Passenger Flows Between Romania and Republic of Moldova as a Determining Factor in Cross-Border Cooperation: A Statistical and Econometric Approach

1. Introduction

In the context of intensifying regional integration processes and the continuously evolving geopolitical dynamics of Eastern Europe, the phenomenon of cross-border cooperation between Romania and the Republic of Moldova is emerging as a subject of significant strategic and scientific importance. Since 2016, the border regions of the European Union (classified as NUTS 3) have encompassed approximately 40% of the EU's total population and over 60% of its territory. Consequently, cross-border cooperation has gained increasing importance within the European Union's public policy agenda, reflecting its essential role in fostering territorial cohesion and regional development. In this context, the present study aims to contribute to a nuanced understanding of bilateral cooperation dynamics through a comprehensive statistical and econometric analysis of air passenger flows recorded between Romania and the Republic of Moldova over the past decade.

The primary objective of this research is to identify the extent to which the evolution of passenger mobility influences the development of cross-border cooperation. To this end, the analysis focuses on identifying the determining factors of cross-border mobility and evaluating the impact of passenger flows on bilateral relations between Romania and the Republic of Moldova.

The research methodology adopts a rigorous quantitative framework, combining both parametric and non-parametric methods. Through multifactorial linear regression, Pearson's linear correlation coefficient, and Spearman's rank correlation coefficient, the study identifies and validates causal relationships between passenger flows and various indicators of bilateral cooperation. This methodological arsenal ensures both the robustness of the findings and provides a relevant toolkit for policymakers seeking to develop strategic measures aimed at strengthening cross-border connectivity.

The structure of the article is organized as follows: First chapter offers a review of the existing literature, delineating two major strands of research—qualitative studies focused on institutional and sociopolitical factors, and quantitative approaches that analyze cross-border mobility using statistical models. Chapter 2 details the research methodology, with an emphasis on the econometric instruments and data sources employed. Chapter 3 presents the results of the empirical analysis, highlighting significant trends and correlations. Chapter 4 discusses the limitations of the research, offering a critical perspective on the weaknesses and constraints of the study. Finally, the last chapter formulates the conclusions and strategic recommendations aimed at enhancing the potential for a sustainable and mutually beneficial cross-border cooperation between Romania and the Republic of Moldova.

In light of the growing importance of regional partnerships, this article aspires to make both a conceptual and practical contribution to the consolidation of mobility and integration in Eastern Europe, emphasizing the essential role of empirical evidence in shaping effective public policy.

2. Literature review

Cross-Border Cooperation is an essential component of the European Union's regional development strategy, designed to transform border regions into dynamic socio-economic spaces and to promote the European integration process. Defined by the Interreg program as a means of "bridging the gaps" between development regions, seen as socio-economic disparities (FOGARASI, 2024), it also aims to reduce the negative effects of national borders, as well as to promote the balanced and sustainable development of border territories between NUTS III regions (Androniceanu & Georgescu, 2023, cited by Bilczak, (2024)). Cross-border cooperation is viewed as a way to address common problems and to fully exploit the potential of neighboring territories, strengthening the economic capacity of the countries involved in cross-border cooperation and providing a common foundation for economic development and well-being (Khmeleva et. al, 2022). Being one of the priorities of the EU's cohesion policy, within the Europe 2020 Strategy, sustainable territorial cooperation is funded through the European Regional Development Fund, for example via the INTERREG program (Kurowska-Pysz and Szczepanska-Woszczyna, 2017). Initiated by the European Union in 1990, the Interreg programs serve as the main tool supporting joint projects and initiatives implemented across borders between EU member states. These programs provide financial resources for a wide range of activities covering economic development, environmental protection, transport, culture, and social integration.

Since 1990, six generations of Interreg programs have been implemented: Interreg I (1990–1993), Interreg II (1994–1999), Interreg III (2000–2006), Interreg IV (2007–2013), Interreg V (2014–2020), and Interreg VI (2021–2027). Starting with Interreg III, the program was divided into three separate components: for cross-border projects (Interreg A), for transnational projects (Interreg B), and for interregional cooperation (Interreg C). Interreg VI introduced a new component—cooperation with outermost regions (Interreg D).

During the 2014–2020 programming period, Interreg VA, which aimed to support cross-border cooperation at the EU’s internal borders, included 56 programs with a total budget of over EUR 6.6 billion (European Commission, 2024). These programs played a vital role in strengthening ties between neighboring regions, encouraging the exchange of knowledge and best practices, and addressing common challenges. The programs allocated funding across 11 thematic priorities: research and technological development, information and communication technologies, small and medium-sized enterprises, a low-carbon economy, climate change, environment and resource efficiency, transport, employment, social inclusion and poverty, education and vocational training, and efficient public administration.

For the 2021–2027 period, 74 cross-border cooperation programs are foreseen, with a budget of EUR 6.7 billion. These cross-border programs consist of 49 internal programs, 24 external programs (10 IPA and 14 NEXT), and the PEACE+ program (European Commission, (2024), cited by Bilczak, (2024)).

Cross-border partnerships are established between at least two partners operating on both sides of the border and pursue common objectives important for the development of the entire border area. They represent a distinctive example of interorganizational cooperation, territorially integrated within the border regions of two or more neighboring countries (Kurowska-Pysz and Szczepanska-Woszczyna, 2017), and function based on well-defined principles (FOGARASI, 2024):

- partnership
- subsidiarity
- joint development
- the existence of common regional or local structures and their own sources of co-financing
- equality in sharing resources, responsibilities, risks, and, of course, benefits.

Also, a frequently used term throughout this analysis that must be defined from the outset, in order to ensure a unified understanding and interpretation of the meaning of the statements, is the term "border." According to Medeiros (2019), "the border is that area which extends parallel to and on both sides of the boundary line."

Despite the rather simplistic and easy-to-understand definitions, the two concepts that are the subject of this analysis possess a highly complex multidimensional nature, composed of distinct types of factors such as geographical, cultural, social, economic, political, and even historical context. These are, in fact, the very reasons why the specialized literature frequently addresses topics concerning how and to what extent these factors can influence one another. It is precisely this high degree of complexity that makes it difficult to identify the determining factors of cross-border cooperation, as well as its subsequent effects. Numerous authors propose and test hypotheses suggesting that improvements in the transport system could increase the intensity of cooperation between countries. Furthermore, the impact of socio-economic differences on the attractiveness of cross-border cooperation is being studied, along with tourism activity in border areas. Nevertheless, the causes/determinants of cross-border cooperation remain a significant gap in the specialized literature (Khmeleva et al., 2022).

The specialized literature does not encompass many articles that directly address the relationship between passenger flows and cross-border cooperation. Therefore, we may consider the present study as one of the first articles written in this field, particularly due to its unique character, granted by the analysis of statistical data recorded at the level of both Romania and the Republic of Moldova. In other words, this analysis does not merely present aspects of general cross-border cooperation, but rather one that is specific to the border of the European Union, given that Romania is a member of this group of states, while the Republic of Moldova is still in the

candidate stage for EU accession. In 2024, accession negotiations were initiated, along with the screening stage of national legislation, aimed at evaluating the extent to which it aligns with the EU acquis.

However, there are studies that evaluate similar subjects within the field of cross-border cooperation, which include in their content the relationship between cross-border cooperation and the transport sector in general, operationalized and measured through other related statistical variables. Moreover, there are bibliographic sources that also explore the influence of this type of inter-state collaboration on other sectors, the most frequently addressed being tourism.

In an attempt to systematize the information presented in this chapter, it should be noted that two categories of bibliographic sources were analyzed. The first category includes analyses based on qualitative research methodology, while the second refers to studies conducted using quantitative research methods.

A first study analyzed is the one conducted by Kurowska-Pysz and Szczepanska-Woszczyna (2017), commissioned by the Managing Authority of the INTERREG Program for the Czech Republic and the Republic of Poland. This study aimed to define the cross-border cooperation index for this program during the 2014–2020 programming period.

In order to achieve this goal, the authors carried out research based on data collection methods such as qualitative interviews, telephone interviews, self-administered surveys, traditional face-to-face interviews, and computer-assisted interviews. All of these were conducted in the Polish-Czech border area over the course of two years, specifically 2015 and 2016.

In order to correctly define the cross-border cooperation index, the research primarily aimed to identify the factors that influence the motivation to cooperate in both involved states. Thus, interviews were conducted on both sides of the border (covering NUTS 3 regions throughout the entire Polish-Czech border area, as well as the five Czech regions), as follows:

- at the level of 466 Polish local administrative units and 199 Czech local administrative units, as well as other public institutions
- at the level of a group of 150 Polish non-governmental organizations and 150 Czech non-governmental organizations
- at the level of a group of 500 Polish residents and 500 Czech residents living in the border area
- at the level of 118 local authorities, 10 local authorities*, 10 non-governmental organizations, 10 companies, and 5 universities

A relevant aspect regarding the questionnaires used in the research refers to the degree of representativeness of the samples selected for their application.

Composed of target groups (local administrations, non-governmental organizations, and residents of the region), these samples managed to provide significant results which, when extrapolated to the general population with a certain degree of probability, could faithfully reflect the views of the analyzed population on the research topics.

Therefore, the results of the study indicated that the form and intensity of cross-border cooperation in the Czech-Polish border area represent the cumulative outcome of several factors with varying impact. Among these, one can mention the legal form of the entity, its status, the purpose of its activity, the type of cooperation model adopted, the level of development of cross-border cooperation structures, as well as external factors from the cross-border environment (economic, social, political, cultural, etc.).

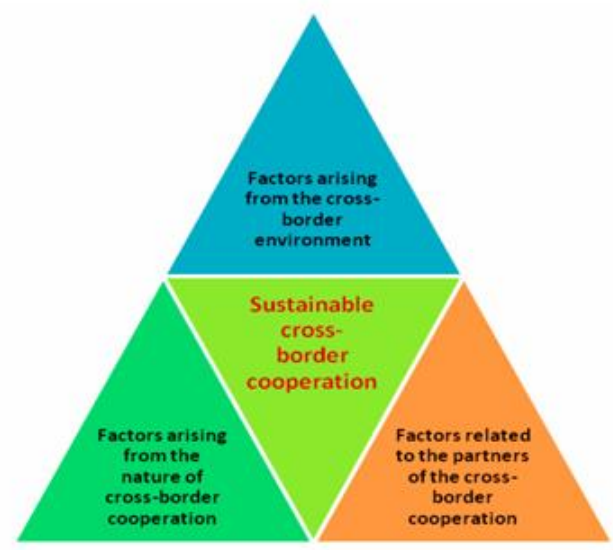

Figure 1 – Diagram of Factors Influencing Sustainable Cross-Border Cooperation

Source - Kurowska-Pysz, J., Szczepanska-Woszczyna, K., (2017) " The Analysis of the Determinants of Sustainable Cross-Border Cooperation and Recommendations on Its Harmonization", Sustainability, vol. 9, pp. 2226, Available online: http://dx.doi.org/10.3390/su9122226

The authors also conclude that the main catalyst for sustainable cross-border cooperation, in the opinion of Polish local administrations and public institutions, is the possibility of obtaining EU funding for joint projects (80.92%), followed by the quality of interpersonal relationships (77.02%), and by historical affinity and geographical proximity (57.04%). Therefore, the Polish partners' approach to cooperation is dominated by economic interest, followed only afterwards by social aspects. A different approach to cooperation is presented by Czech local administration officials and public institution representatives, for whom the most important aspects of cooperation are: the quality of interpersonal relationships, the mutual desire to get to know each other better (65.97%), as well as historical affinity and geographical proximity (59.76%). Economic interest (50.51%) ranks third.

For Polish organizations, as well as for local administrations and public institutions, the possibility of jointly obtaining EU funding is crucial (68.81%) in the context of sustainable cross-border cooperation. This is followed by the quality of interpersonal relationships and the mutual desire to get to know each other better (58.88%), and by support from the regional and local system

(41.75%), which should primarily be interpreted as assistance in securing funds for their own contribution to projects. It can be concluded that, as in the case of local administrations and public institutions, Polish non-governmental organizations prioritize economic aspects in cooperation, while placing social aspects in second place. As for Czech non-governmental organizations, the responses were similar to those of local administrations and public institutions. A social aspect is of key importance: the quality of interpersonal relationships and the mutual desire to get to know each other better (71.01%), as well as historical affinity and geographical proximity (63.47%). Economic interest (47.58%) also ranks third.

As for the opinion of Polish residents, a key factor in the development of cooperation is the friendship between the two nations (34.59%), followed by economic factors (33.52%). The similarity of languages is also of great importance (31.41%). On the other hand, the similarity of languages (54.71%) and culture (37.40%) is crucial for residents of regions on the Czech side. As can be observed, the motivation of residents on both sides of the border area to develop Polish–Czech cooperation varies. On the Polish side, as in the case of local administrations and non-governmental organizations, the economic factor plays a very important role, whereas for the Czech community, the determining factor in the development of cross-border cooperation is the social aspect.

The research conducted by (FOGARASI, 2024) adopts a broader qualitative perspective, aiming to identify both the elements that stimulate cross-border cooperation and the factors that exert negative effects on this phenomenon. To this end, the authors analyze both institutionalized and non-institutionalized forms of cooperation and their implications for the governance process, knowledge transfer, and sustainable development.

According to other authors cited by (FOGARASI, 2024), the success of cross-border cooperation may be attributed to factors such as political mobilization aimed at attracting the necessary resources, the sharing of competences between local and national authorities, and strategic unification inspired by a common vision for efficient and sustainable cooperation. Equally important, according to the specialized literature, are knowledge transfer and the degree of innovation.

Other authors have concluded that the factors underlying the effectiveness of cooperation include: regional and local autonomy, the legal context, socio-economic factors—including development gaps along the border or poorly developed infrastructure—insufficient funding, border-crossing conditions, trade or financial conditions, lack of technical assistance, corruption levels, political variables, inflation, language barriers, cultural elements, or even institutional capacity among partners, staff training levels, and the vague formulation of cross-border initiatives, which can lead to inefficiency among members.

Thus, the results of this study highlight the complex nature of cross-border cooperation and its essential role in European regional policy. In conclusion, the findings emphasize the importance of improving mechanisms for measuring and evaluating the impact of cross-border cooperation, since the lack of clear indicators may hinder the accurate assessment of project effectiveness.

Opiłowska (2021) examines the development of cooperation between Germany and Poland in border regions and identifies the factors that stimulate and inhibit cross-border cooperation. The analysis is based on 24 semi-structured interviews with actors involved in cross-border cooperation at the subnational (local and regional) and national levels, including representatives from cooperation sectors such as governance structures, economic departments, cultural and educational institutions, and NGOs. The interviews were conducted between 2018 and 2019 and were coded to ensure anonymity. In addition, document analysis was also used, involving an in-depth review of official documents such as bilateral agreements, reports, development strategies, and secondary studies in order to identify the key determinants of cross-border cooperation.

Thus, the authors observed that among the main factors influencing the cross-border cooperation process are:

- Intergovernmental relations and EU policies
- Historical legacy – refers to the impact of history on current relations and actions, which may vary from state to state. In this case, it is known that the Polish-German border was created as compensation for the territorial losses Poland suffered to the Soviet Union. Therefore, it can be said that after the fall of communism, the historical legacy had a negative impact. However, at present, the respondents stated that they do not consider historical legacy to play an important role in cross-border cooperation, focusing instead on practical objectives and the potential benefits of economic cooperation and shared infrastructure.
- Linguistic and cultural barriers
- Functional or social interdependence – refers to the existence of coordinating bodies (EU procedures and institutions managing access to cross-border cooperation funds)
- Asymmetry – defined as an imbalance between states and regions in terms of geographic, demographic, economic, or political criteria.
- The role of state actors
- Local leadership – Interviewees emphasized intercultural/transnational competence as an essential and desirable quality for leaders in border regions. From this perspective, four sets of competencies can be distinguished: analytical, emotional, creative, and behavioral..

Lastly, Medeiros (2019) aims to conduct an analysis of one of the most persistent barriers faced by EU citizens—particularly cross-border commuters, short-term travelers, and tourists—namely, the barrier represented by the lack or limited presence of cross-border public transport services within the EU territory.

The study uses as its data source the open-ended responses from the online public consultation on persistent border obstacles in the EU area, which revealed that the dimension of accessibility was mentioned by one-quarter of survey respondents as the main obstacle to crossing the border, primarily due to the poor connectivity of passenger transport and the absence or limited availability of suitable passenger transport services.

Data from a recent EU survey (Eurobarometer) on the presence of border obstacles in each EU-funded cross-border program was also used. The results indicated that approximately one in three respondents considered accessibility-related barriers to be the fifth most significant obstacle to crossing borders (30%), following cultural barriers (32%), legal and administrative barriers (45%), socio-economic barriers (47%), and language barriers (56%). Therefore, the authors conclude that crossing European borders via public transport is still considered one of the main barriers for EU citizens and remains fairly widespread throughout the EU.

The authors also describe how, at the EU level, the INTERREG programs have been the most important financial instrument for supporting the process of cross-border cooperation. They emphasize that investments in improving cross-border transport can generate a dual positive impact: reducing travel barriers, mitigating the environmental impact associated with private transport use, and reducing disparities between border regions. From the outset, these programs have funded transport infrastructure projects in all EU border areas (e.g., the construction of two transport bridges and the improvement of several border crossings between Portugal and Spain, or the ferry line in the Elbe-Labe Euroregion, etc.).

In addition to the obstacles already mentioned and analyzed above, survey respondents also pointed out the following:

- Lack of information regarding existing fares and schedules;
- Poor quality of transport infrastructure;
- Inadequate speed and frequency of cross-border public transport modes;
- Excessive ticket prices;
- Lack of interoperability among existing cross-border transport systems;
- Lack of cross-border planning in the establishment of cross-border transport systems.

When analyzing research based on quantitative methodologies, a first study examined is the one conducted by Khmeleva et al. (2022). This study investigates the fundamental factors influencing the external cooperation of Hungary's cross-border regions using the PLS-SEM method (Partial Least Squares Structural Equation Modeling), a method with superior explanatory and predictive functions that allows researchers to identify and approximate the connections between variables and to construct a regression model to describe the relationships among them. In order to answer the research question formulated in the early stage of the study—"Does the development of transport infrastructure have a positive impact on cross-border cooperation?"—the author employed linear regression functions as well as factor analysis. The study also used the specialized software SmartPLS 3 to carry out factor analysis, path analysis, and to facilitate the construction of the regression model and covariance structure models.

From the perspective of statistical data used, the research involved the collection, processing, and interpretation of figures sourced from Eurostat for the period 2012–2019, specific to Hungary and its neighboring countries (Austria, Slovakia, Slovenia, Romania, and Croatia). Regarding the dependent variables included in the analysis, these were: business travel, cross-border cooperation, transport infrastructure, tourism, and socio-economic conditions, while the

independent variables were exports, imports, and exports of high-tech products from Hungary to neighboring countries.

The main findings of the research indicated that the endogenous variable—cross-border cooperation—shows a coefficient of determination R^2 equal to 0.521. This means that the causal variable analyzed (transport infrastructure) explains approximately 52% of the variation in the effect, which designates it as a determining factor for the variation in cross-border cooperation, as it exceeds the 50% threshold.

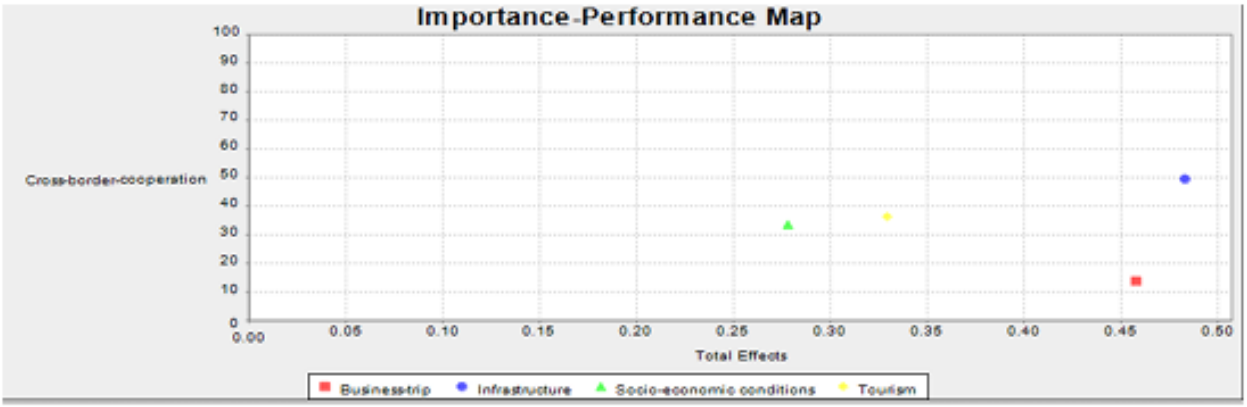

Figure 2 – Importance–Performance Map

Source: Khmeleva, G. A., Kurnikova, M. V., Nedelka, E., Tóth, B. I., (2022) " Determinants of Sustainable Cross-Border Cooperation: A Structural Model for the Hungarian Context Using the PLS-SEM Methodology", Sustainability, vol. 14, pp. 893, Available online: https://doi.org/10.3390/su14020893

As shown in Figure 1, the most important factor influencing cross-border cooperation is transport infrastructure, which registers significantly higher values compared to the other variables. Therefore, the authors draw attention to the special focus that should be given by authorities to transport infrastructure, particularly during the formulation of policies and development strategies for border regions.

The second bibliographic source based on a quantitative methodology is the study conducted by Tomeš et al. (2022). It addresses the impact of the border effect on European air transport, specifically focusing on the following countries: Spain, France, Germany, and Poland—large states with significant domestic and international passenger air traffic. From a conceptual perspective, the border effect refers to the way in which trade or transport flows decrease when crossing a national border.

To carry out this study, the authors included in their analysis the explanatory (causal) variable: the seat capacity on European air routes in November 2019 (a period of the year unaffected by the artificially increased volume of travel due to winter holiday seasons). The outcome variables were GDP value, population, geodesic distance between airports, as well as

additional control variables such as language and tourist destinations. All data were processed using the augmented gravity model, a standard tool for estimating trade relationships.

The main data source on traffic flows was the Kiwi.com database, an online travel agency specialized in finding itineraries for air transport services. It is also a fairly extensive database that covers almost all existing connections. Following the selection of the desired sample, the analysis included 217 unique destinations, with the total number of observations in the dataset amounting to 1,574.

Existing studies at that time estimated that the border effect could reduce air passenger transport flows by a factor of five to six. However, subsequent economic developments managed to reduce the magnitude of this effect, with the authors obtaining a considerably lower value—approximately two (border effect ranging between 1.7 and 2.1). One of the most plausible explanations for this difference is the increasing integration of the European economy and the development of low-cost airlines in Europe between 2000 and 2019. Nevertheless, the border effect is expected to shift again due to the COVID-19 pandemic and the military conflict in Ukraine.

The analysis also identifies differences in the magnitude of border effects across certain European countries. For instance, no significant border effect was detected for France—most likely due to the high intensity of competition between high-speed rail and airlines on domestic routes. However, large and significant effects were observed for Germany, Spain, and Poland, which may be attributed to varying intensities of intermodal competition on internal routes.

Finally, the analysis conducted by Bilczak (2024) examines the key components that influence the intensity of cross-border cooperation among the 56 Interreg programs implemented at the internal EU borders during the 2014–2020 period. Using a quantitative approach that combines correlation analysis and linear regression modeling—similar to the methodology used in the present scientific research—the article evaluates the relationship between financial resources and indicators of cross-border cooperation intensity. The variables analyzed were:

- Dependent variables: the number of implemented projects and the number of partner organizations
- Independent variables: the total program budget and EU funding

The methods of analysis involved generating descriptive statistics, correlation analysis, calculating mean values, standard deviations, a matrix of paired Pearson correlation coefficients, as well as linear regression using the ordinary least squares (OLS) method to test the impact of program budget characteristics on cross-border cooperation indicators.

The basic descriptive statistics indicated that, on average, a single program implements 107 projects with the participation of 533 partner organizations. Meanwhile, the correlation analysis revealed a moderate positive relationship between the budgetary characteristics of the programs and the cooperation indicators, with correlation coefficient values ranging between 0.48 and 0.66.

Regarding the results provided by the regression model, it confirms the hypothesis of a stimulative influence of financial resources on the intensity of cross-border cooperation. A 1% increase in the total program budget is associated with a 0.25% increase in the number of projects and a 0.30% increase in the number of partnerships. Additionally, in testing the hypothesis of a stronger effect of financial resources on the cooperation network dimension, positive and significant coefficients were obtained, indicating that a 1% increase in funding leads to a 0.20–0.15% increase in the number of projects and a 0.25–0.20% increase in the number of partnerships.

Overall, the results confirm a positive association between the financial scale of programs and the intensity of cooperation, with a more pronounced effect on the network dimension, operationalized through the variable "number of partnerships," compared to the initiative dimension represented by the statistical variable "number of projects."

3. Research Methodology

3.1. Selection of Statistical Variables and Database Construction

For the study of the relationship between air transport and cross-border cooperation, as well as for measuring the intensity of the potential impact that one of these two phenomena may have on the other, four primary, dynamic, and attribute-based statistical datasets were constructed, processed, and analyzed. Two of these datasets represent numerical statistical variables specific to the field of air transport, namely: the number of passengers from scheduled flights who boarded in the Republic of Moldova and disembarked at airports on Romanian territory, and the number of passengers from scheduled flights who boarded in Romania and disembarked at airports in the Republic of Moldova. The absolute values of these statistical variables were sourced from the Statistical Yearbooks of Romania for the period 2015–2024, forming a dynamic/chronological statistical series that reflects the temporal evolution of the phenomenon.

Additionally, two datasets were constructed to represent numerical statistical variables specific to the field of cross-border cooperation—a concept operationalized through two numerical variables: the number of projects contracted and implemented through collaboration between the two neighboring states, and the total value of these projects, expressed in euros. It is important to note that the variable analyzed includes exclusively those projects that were both contracted and implemented within the eligible area of the funding program. This is because, during the 2014–2021 programming period, three projects were terminated, amounting to €3,934,014.73, which reduced the total value of projects implemented between 2016 and 2022. Nevertheless, the cumulative value exceeded €115 million, despite the initial financial allocation set by the European Union for the Romania–Republic of Moldova Joint Operational Programme, under the European Neighbourhood Instrument (ENI), being only €81 million. As for the data sources or bibliographic resources used to build the statistical database for the present analysis, the data were extracted from official reports available on the website of the Romania–Republic of Moldova Cooperation

Programme. These are open, public, and accessible datasets, ensuring transparency in the use of European funds.

To ensure consistency within the database, only those time periods for which all variables had available records were selected for analysis. As a result, a dataset comprising 7 records was obtained, covering the period from 2016 to 2022.

A brief overview of the available datasets reveals that they belong to the category of statistical data that are relatively underutilized—mainly due to the high degree of difficulty involved in identifying and accessing them. This suggests that the benefits potentially derived from their statistical analysis are neither well-known nor widely used. Consequently, stakeholders in the field are deprived of the insights and conclusions that could emerge from relevant studies or research, which would otherwise contribute to the efficiency of their measures, plans, and projects.

3.2. Analytical Methods Applied

Regarding the methods applied during the analysis, these fall within the statistical domain, contributing to the efficiency of the data processing and interpretation process. Statistical processing operations were carried out using Excel software, with the process facilitated by the numerous mathematical functions available in its main menu, as well as the use of the Analysis ToolPak add-in.

In the first stage, the data series were analyzed individually using the Descriptive Statistics menu. Thus, a descriptive statistics output was generated for each of the four data series, providing essential values on which the interpretation of results could be initiated—namely, values of central tendency indicators, measures of variability, as well as kurtosis and skewness indicators.

Number of passengers from scheduled flights embarking in Moldova and disembarking in Romania		Number of passengers from scheduled flights embarking in Romania and disembarking in Moldova	
Mean	34370,71429	Mean	32670
Standard Error	6052,81872	Standard Error	5681,875
Median	36526	Median	35051
Mode	#N/A	Mode	#N/A
Standard Deviation	16014,25307	Standard Deviation	15032,83
Sample Variance	256456301,2	Sample Variance	2,26E+08
Kurtosis	-0,744163265	Kurtosis	-0,64427
Skewness	-0,690922182	Skewness	-0,64449
Range	42472	Range	40155
Minimum	9115	Minimum	8701
Maximum	51587	Maximum	48856

Sum	240595	Sum	228690
Count	7	Count	7

Table 1 – Descriptive Statistics Output for Variables Specific to the Air Transport Sector

Number of Implemented Projects		Value of Implemented Projects (EUR)	
Mean	12,42857	Mean	16463005,27
Standard Error	7,124262	Standard Error	6071280,86
Median	4	Median	12661387,25
Mode	1	Mode	#N/A
Standard Deviation	18,84902	Standard Deviation	16063099,29
Sample Variance	355,2857	Sample Variance	2,58023E+14
Kurtosis	3,89625	Kurtosis	-1,453872839
Skewness	1,998489	Skewness	0,566186302
Range	51	Range	40250837,89
Minimum	1	Minimum	295000
Maximum	52	Maximum	40545837,89
Sum	87	Sum	115241036,9
Count	7	Count	7

Table 2 - Descriptive Statistics Output for Variables Specific to the Field of Cross-Border Cooperation

By analyzing the results presented in Table 1 and Table 2, it can be observed that, in addition to the mean, median, and mode of the data series, the outputs also include the results of more complex indicators, such as the Adjusted Fisher–Pearson Coefficient of Skewness, as well as the Kurtosis coefficient. Each of the four calculated values for these indicators can be interpreted as follows: negative values of the skewness coefficient (i.e., less than 0) indicate a negatively skewed (right-skewed) distribution, where values greater than the mean are more prevalent. In contrast, positive values (i.e., greater than 0) indicate a positively skewed (left-skewed) distribution, where values smaller than the mean dominate. These interpretations can also be confirmed through the analysis of boxplot graphs created for the four variables, specifically by examining the position of the median in relation to the two quartiles. If the median is closer to the first quartile, the series is positively skewed; if it is closer to the third quartile, the series is negatively skewed.

The values of the kurtosis coefficient provide relevant information regarding the shape of the distribution of the analyzed variables. Negative values of this indicator suggest a platykurtic distribution—meaning a very flat or broad distribution—while positive values indicate a leptokurtic distribution—meaning a sharply peaked one. These findings can be visually confirmed

by creating column charts, which are commonly used to represent the distribution of statistical variables.

Based on the indicators already calculated in the output, additional coefficients can be derived to complement the existing interpretations—namely, the coefficient of variation and the relative range. The values of these coefficients provide insight into the homogeneity of the data series, as well as the degree of representativeness of the calculated arithmetic means. As shown in Table 3, the values of the relative range exceed the critical threshold of 100% for all the analyzed data series, and the values of the coefficient of variation also surpass the homogeneity threshold of 35%. This indicates that none of the four series under analysis are homogeneous, and their means have a low degree of representativeness. Moreover, coefficient of variation values exceeding the critical level of 75% point to a very high variation in the data.

	Number of passengers from scheduled flights embarking in Moldova and disembarking in Romania	Number of passengers from scheduled flights embarking in Romania and disembarking in Moldova	Number of Implemented Projects	Value of Implemented Projects (EUR)
Relative Range	123,5703153	122,9109	410,3448	244,4926502
Coefficient of Variation (CV)	46,59272697	46,01417	151,6588	97,57088107

Table 3

The same outputs also provide results for the main indicators of variation—namely, variance and standard deviation. While sample variance is an abstract indicator without a measurement unit and does not have a direct statistical or economic interpretation, standard deviation (also known in the literature as the mean square deviation) indicates how much the values of the variable deviate, on average, from the variable's mean. The results may include both positive and negative values.

As part of this individual analysis of each data series, additional graphs were also created to illustrate the temporal evolution of the variables (chronogram-type graphs), as well as boxplot charts that confirm the type of skewness specific to each statistical characteristic.

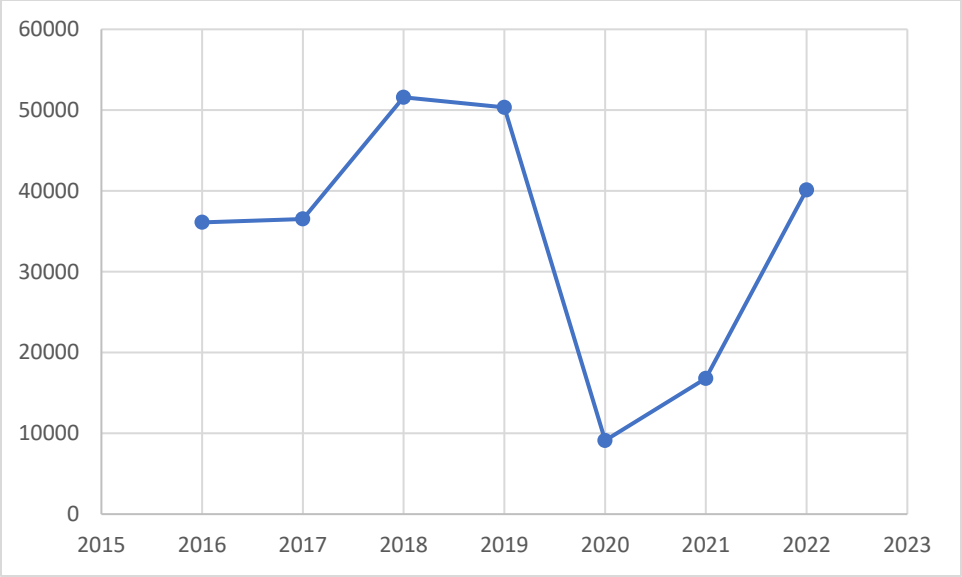

Figure 3 - Evolution of the Number of Passengers from Scheduled Air Flights Between the Republic of Moldova and Romania

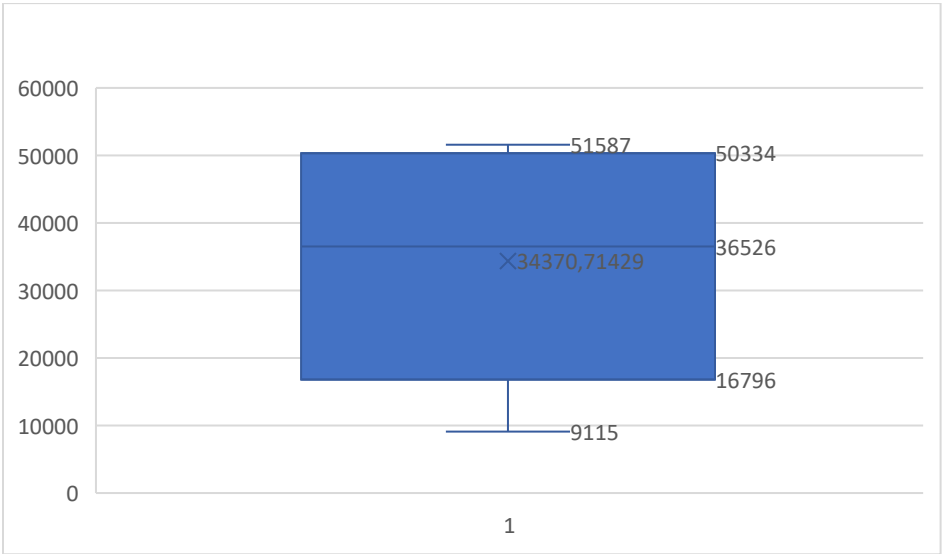

Figure 4 - Boxplot of the Number of Passengers from Scheduled Air Flights Between the Republic of Moldova and Romania

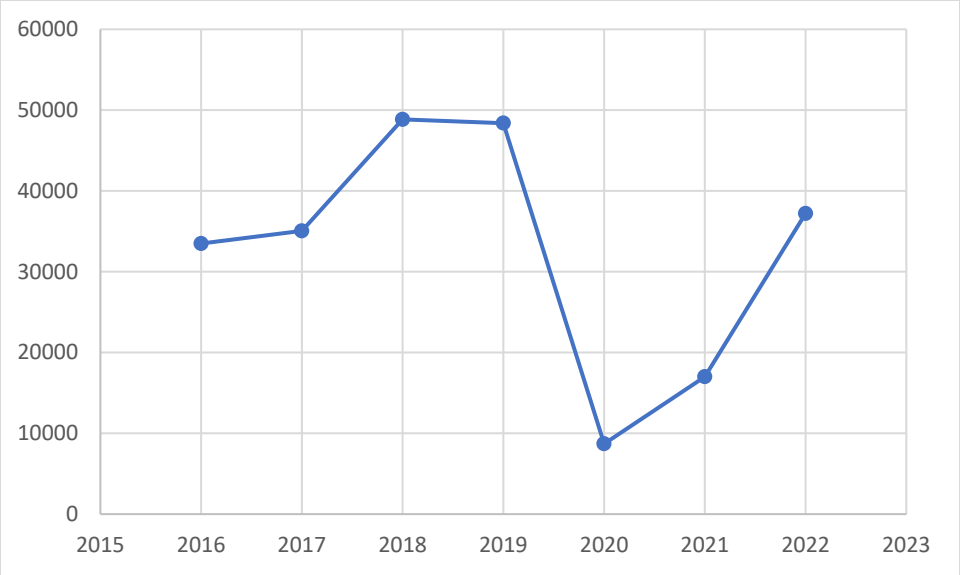

Figure 5 - Evolution of the Number of Passengers from Scheduled Air Flights Between Romania and the Republic of Moldova

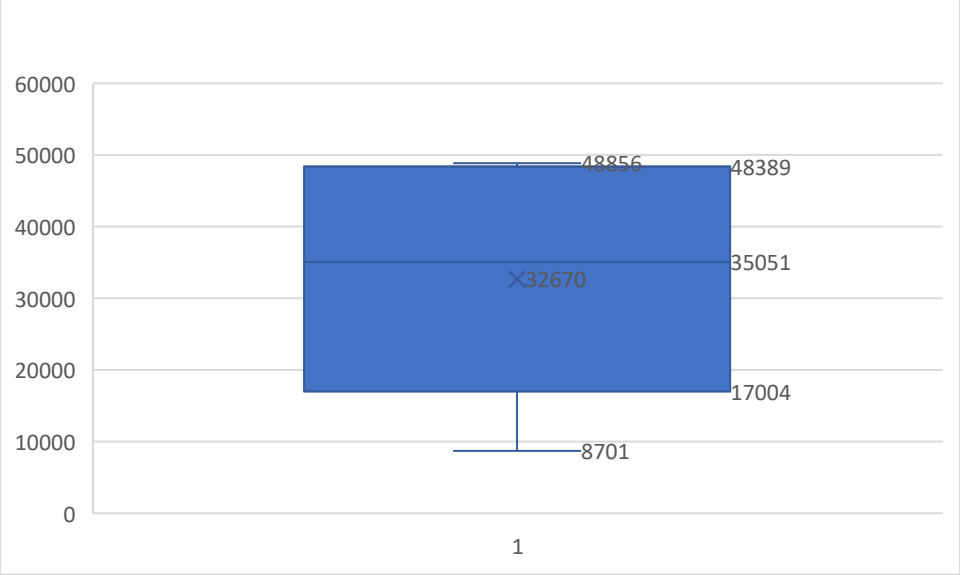

Figure 6 - Boxplot of the Number of Passengers from Scheduled Air Flights Between Romania and the Republic of Moldova

Specifically, Figures 4 and 6 illustrate the fluctuation and temporal evolution of the number of passengers from scheduled air flights between the two neighboring states. It can be clearly observed that in the year 2020, there was a sharp decline, caused by the outbreak of the COVID-19 pandemic—an event that drastically reduced population mobility, including air travel, as a measure to limit the spread of the virus. Nevertheless, the same graph highlights the speed at which the air transport sector managed to recover, quickly adapting to market conditions and

requirements. Within just two years, the total number of passengers nearly returned to the pre-pandemic peak.

As for Figures 5 and 7, these provide, in a simple and highly visual manner, the most important statistical values of a series, as follows: the minimum and maximum values, represented by the "whiskers" of the boxplot; the first and third quartiles, shown by the edges of the box; the mean, marked by an "X"; and the median, indicated by the line inside the box.

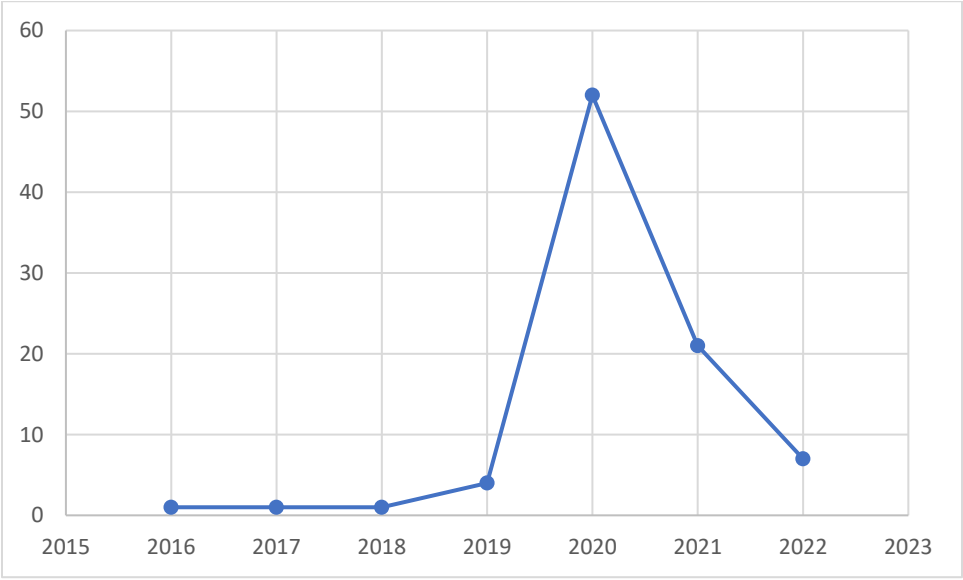

Figure 7 - Evolution of the Number of Projects Implemented Under the Romania–Republic of Moldova Joint Operational Programme

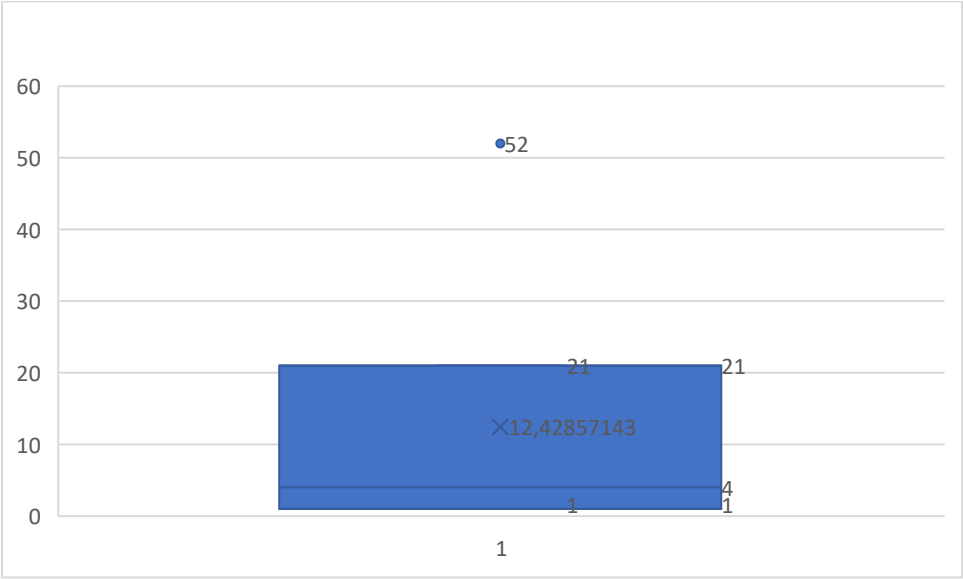

Figure 8 - Boxplot of the Number of Projects Implemented Under the Romania–Republic of Moldova Joint Operational Programme

A characteristic element of the boxplot graph, as shown in Figure 9, is the value represented by a single point positioned above the upper whisker of the plot. From a statistical perspective, this point signifies and indicates the extreme or outlier value of the data series—that is, a value that exceeds the maximum range considered normal, and which significantly affects the mean of the variable.

In the absence of a boxplot, the presence of outlier values can be tested using the following calculation formulas:

(1) Q1 – 1.5 × IQR or

(2) Q3 + 1.5 × IQR

All values lower than the result obtained from formula (1), or higher than the result from formula (2), are considered outliers.

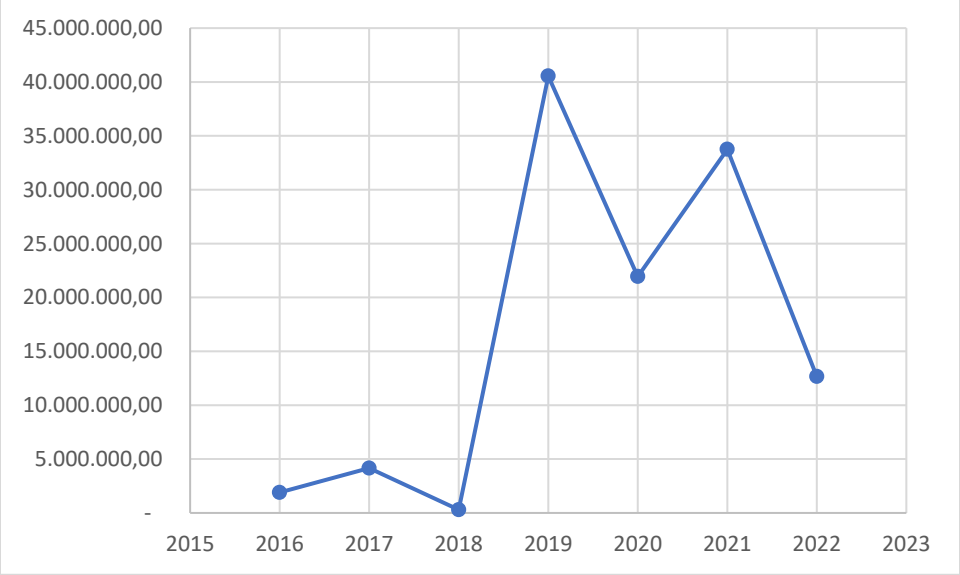

Figure 9 - Evolution of the Monetary Value (EUR) of Projects Implemented Under the Romania–Republic of Moldova Joint Operational Programme

Figures 8 and 10 illustrate the evolution of the two variables specific to the field of cross-border cooperation—namely, the number of projects implemented under the Romania–Republic of Moldova Joint Operational Programme and their monetary value, expressed in the European Union's currency, the euro. It can be observed that the highest number of contracted projects within the analyzed period was recorded in 2020, whereas the maximum cumulative value of the contracted projects was reached in the previous year, 2019. At first glance, this may appear contradictory to logical expectations, but it is easily explained. An analysis of the raw data series shows that in 2020, a total of 52 funding projects were contracted, implemented, and finalized, with an average value of approximately €422,000. In contrast, in 2019, only four projects were contracted, yet their cumulative value exceeded €40.545 million.

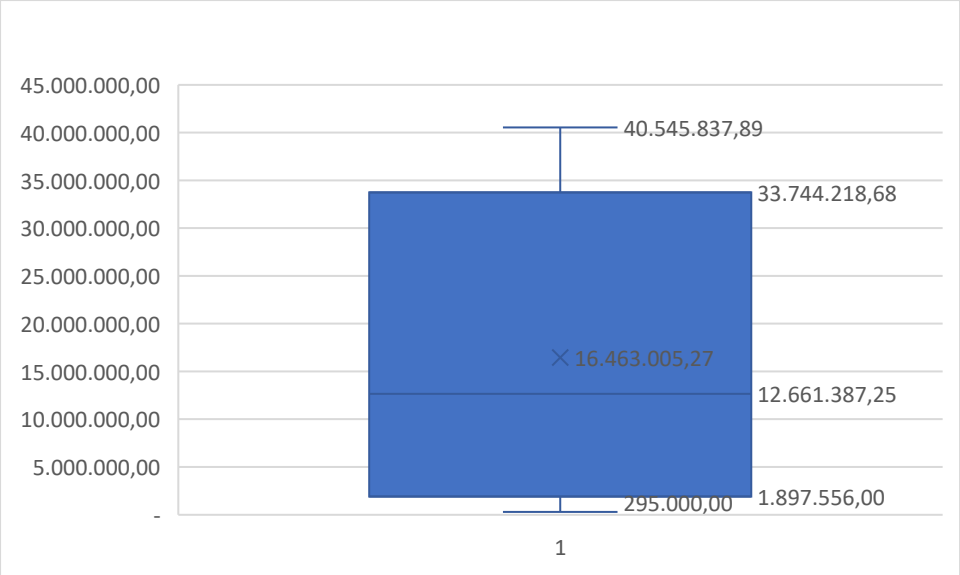

Figure 10 - Boxplot of the Monetary Value (EUR) of Projects Implemented Under the Romania–Republic of Moldova Joint Operational Programme

The second stage of the analysis involved studying the relationship between the two analyzed variables using two types of methods: parametric methods, which rely on mathematical calculation functions, and non-parametric methods.

For the application of parametric methods, covariance and the Pearson linear correlation coefficient were calculated.

- For the parametric analysis of the relationship between variables 1 and 4 (i.e., the number of passengers from scheduled flights from Moldova to Romania and the value of the contracted projects), the connection between them is inverse, as both calculated values were less than zero, meaning negative. However, in terms of the strength of this relationship, the analysis reveals a weak correlation, with the value of the Pearson linear correlation coefficient r = -0.26, which falls within the interval (0.2–0.4). This almost negligible link between the two variables is also easily observable in the correlogram generated based on their relationship (Figure 12).

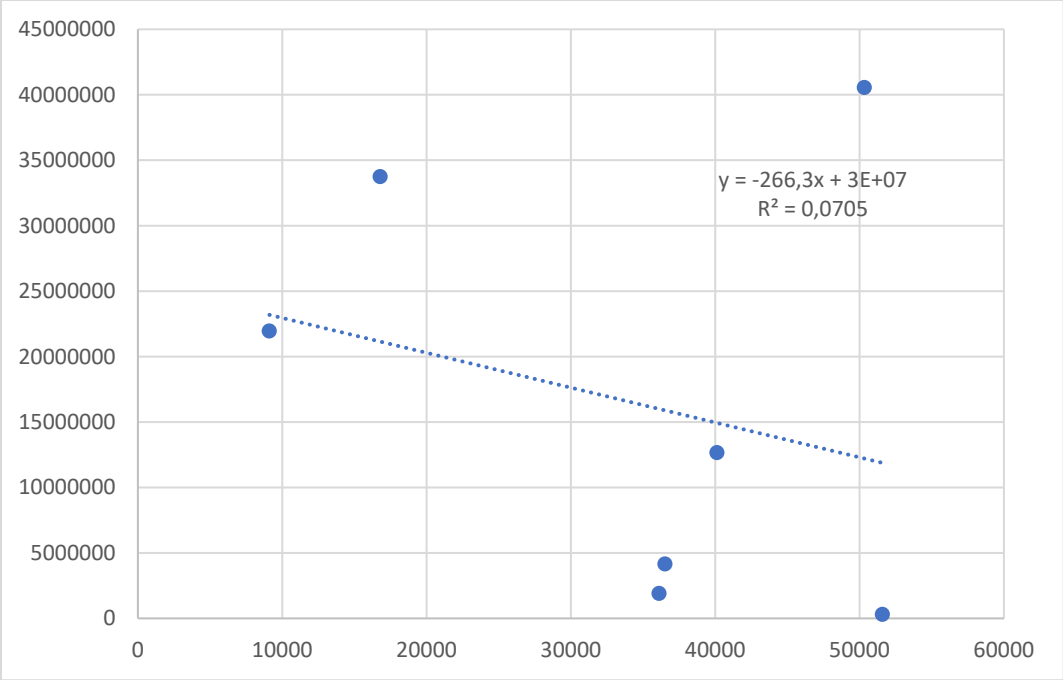

Figure 11 – Graphical Representation of the Linear Relationship Between the Number of Passengers from Scheduled Flights Moldova–Romania and the Value of Contracted Projects (Correlogram)

- For the parametric analysis of the relationship between variables 2 and 4 (i.e., the number of passengers from scheduled flights Romania–Moldova and the value of contracted projects), the results are similar in terms of both the direction and the intensity of the relationship. The values of both the covariance and the Pearson linear correlation coefficient were negative, indicating an inverse relationship between the two variables. In other words, when one variable increases, the level of the other tends to decrease. Additionally, the correlation coefficient r = -0.23 also suggests a weak correlation, just as in the case of the correlation between the number of passengers from Moldova to Romania and the value of contracted projects.

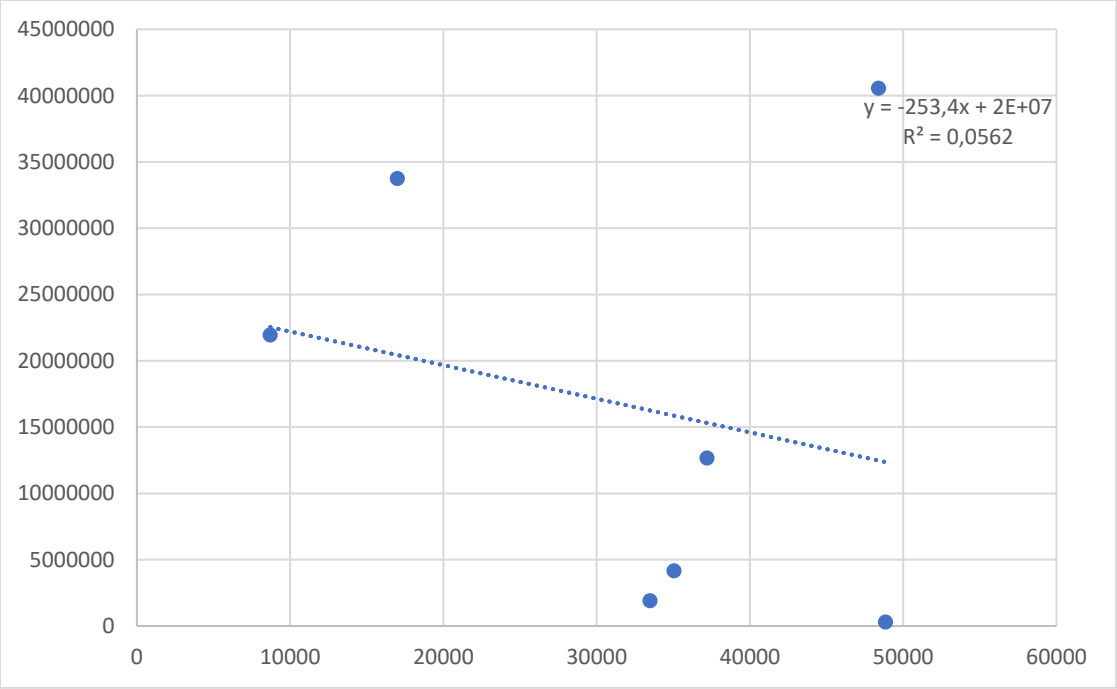

Figure 12 - Graphical Representation of the Linear Relationship Between the Number of Passengers from Scheduled Flights Romania–Moldova and the Value of Contracted Projects (Correlogram)

- The parametric analysis of the relationship between variables 2 and 3 (i.e., the number of passengers from scheduled flights Romania–Moldova and the number of projects implemented during the analyzed period) also indicated an inverse relationship, as shown by the negative results obtained for both the covariance and the Pearson linear correlation coefficient, with r = -0.85. However, in this case, the relationship exhibits a much stronger intensity, as the coefficient value falls within the range of 0.8 to 1—boundaries that characterize a strong correlation..

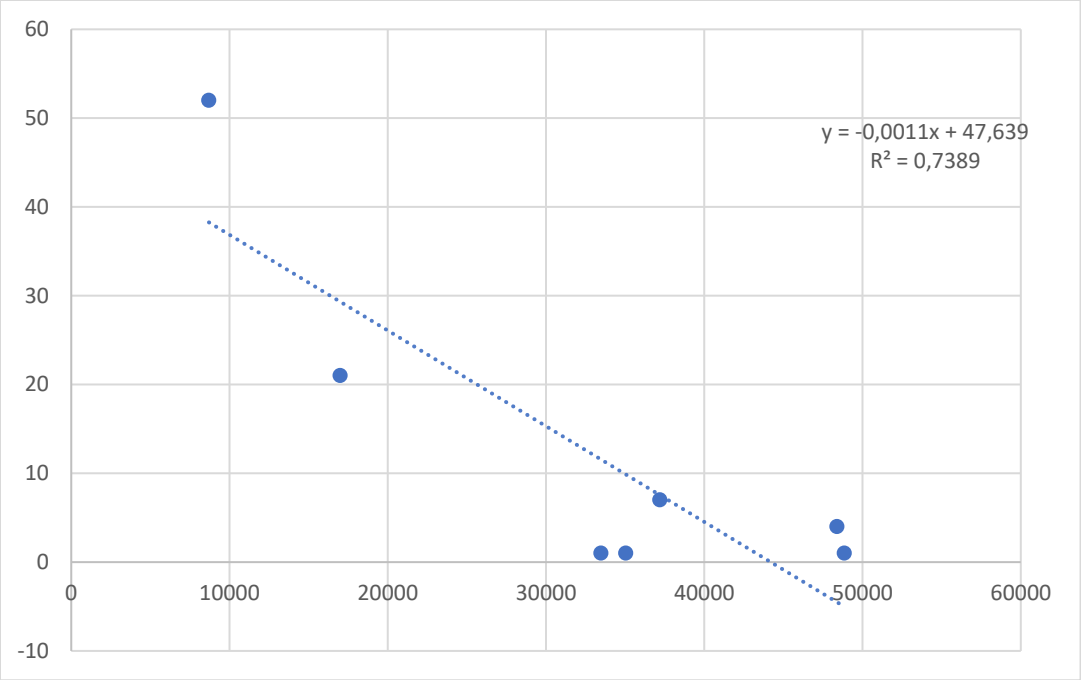

Figure 13 - Graphical Representation of the Linear Relationship Between the Number of Passengers from Scheduled Flights Romania–Moldova and the Number of Implemented Projects (Correlogram)

- Lastly, the application of parametric methods to variables 1 and 3 (i.e., the number of passengers from scheduled flights Moldova–Romania and the number of implemented projects) yielded results similar to those obtained for variables 2 and 3 (i.e., the number of passengers from scheduled flights Romania–Moldova and the number of implemented projects). Specifically, both sets of variables recorded negative values, with the Pearson linear correlation coefficient for this pair being r = -0.85, indicating a strong correlation between the variables in terms of intensity.

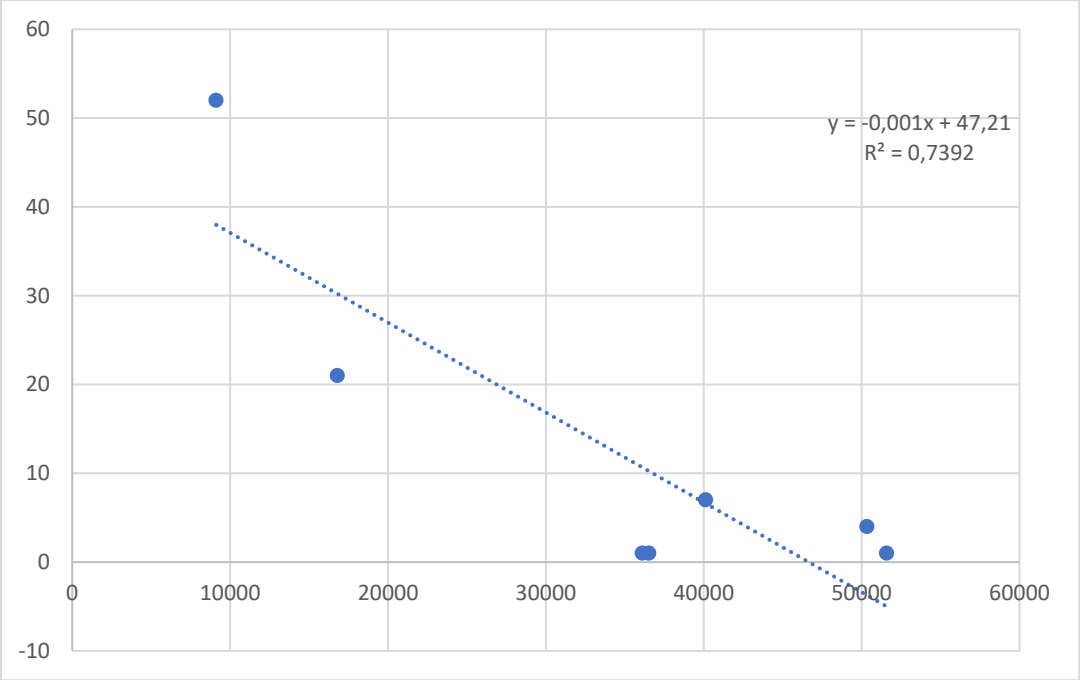

Figure 14 - Graphical Representation of the Linear Relationship Between the Number of Passengers from Scheduled Flights Moldova–Romania and the Number of Implemented Projects (Correlogram)

The second category of methods applied was that of non-parametric methods, which involved the calculation of the Spearman rank correlation coefficient. This method is not influenced by the causal relationship between the analyzed variables. Thus, regardless of which variable is considered the causal factor, the result of the coefficient remains unchanged.

- For the non-parametric analysis of the relationship between variables 1 and 4 (i.e., the number of passengers from scheduled flights Moldova–Romania and the value of implemented projects), the relationship is inverse and of weak intensity, as the calculated Spearman rank correlation coefficient was $r_s = -0.28$.
- Similarly, in the case of variables 2 and 4 (i.e., the number of passengers from scheduled flights Romania–Moldova and the value of implemented projects), the results mirrored those of variables 1–4, indicating an inverse relationship of weak intensity, with the same coefficient value of $r_s = -0.28$.
- When computing the non-parametric correlation for both passenger-related variables (regardless of country of departure or destination) with the variable "number of implemented projects," the Spearman coefficients were both $r_s = -0.53$, suggesting the existence of an inverse relationship of moderate intensity.

Lastly, the relationship between the variables of interest was also tested using the linear regression function. The results obtained were as follows:

- For the variable pair $1-4$, where the independent variable (x) was the number of passengers from scheduled flights Moldova → Romania and the dependent variable

(y) was the value of implemented projects, the obtained regression coefficients were as follows:

Coeff. a – (intercept)	25615942,24
Coeff. b – (slope)	-266,3004585

Table 4 – Regression Equation Coefficients for Variables 1–4

To facilitate the understanding of the meaning of these two coefficients, their statistical interpretation suggests the following: the intercept, also known as the constant term or the origin ordinate, does not possess a clear economic interpretation per se; rather, it represents the level of the dependent variable when the independent variable is zero. By contrast, the slope coefficient (denoted b) indicates the amount by which the dependent variable changes with a one-unit change in the independent variable. It also reveals the direction of the relationship between the variables through its sign. In this case, the relationship is inverse, as the coefficient is negative, meaning that an increase of one unit in the number of airline passengers would correspond to a decrease of approximately 266 units in the value of implemented projects.

Finally, as the last step of the analysis, in order to evaluate the quality of the regression model, two coefficients were calculated: the error coefficient, e = 87.09%, and the coefficient of determination, R^2, which indicates the percentage extent to which the number of airline passengers between Moldova and Romania influences the value of implemented projects. In this case, the result showed a relatively low—but not entirely insignificant—value of 7%.

Similarly, the same coefficients were calculated for all pairs of variables considered in this study, and the results were organized in Table 5. It is important to note that three of the four values presented in Table 5 are also visible in the correlogram charts produced for each variable pair, thanks to the feature that displays the regression equation and the R^2 value directly on the graph.

	Coeff.	Result
Number of passengers from scheduled flights embarking in Moldova and disembarking in Romania - Number of Implemented Projects	a	47,20989108
	b	-0,001011946
	e	71,71 %
	R^2	74%
Number of passengers from scheduled flights embarking in Moldova and disembarking in Romania - Value of Implemented Projects (EUR)	a	25615942,24
	b	-266,3004585
	e	87,09%
	R^2	7%
	a	47,63934026

Number of passengers from scheduled flights embarking in Romania and disembarking in Moldova - Number of Implemented Projects	b	-0,001077771
	e	71,75%
	R^2	74%
Number of passengers from scheduled flights embarking in Romania and disembarking in Moldova - Value of Implemented Projects (EUR)	a	24741436,6
	b	-253,3955106
	e	87,76%
	R^2	6%

Table 5 – Regression Coefficient Values and Quality Evaluation Indicators for the Regression Models

4. Results

The application of the selected statistical and econometric methods—including multifactorial linear regression, Pearson's correlation coefficient, and Spearman's rank correlation—led to convergent results, highlighting an inverse relationship between the variables analyzed. More precisely, all methods employed revealed that as one of the studied variables increases, the other tends to decrease. This negative correlation between air mobility indicators and certain dimensions of cross-border cooperation suggests a complex dynamic that warrants further in-depth investigation in future studies. At the same time, the results provide a solid foundation for formulating public policy recommendations aimed at mitigating imbalances and optimizing the impact of mobility on bilateral cooperation.

5. Research Limitations

Although the results obtained provide a solid foundation for analyzing the relationship between air mobility and cross-border cooperation, this study faces a series of limitations that must be considered when interpreting the conclusions. One of the main challenges encountered was limited access to relevant data, particularly with regard to quantitative variables, which are essential for constructing robust econometric models. Identifying reliable and comprehensive data sources required considerable effort, and in some cases, the lack of standardization of statistical indicators between the two countries hindered the direct comparability of results.

Furthermore, the complexity of the phenomenon under analysis and the dynamic nature of cross-border cooperation posed difficulties in the operationalization of this concept, also involving a series of contextual factors that are difficult to quantify, such as political influences or administrative regulations. Although relevant, these elements could not be fully integrated into the

analytical model. Therefore, the methodological limitations highlighted here call for caution when generalizing the conclusions but do not diminish the exploratory and applicative value of the study.

The study also presents several specific limitations. Firstly, the analysis does not account for the variations in the characteristics of individual projects and partnerships. Secondly, the research focused exclusively on quantitative indicators of cooperation intensity, without addressing qualitative aspects of the implemented initiatives, such as thematic focus, innovativeness, or sustainability of the outcomes.

Addressing these research gaps could support a more in-depth exploration of the qualitative dimension of cross-border cooperation, the role of non-financial factors (such as trust, institutional culture, and administrative capacity), and the particularities of cooperation in different types of border regions and programs. Such studies would enable the development of a more comprehensive understanding of the determinants of cross-border cooperation and contribute to the creation of more effective support tools. These findings would offer valuable input for the European Union's cohesion policy and the design of future cross-border cooperation programs, emphasizing the need to ensure sufficient financial resources and to support projects focused on building sustainable partnerships (Bilczak, 2024).

6. Recommendations and Improvements

Based on the findings of the study and the identified limitations, a series of recommendations and proposals can be formulated to support the development of sustainable cross-border cooperation between Romania and the Republic of Moldova. Firstly, there is a need to improve access to detailed and standardized data concerning both passenger flows and socio-economic indicators relevant to the analysis of cross-border cooperation. To this end, it is recommended to adopt modern technologies for data collection and processing, such as artificial intelligence, automated monitoring systems, advanced data processing tools, and high-speed traffic technologies (Khmeleva et al., 2022).

Furthermore, among the concrete measures that can be implemented to enhance cross-border cooperation in general are the harmonization of existing cross-border railway systems; expansion and modernization of railway and road networks; provision of clear and accessible information for travelers; and the implementation of faster, more direct, and more frequent transport connections.

Additionally, it is proposed to finance further studies regarding the current supply and demand for public transport in border areas, with the aim of aligning services to the real needs of commuters. Concurrently, it is essential to improve the physical accessibility of public transport infrastructure, as well as to implement proactive policies encouraging public transport use, through measures such as cost reduction, increased frequency and speed of services, and enhancement of public information systems on both sides of the border.

In this context, it is crucial to acknowledge the dual nature of borders: they can function both as barriers and as bridges—like doors that can be easily opened but can also close rapidly. From this perspective, public policies must be oriented towards transforming borders from obstacles into opportunities, ensuring the necessary conditions for mobility, connectivity, and mutually beneficial interaction between the communities on both banks of the Prut River (Opiłowska, 2021).

In the long term, these measures can generate significant benefits, including environmental advantages through the reduction of private vehicle use; stimulation of tourism by increasing accessibility to tourist attractions; enhanced economic efficiency due to increased use of public transport; positive social impact by facilitating easier access to mobility services for vulnerable groups; and the strengthening of cross-border cultural exchanges.

Finally, there is a growing awareness that the European Union's objective of creating a more integrated and cohesive space cannot be achieved without concrete measures to reduce the barriers imposed by administrative borders. In this regard, the results of this study can serve as a valuable starting point for public policies aimed at sustainable cooperation and genuine territorial integration (Medeiros, 2019).

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