, diversifying services and sustainable tourism, preserving and promoting cultural heritage
C4. Regional cohesion and territorial balance	Reducing the differences between urban and rural areas and connecting islands and hinterlands.
C5. Resilience and security	Increasing preparation for crisis situations (floods, droughts, pandemics, earthquakes)
C6. Cooperation and partnerships	Encouraging networks between institutions, entrepreneurs, the education sector and civil society
C7. Economic impacts (general)	Growth in GDP, employment, private investment and productivity
C8. Institutional impacts	Management capacity, transparency, accountability and sustainability of project results

The second phase is intended for conducting the research. This research utilized the Zadar County as a regional case study within the Republic of Croatia, focusing on both quantitative and qualitative analyses of the long-term impacts of EU fund utilization. To facilitate this research, professionals from the Zadar development agency ZADRA NOVA and Zadar Innovations were engaged, possessing practical experience in project preparation and execution, along with a profound understanding of the regional context. These professionals were the subjects of the study, and a questionnaire was distributed for them to complete. The questionnaire was sent electronically to the respondents, and a follow-up message was dispatched twice to encourage maximum participation. Consequently, at the conclusion of this research, a total of 16 completed questionnaires were gathered, which were used to obtain the results of this research. While the assessment from 16 experts may be considered relatively limited, it is important to note that the selected experts possess extensive experience in the preparation and execution of EU projects, thereby enhancing the professional validity of their evaluations. To mitigate the individual influence of the experts, an aggregate approach utilizing the average values of the scores will be employed. Furthermore, the application of the neutrosophic set allows for the incorporation of uncertainty in the decision-making process regarding which projects yielded the most favourable outcomes. This approach enhances the robustness of the decision model compared to the traditional fuzzy methodology.

Given that the scores were represented in linguistic values, it is essential to process these values. The third phase of this research involves data processing. Following the collection of data, evaluations regarding the significance of criteria and the assessment of alternatives in relation to the fulfilment of these criteria are derived in the form of linguistic values. To subsequently utilize these scores in Multi-Criteria Decision-Making (MCDM) methods, it is necessary to convert them into numerical values [20]. In practice, various methods exist for transforming linguistic values into numerical values [21]. This research will employ the neutrosophic set, which serves as an extension of the classic fuzzy and intuitive fuzzy approaches [22] to convert linguistic values into numerical values.

The neutrosophic set approach was proposed by Smarandach [23] to facilitate decision-making under conditions of uncertainty, vagueness, and contradictions present in the data utilized for decision-making. The neutrosophic approach is particularly applicable when the data originates from unreliable sources and contains noise or ambiguities, which can influence the final decision, as it operates with unclear data [24]. Let X represent the universe of discourse; hence, the neutrosophic set A within the universe X is defined as:

$$A = \{\langle x, T_A(x), I_A(x), F_A(x)\rangle | x \in X\} \quad (1)$$

Whereby the factors are:

$$T_A(x), I_A(x), F_A(x): X \rightarrow [0, 1] \quad (2)$$

Thus, the elements in a neutrosophic set are: T - Degree of truth, I - Degree of indeterminacy and F - Degree of falsity.

Unlike an intuitionistic fuzzy set, here the following holds:

$$0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3 \quad (3)$$

Consequently, the total of these elements does not necessarily need be equal one; however, their individual values can range from [0, 1]. The distinction between this method and the fuzzy approach lies in the fact that the values of fuzzy numbers are comparable and increase uniformly with a higher score [25]. Thus, the fuzzy approach solely accounts for the degree of membership of a fuzzy number within a specific set [26]. Degrees of non-membership or uncertainty are not considered. In contrast, the intuitive fuzzy approach considers both the degrees of membership and non-membership to a particular set, with the stipulation that the sum of these degrees must not exceed one ($T_A(x) + F_A(x) \leq 1$). The portion that is not accounted for by membership and non-membership represents a degree of uncertainty [27]. When utilizing the neutrosophic set, there are no rigidly defined rules, which means that the sum of the degrees of membership, non-membership, and uncertainty does not have to equal one; it may be greater or less than one [28]. From this, it can be inferred that if the sum is less than one, it indicates incomplete information, whereas if the sum exceeds one, it signifies contradictory information [29]. Therefore, in determining the values of the components of the neutrosophic set, the initial assumption was that the evaluator partially believes the assessment to be correct, partially believes it to be incorrect, and partially is uncertain about the correctness of the assessment. When assigning values for extreme scores (very bad / very good), experts exhibit greater confidence and there is minimal ambiguity or uncertainty; conversely, for moderate scores, uncertainty prevails, and these scores aim to reflect human decision-making. In this manner, the values of the components within the neutrosophic set are established such that the values of T and F exhibit asymmetry; while the maximum value for the very poor component F corresponds to the maximum value for the very good component T, and vice versa. Consequently, these values are interconnected and asymmetrical. Subsequently, indecision and uncertainty escalate towards the mean value, where they reach their peak, and then diminish as they approach the highest value. This reduction in the value of component I is proportional from the mean value to either the highest or lowest value.

Table 3
Linguistic scale of values and defined values of the neutrosophic set

Level	Linguistic score	T	I	F
1	Very bad (V.BA)	0.05	0.20	0.90
2	Bad (BAD)	0.20	0.30	0.75
3	Moderately bad (M.BA)	0.35	0.40	0.60
4	Medium (MED)	0.50	0.50	0.50
5	Moderately good (M.GO)	0.60	0.40	0.35
6	Good (GOO)	0.75	0.30	0.20
7	Very good (V.GO)	0.90	0.20	0.05

When establishing the value of uncertainty or independence, it is essential to consider the attitude towards uncertainty. This perspective influences the level of uncertainty the respondent feels regarding their final decision. Consequently, this level of uncertainty (α) can range from

complete acceptance of uncertainty, where the degree of uncertainty (α) is zero, to an extreme aversion to uncertainty, where the degree of uncertainty (α) exceeds one. In this study, a stance of moderate realism will be adopted, with the degree of uncertainty set at (α = 0.5). In this study, a stance of moderate realism was adopted, with the degree of uncertainty set at α = 0.5.

To implement the method utilizing the neutrosophic set for assessing the impact of EU funds, it is essential to convert the values of the neutrosophic set components into a crisp value. The determination of the crisp value will be executed through the application of the Euclidean distance, which involves calculating the deviation of these values in relation to both the ideal and anti-ideal solutions. The transformation of each linguistic evaluation into a crisp number was performed by calculating its Euclidean distance from both an ideal neutrosophic set (1,0,0) and an anti-ideal set (0,0,1), while incorporating a constant uncertainty factor (α = 0.5 to reflect moderate realism). For instance, the linguistic value "good" (T=0.75, I=0.30, F=0.20) was transformed into a crisp value of 0.7579, indicating a high degree of membership. This procedure ensures that the inherent uncertainty of each expert judgment is preserved and systematically accounted for in subsequent calculations. This process begins with the computation of the deviation from these values, which is determined as follows:

$$d_{ij}^{+} = \sqrt{\left(T_{ij} - 1\right)^2 + \left[\left(I_{ij} \times \alpha\right) - 0\right]^2 + \left(F_{ij} - 0\right)^2} \tag{4}$$

$$d_{ij}^{-} = \sqrt{\left(T_{ij} - 0\right)^2 + \left[\left(I_{ij} \times \alpha\right) - 0\right]^2 + \left(F_{ij} - 1\right)^2} \tag{5}$$

As can be seen from the calculation of deviations from ideal and anti-ideal solutions, the influence of uncertainty is constant and does not deviate in value. Finally, the crisp value is calculated based on these deviations as follows:

$$c_{ij} = \frac{d_{ij}^{-}}{\left(d_{ij}^{+} + d_{ij}^{-}\right)} \tag{6}$$

By implementing this procedure, the values of crisp numbers are derived, where crisp numbers are defined as c_{ij} = [0,1]. Consequently, the values of crisp numbers fall within the range of zero to one, rendering them appropriate for subsequent analysis.

Once the data has been processed and prepared for analysis, the next phase involves conducting the analysis, during which the collected data is utilized alongside the steps of the selected MCDM methods to derive research outcomes [30,31]. The crisp value serves as the initial value for the application of these methods. In this study, the SWARA (Stepwise Weight Assessment Ratio Analysis) method will be employed to ascertain the significance of the criteria. This method was selected due to its practical application over the past 15 years, demonstrating favourable results [32]. Furthermore, this method is user-friendly and facilitates rapid results. This efficiency is attributed to the procedural steps outlined by the authors Keršulienė *et al.* [33]. These steps have been refined in this research and are as follows:

Step 1. Evaluation of the importance of the criteria by the respondents,

Step 2. Transformation of neutrosophic set values into crisp values,

Step 3. Calculation of the average values of the criteria,

Step 4. Ranking criteria based on average values.

These steps represent the preparatory steps for implementing the SWARA method. These steps are followed by the classic steps of the SWARA method, namely [34]:

Step 5. Determining the relative importance of criteria.

$$k_j = \begin{cases} 1 \; if \; j = 1 \\ s_j + 1 \; if \; j > 1 \end{cases} \tag{7}$$

Step 6. Determining the relative q_j value.

$$q_j = \begin{cases} 1 \; if \; j = 1 \\ \frac{q_{j-1}}{k_j} \; if \; j > 1 \end{cases} \tag{8}$$

Step 7. Calculating the values of the criteria weights.

$$w_j = \frac{q_j}{\sum_{j=1}^{n} q_k} \tag{9}$$

After determining the importance of the criteria using weight values, the alternatives identified in this study are ranked. These alternatives pertain to infrastructure projects across various sectors of Zadar County. To facilitate the ranking of these alternatives, a modified version of the CORASO (COmpromise Ranking from Alternative SOlutions) method was used. The modification occurs in the final step, where the value of this method is established. This adjustment was implemented to scale the values of the method from zero to one. The reasons for selecting this method is primarily based on the reliability of the results it yields, the straightforward nature of its steps, and its practical application, as it is categorized among the newer Multi-Criteria Decision-Making (MCDM) methods. The procedure of this method was delineated by the authors Puška *et al.* [35], with certain adaptations made for this research. The initial two steps mirror those found in the SWARA method.

Step 1. Evaluation of the importance of the criteria by the respondents,

Step 2. Transformation of neutrosophic set values into crisp values.

These steps are followed by the classic steps of the CORASO method, namely:

Step 3. Normalization of crisp values

$$n_{ij} = \frac{x_{ij}}{\max x_j} \tag{10}$$

Step 4. Determination of alternative solutions.

These solutions represent the highest values (max AS) and the lowest values of alternatives (min AS) for certain criteria.

Step 5. Weighting normalized values and alternative solutions as well

$$v_{ij} = w_j \cdot n_{ij} \tag{11}$$

Step 6. Forming aggregate values of alternatives, including alternative solutions

$$S_j = \sum_{i=1}^{n} v_j \tag{12}$$

Step 7. Deviations from alternative solutions.

$$Rj = SjSj \; max \; AS \tag{13}$$

$$R'_j = \frac{S_{j \; min \; AS}}{S_j} \tag{14}$$

Step 8. Calculating the value of the CORASO method.

$$Q_i = \frac{R_j}{R_j + R'_j} \tag{15}$$

By implementing the revised step 8 of the CORASO method, the outcome is adjusted to fall within the range of zero to one, rather than the typical range of minus one to one associated with the standard step of the CORASO method.

Once the alternatives have been ranked, a sensitivity analysis will be performed to assess the extent of influence each criterion exerts on the final ranking of the criteria. This process will reveal the significance of each criterion within the ranking list. To execute this analysis, individual criteria will be decreased by 30, 60, and 90%, while the remaining criteria will be proportionally increased to

account for this reduction. Consequently, a single criterion will exert less influence on the ranking of alternatives, whereas the impact of other criteria will be somewhat enhanced.

4. Results

The utilization of this research hinges on the implementation of evaluations represented as linguistic values, alongside an approach grounded in the neutrosophic set. Prior to delving into the processing of the research findings, the principle of converting the values of the neutrosophic set elements into precise numerical values will be explained, which will form the foundation for deriving results through the SWARA and CORASO methods. For instance, let us consider the score 'good'; the procedure for converting this score into crisp numbers is outlined as follows:

$$d_{good}^{+} = \sqrt{(0.75-1)^2 + [(0.30 \times 0.50) - 0]^2 + (0.20-0)^2} = 0.3536$$

$$d_{good}^{-} = \sqrt{(0.75-0)^2 + [(0.30 \times 0.50) - 0]^2 + (0.20-1)^2} = 1.1068$$

$$c_{good} = \frac{1.1068}{(0.3536 + 1.1068)} = 0.7579$$

Utilizing this principle, the transformation of all linguistic values into crisp values is executed in this manner through an approach grounded in the neutrosophic set. In assessing the impacts of projects funded by the EU, it is essential to first ascertain the significance of the weight of the criteria by implementing the steps of the SWARA method. The initial step involves evaluating the importance of the criteria by 16 experts (refer to Table 4). These experts, designated as EX1-EX16, assessed the significance of these criteria using linguistic values. Subsequently, based on the outlined procedure, these assessments are converted into crisp numbers, and the steps of the SWARA method are subsequently applied.

Table 4
Evaluation of the significance of criteria in assessing the impacts of EU funds

Expert	C1	C2	C3	C4	C5	C6	C7	C8
EX1	GOO	MED	BAD	MED	V.BA	MED	M.GO	M.GO
EX2	GOO	V.GO	M.GO	GOO	V.GO	V.GO	GOO	V.GO
EX3	M.GO	V.GO	V.GO	GOO	V.GO	V.GO	V.GO	V.GO
EX4	V.GO	V.GO	GOO	GOO	V.GO	GOO	V.GO	V.GO
EX5	V.GO	V.GO	V.GO	GOO	GOO	GOO	GOO	GOO
EX6	V.GO	V.GO	M.GO	V.GO	V.GO	M.GO	V.GO	GOO
EX7	MED	MED	MED	M.BA	M.BA	GOO	M.GO	GOO
EX8	GOO	M.GO	M.GO	M.GO	M.GO	M.GO	M.GO	M.GO
EX9	V.GO	M.GO	GOO	M.GO	V.GO	V.GO	V.GO	M.GO
EX10	V.GO	V.GO	V.GO	V.GO	V.GO	V.GO	V.GO	V.GO
EX11	M.BA	M.BA	MED	BAD	BAD	M.GO	BAD	MED
EX12	GOO	V.GO	GOO	MED	M.GO	GOO	M.GO	GOO
EX13	GOO	V.GO	V.GO	V.GO	M.GO	GOO	V.GO	M.GO
EX14	M.GO	V.GO	V.GO	V.GO	V.GO	V.GO	V.GO	V.GO
EX15	V.GO	GOO	M.GO	GOO	M.GO	GOO	V.GO	MED
EX16	V.GO	V.GO	M.GO	GOO	GOO	V.GO	GOO	GOO

By converting scores expressed as linguistic values into crisp numbers, it is possible to determine the average expert score for the evaluated criteria, thereby facilitating the preparation for the execution of the traditional steps of the SWARA method. Once the average value of the criteria is computed, the criteria are subsequently ranked according to these values. Criterion C2 exhibited the

highest average value, succeeded by criterion C6. Following this, the criteria are organized based on their average values, and the components of the SWARA method are determined. Initially, the relative significance of the criteria is assessed. This is done by assigning a value of 1 to the highest-ranked criterion, while for the remaining criteria, the difference between the average values of the previously ranked criterion and those of the other criteria is calculated, with one added to this difference. Taking criterion C6 as an example, the calculation proceeds as follows:

$$k_{C2} = 1 + (0.7717 - 0.7673) = 1.0044$$

Then the value q_j is calculated, which is obtained by rewriting the value one for the top-ranked criterion, while for the remaining criteria, the value q_j is calculated by taking the value q_j from the preceding ranked criterion and dividing it by the relative importance value of that criterion. For the identical criterion, this is calculated in the following manner:

$$q_{C6} = \frac{1.0000}{1.0044} = 0.9956$$

Once the q_j values have been computed, their total is determined, and each individual value is divided by this total to establish the weight of the criterion. The calculation for the same criterion is performed as follows.

$$w_j = \frac{0.9956}{7.3828} = 0.1349$$

The specificity of this method lies in the fact that the weight values assigned to the criteria are determined by the ranking of their average scores. Consequently, the criterion with the highest average score was allocated the greatest weight and the rest (refer to Table 5). As a result, criterion C2 was assigned the highest weight, followed by demographic effects and criterion C6. Cooperation and partnerships were given a lower weight, while criterion C5 received the least weight, pertaining to resilience and security. It is important to highlight that there is no substantial difference in the weights of the criteria, indicating that all criteria significantly influence the ranking of alternatives.

The subsequent phase involves ranking the alternatives utilizing the CORASO method. Initially, the selected alternatives are evaluated based on their adherence to the established criteria. In this process, experts assess the extent to which each alternative satisfies the defined criteria (refer to Table 6). Following this evaluation, the linguistic values are converted into crisp values as previously described. Then, a collective decision matrix is created, serving as the foundation for ranking the alternatives.

Table 5
Calculation of the SWARA method results

Average scores	Criterion	k_j	q_j	w_j
0.7717	C2	1.0000	1.0000	0.1354
0.7673	C6	1.0044	0.9956	0.1349
0.7616	C1	1.0056	0.9900	0.1341
0.7597	C7	1.0745	0.9214	0.1248
0.7335	C8	1.0262	0.8979	0.1216
0.6923	C3	1.0412	0.8624	0.1168
0.6871	C4	1.0052	0.8579	0.1162
0.6867	C5	1.0004	0.8575	0.1162
		Sum:	7.3828	

Table 6
Scores of alternatives and summary decision-making matrix

EX1	C1	C2	C3	C4	C5	C6	C7	C8
Alternative 1	MED	BAD	V.BA	BAD	MED	MED	BAD	MED
Alternative 2	M.GO	MED	M.GO	MED	M.BA	MED	MED	BAD
Alternative 3	M.GO	BAD	V.BA	BAD	BAD	M.GO	BAD	MED
Alternative 4	M.GO	V.BA	MED	BAD	MED	MED	MED	BAD
Alternative 5	M.GO	V.BA	M.BA	M.BA	V.BA	MED	M.GO	V.BA
Alternative 6	M.BA	V.BA	M.GO	M.BA	V.BA	M.GO	MED	BAD
Alternative 7	M.GO	MED	M.BA	MED	M.BA	M.GO	M.GO	V.BA
Alternative 8	MED	V.BA	M.BA	V.BA	MED	GOO	M.BA	MED
Alternative 9	MED	MED	V.BA	BAD	BAD	MED	M.BA	M.GO
Alternative 10	MED	MED	GOO	MED	V.BA	BAD	M.GO	V.BA
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
EX16	C1	C2	C3	C4	C5	C6	C7	C8
Alternative 1	M.GO	MED	M.BA	M.GO	MED	MED	MED	M.BA
Alternative 2	GOO	MED	MED	MED	MED	MED	M.GO	M.GO
Alternative 3	GOO	GOO	MED	GOO	GOO	GOO	M.GO	GOO
Alternative 4	M.GO	MED	M.BA	M.GO	MED	M.BA	M.BA	M.GO
Alternative 5	MED	MED	M.GO	MED	M.GO	M.GO	M.GO	M.GO
Alternative 6	M.GO	M.GO	V.GO	GOO	MED	GOO	GOO	GOO
Alternative 7	V.GO	GOO	GOO	V.GO	GOO	V.GO	V.GO	V.GO
Alternative 8	V.GO	M.GO	GOO	V.GO	V.GO	V.GO	GOO	V.GO
Alternative 9	V.GO	V.GO	GOO	V.GO	V.GO	V.GO	GOO	V.GO
Alternative 10	M.GO	GOO	V.GO	V.GO	M.GO	GOO	GOO	GOO
Summary	C1	C2	C3	C4	C5	C6	C7	C8
Alternative 1	0.5788	0.5730	0.6623	0.6764	0.6213	0.6799	0.6460	0.6549
Alternative 2	0.6621	0.6357	0.7599	0.6869	0.6231	0.6301	0.6603	0.6603
Alternative 3	0.7540	0.6490	0.5231	0.6580	0.5747	0.7292	0.6810	0.7030
Alternative 4	0.6485	0.6083	0.6372	0.6549	0.5338	0.5906	0.5998	0.6564
Alternative 5	0.6357	0.5448	0.6706	0.6475	0.6693	0.6442	0.6017	0.6547
Alternative 6	0.5786	0.5130	0.8008	0.5625	0.4664	0.6161	0.6091	0.6475
Alternative 7	0.8039	0.7512	0.6495	0.6797	0.6336	0.7583	0.8109	0.7102
Alternative 8	0.7117	0.5538	0.6068	0.5750	0.8111	0.7015	0.6037	0.7028
Alternative 9	0.7102	0.7525	0.5786	0.6547	0.6778	0.6819	0.6516	0.7599
Alternative 10	0.5610	0.6690	0.8111	0.7028	0.4982	0.6386	0.6122	0.6052

The steps of the CORASO method will be explained on the example of alternative 1 and criterion C1. First, normalization is performed:

$$n_{11} = \frac{0.5788}{0.8039} = 0.7200$$

The best alternatives are subsequently identified, where the maximum optimal alternative locates the highest normalized values of the alternatives for each criterion, whereas the minimum optimal alternative identifies the lowest normalized values of the alternatives for each criterion. Following this, the aggregation of these values occurs.

$$v_{11} = 0.1341 \times 0.7200 = 0.0965$$

After the values are weighted, the total values of the alternatives are calculated. In the example of alternative 1, this is calculated as follows:

$$S_1 = 0.0966 + 0.1031 + 0.0954 + 0.1118 + 0.0890 + 0.1209 + 0.0994 + 0.1048 = 0.8210$$

Then the deviation from the alternative solutions is calculated and the value of the CORASO method is calculated (refer to Table 7)

$R_1 = \frac{0.8210}{1.0000} = 0.8210$; $R'_1 = \frac{0.7153}{0.8210} = 0.8710$; $Q_1 = \frac{0.8210}{0.8210+0.8712} = 0.4852$

According to the assessment of the outcomes derived from the CORASO method, it can be inferred that, based on the opinions of experts, the projects executed under the Entrepreneurial and Research Infrastructure yielded the most favorable results, followed by those in Health and Social Services, whereas the projects conducted in the area of Culture and Heritage received the least favorable evaluations.

Table 7
Calculation of the CORASO method values

Alternative	S_i	R_j	R'_j	Q_i	Rank
Alternative 1	0.8210	0.8210	0.8712	0.4852	7
Alternative 2	0.8565	0.8565	0.8351	0.5063	3
Alternative 3	0.8560	0.8560	0.8356	0.5061	4
Alternative 4	0.7966	0.7966	0.8979	0.4701	9
Alternative 5	0.8155	0.8155	0.8771	0.4818	8
Alternative 6	0.7709	0.7709	0.9278	0.4538	10
Alternative 7	0.9393	0.9393	0.7615	0.5523	1
Alternative 8	0.8472	0.8472	0.8443	0.5008	5
Alternative 9	0.8857	0.8857	0.8076	0.5231	2
Alternative 10	0.8230	0.8230	0.8691	0.4864	6
AS max	1.0000				
AS min	0.7153				

Once the alternatives have been ranked, a sensitivity analysis is conducted [36-38]. Given the nature of the sensitivity analysis, which involves reducing the significance of an individual criterion by a factor of three, and considering that there are eight criteria, a total of 24 scenarios were developed. The results of these scenarios indicate that altering the weight of four criteria resulted in a shift in the ranking of the alternatives. Specifically, when the weight of criterion C2 was diminished, the ranking of alternative A10 deteriorated, moving from the sixth position to the eighth position in the overall ranking. This change can be attributed to the fact that alternative A10 performed better on this criterion compared to alternatives A1 and A5; thus, with the decreased importance of these criteria, the latter two alternatives achieved a more favourable ranking. Similarly, adjustments in the ranking of other alternatives occurred for criteria C3, C4, and C5. The findings from the sensitivity analysis revealed that the rankings of alternatives A7 and A9, which were the highest ranked, remained unchanged. Furthermore, there was no alteration in the rankings of alternatives A4 and A6, which were the lowest ranked (Figure 1).

5. Discussion

Understanding the impact of EU funds is essential for the ongoing development of the Republic of Croatia, enabling the adjustment of policies for their future utilization based on this knowledge. To investigate this matter, the present research was undertaken. Unlike other similar studies that concentrated on the financial outcomes of specific projects, this research prioritized expert opinions instead. Any investment, and consequently the allocation of EU funds, should contribute to enhancing the performance of particular sectors and increasing employment within those sectors [39]. A distinctive feature of this methodology is the ability to uniformly compare projects across various sectors. The evaluation of the projects in this study was conducted using linguistic values. A total of 16 experts participated in this research to ensure the provision of the most accurate information.

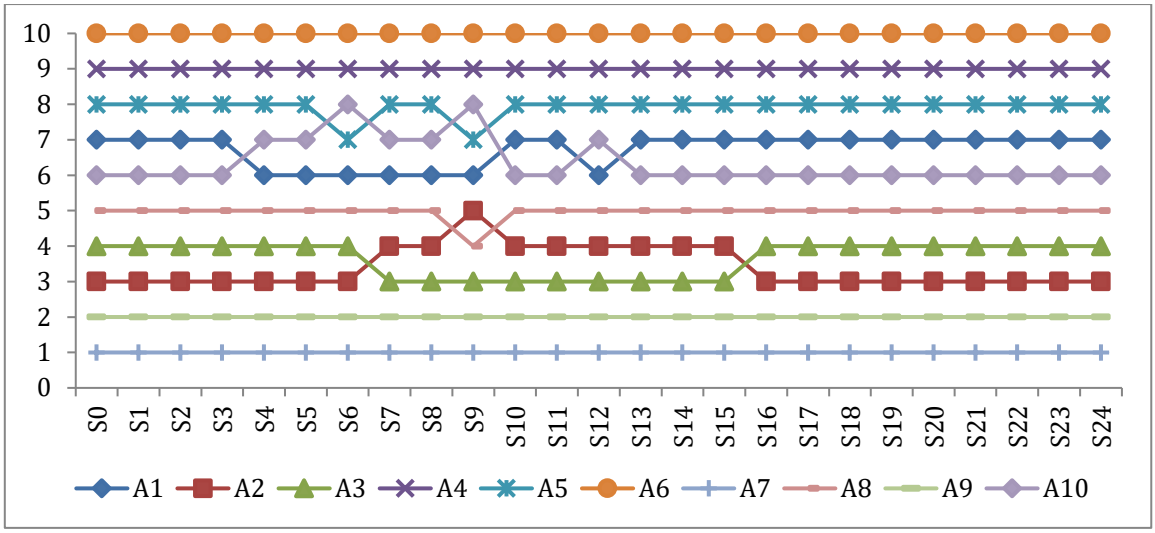

Fig. 1. Results of the sensitivity analysis

However, given the variety of sectors examined in this study, a neutrosophic set-based approach was employed. This method allows for the assessment of uncertainty levels. Consequently, it addresses the uncertainty that arises from the challenges in accurately evaluating projects across different sectors. Therefore, it was imperative to enhance the evaluation process by incorporating the degree of uncertainty. Additionally, this research aimed to establish a method for converting scores expressed as linguistic values into crisp values to facilitate their analysis. In this context, the calculation of the Euclidean deviation from ideal or anti-ideal solutions was utilized. The application of this approach simplifies the integration of the neutrosophic set into decision-making processes. This is advantageous as it allows for the straightforward transformation of the components of the neutrosophic set into crisp values.

In the process of obtaining the results from this research, the SWARA and CORASO methods were employed. The SWARA method identifies which key criteria hold greater significance than others. The results obtained indicated that demographic effects (C2), cooperation and partnerships (C6), and innovation and technological effects (C1) are deemed more critical in comparison to the other eight criteria observed. This emphasis can be attributed to the fact that the accession of Croatia to the EU has granted it access to the labour markets of other EU member states. Consequently, this has led to a migration of the working-age population from Croatia, necessitating the enhancement of specific sectors and the improvement of conditions to mitigate population outflow. Demography assumes additional significance within the framework of long-term priorities established by the European Commission, particularly concerning the development of territorial cohesion and the reduction of depopulation. Therefore, it is imperative for Croatia to address the negative migration balance and to bolster strategic initiatives aimed at investing in sectors that will yield sustainable employment opportunities. Furthermore, fostering cooperation and partnerships among various sectors and institutions is essential to create improved conditions for the development of Croatia. It is also crucial to enhance innovation and technological advancements to advance the Croatian economy, thereby increasing its competitiveness in the global market.

The results that demographic effects (C2) are the most important criteria coincide with the macroeconomic analysis of the Republic of Croatia, which highlights the large migration of population to other EU countries [10, 14]. This coincidence confirms that local authorities must prioritize long-term structural challenges over short-term financial indicators. The high importance of the criterion cooperation and partnership (C6) correlates with the conclusions of the European Commission report [8], which identifies networked innovation ecosystems as a prerequisite for sustainable

competitiveness. In contrast, resilience and security (C5) received the lowest weight, which may reflect the specific geographical and economic context of Zadar County.

The findings of this study are aligned with recent research that emphasizes the importance of advanced analytical frameworks for evaluating efficiency and decision-making outcomes. For example, Shaw *et al.* [40] applied Data Envelopment Analysis (DEA) to assess firm efficiency over multiple periods, demonstrating the value of structured efficiency measurement in complex economic systems. While DEA focuses primarily on input-output efficiency, the present study extends this perspective by incorporating a broader set of qualitative and strategic criteria, thereby offering a more comprehensive evaluation of long-term development potential.

Furthermore, the growing role of intelligent and data-driven decision-support systems is highlighted in contemporary research. Mittal [41] proposes an artificial intelligence-based framework for market optimization in the pharmaceutical industry, demonstrating how advanced analytical tools can enhance strategic decision-making processes. In a similar vein, the approach adopted in this study contributes to this stream of research by integrating expert knowledge, uncertainty modelling, and multi-criteria evaluation, thereby supporting more informed and strategic allocation of EU funds.

Utilizing the CORASO method yielded results indicating that projects in the entrepreneurship and research infrastructure sector derive the most significant benefits from EU funds. This can be attributed to the critical role that entrepreneurship and research infrastructure play in the ongoing development of any nation. Consequently, it is imperative to bolster entrepreneurship and innovate new products and services through research to achieve optimal outcomes for the advancement of the Republic of Croatia. It is crucial to note that the findings of this study do not accurately represent the actual distribution of EU fund allocations; rather, they reflect an evaluation of the long-term developmental potential of specific project categories as assessed by experts. This brings forth the issue of the strategic focus of investments. EU funds ought to be directed towards sectors that yield the most substantial long-term structural impacts, rather than solely towards projects that are prevalent in short-term infrastructure investment cycles. While infrastructure projects are vital for regional development, the enduring success of the economy relies more heavily on enhancing entrepreneurial and research infrastructure, fostering innovation capabilities, and promoting collaboration between institutions and the business sector. Such a strategic focus has immediate consequences for the labour market and the competitiveness of the nation, as it aids in the creation of higher-quality jobs, boosts productivity, and retains a highly educated workforce. Therefore, the sustainable impacts of EU funds are not primarily derived from the magnitude of investments, but rather from their capacity to encourage structural transformation within the economy and the long-term fortification of the labour market.

The contributions of EU funds to the Republic of Croatia include the enhancement of health and social services, leading to the modernization of hospitals and the improvement of social programs, which in turn has resulted in better living conditions for the population. Nevertheless, these outcomes indicate that the impact on the strengthening of culture and heritage in Zadar County has been minimal. This may be attributed to various factors, as this area is unique and has received less investment, resulting in smaller effects due to fewer projects. Consequently, it is essential to consider the equitable distribution of investments across different sectors utilizing EU funds to facilitate balanced development throughout all sectors in the Republic of Croatia.

6. Conclusions

This research was conducted to investigate the impact of EU funds on various projects across different sectors in the Republic of Croatia, specifically focusing on Zadar County. To ensure a comprehensive evaluation, experts from the Zadar Development Agency ZADRA NOVA and Zadar

Innovations were consulted, as they have primarily worked on these projects and possess extensive knowledge in this field. Alongside their existing expertise, this study incorporates uncertainty through a methodology based on the neutrosophic set, which facilitates the assessment of truth and falsity in linguistic evaluations via membership functions, while also allowing for the quantification of uncertainty. By employing this approach in conjunction with the SWARA and CORASO methods, findings revealed that the most significant criteria identified by experts are demographic effects (C2) and cooperation and partnership (C6), with the most substantial impacts arising from projects focused on entrepreneurship development and research infrastructure.

The results obtained suggest that the true value of EU funds is not primarily measured by the amount of funds utilized, but rather by their capacity to enhance the economic structure over the long term, bolster competitiveness, and improve labour market results. Strengthening entrepreneurial and research infrastructure, fostering innovation, and promoting collaboration between institutions and the business sector are essential prerequisites for generating quality employment, boosting productivity, and retaining the workforce. Consequently, it can be concluded that the strategic allocation of EU funds towards sectors with the most significant structural impact plays a vital role in fostering long-term economic growth and enhancing the resilience of the labour market.

Nevertheless, alongside the results demonstrated by this study, certain limitations have emerged that require addressing in future research. These limitations primarily pertain to the reliance on qualitative indicators rather than quantitative ones, the extent of project realization, and the financial impacts derived from the utilization of EU funds. Furthermore, the limitations also point towards the necessity of employing a more intricate procedure that incorporates the neutrosophic set. This research aimed to simplify this methodology, ensuring it is not overly mathematical, while also striving to make it comprehensible for decision-makers lacking a foundational understanding of this approach. Consequently, the limitations of this study can be attributed to the criteria employed; thus, it is essential for future research to enhance these criteria to encompass the achievement of additional research objectives, which should be further explored in subsequent studies. The rationale behind this necessity lies in the fact that this is a conceptual framework that opens up new avenues for assessing the effects of EU funds, and it could also be applicable for evaluating the influence of other financial instruments on the development of specific regions or countries.

In this regard, forthcoming studies ought to concentrate on examining the correlation between the current distribution of EU funds and the sectors that produce the most significant long-term impact on competitiveness and the labour market, thus enhancing the comprehension of the strategic efficacy of European development policies.

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Conflicts of Interest
The authors declare no conflicts of interest.

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