The Effects of Population Aging on Public Services in Romania: An Econometric and Spatial Approach

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1. Introduction

Demographic aging represents one of the most significant challenges faced by contemporary societies, and Romania is no exception to this trend, on the contrary, statistical data indicate that this process is unfolding with an intensity and pace that place the country among the most pronounced cases in the region. The combination of prolonged declining birth rates, massive emigration of the young and active population after 1990, and the aging of the large generations born under the pronatalist policies of the communist regime has led to a profound structural transformation of the resident population, with direct implications for the sustainability of social protection systems, the labor market, and the budgetary balance at both local and national levels.

The relevance of this topic stems from the short-term irreversibility of the demographic trajectory: the cohorts that will reach the age of 65 over the next two to three decades are already identifiable within the current population structure, which gives the aging process a high degree of predictability. At the same time, the increasing pressure on public expenditure allocated to social services, pensions, social assistance, and long-term care can also be forecast with a reasonably high degree of accuracy and confidence. Understanding the extent to which this demographic pressure is, or is not, reflected in the actual allocation of budgetary resources at the territorial level therefore constitutes a research question of relevance both from an academic and future public policies standpoint.

Regarding the innovative character of the paper, the present research brings an element of novelty through its integrated approach to three dimensions rarely analyzed together in the case of Romania: a detailed characterization of the demographic aging process by means of a complex set of specific indicators, calculated at the county level and disaggregated by sex, over a period of more than three decades; a spatial analysis of the territorial distribution of the phenomenon, using spatial autocorrelation tools that allow the identification of territorial clusters; and the testing of the relationship between demographic aging and public expenditure on social services, including through the exploration of certain spatial specifications. Although isolated studies on demographic structure or analyses of social expenditure exist in the specialized literature, the combined approach, at the level of Romania, remains insufficiently explored, and the present research aims to contribute to filling this gap.

The general objective of the article is to analyze the relationship between the process of demographic aging and the level of public expenditure on social services across Romania's counties, for the reference years 2012 and 2025. Several specific objectives derive from this general objective: characterizing the evolution of demographic aging indicators at the national and county level, by comparison with the 1992 reference situation; highlighting the territorial disparities of the aging process and the way in which these have intensified over time, through spatial autocorrelation analysis and testing, through progressively refined econometric tools, the relationship between the demographic aging index and per capita social expenditure, with explicit verification of any spatial dependencies within this relationship.

The research hypothesis from which the study departs is that the process of demographic aging, manifested with increasing intensity and concentrated in increasingly well-defined territorial clusters, exerts significant pressure on public expenditure on social services at the county level, pressure that is not reflected in a corresponding spatial distribution of this expenditure, suggesting a possible decoupling between the territorial dynamics of demographic needs and the current mechanisms of budgetary allocation.

In terms of structure, the article is organized into six chapters. Following this introduction, the second chapter reviews the main contributions of the specialized literature on demographic aging and its relationship with public social expenditure. The following chapters describe the data sources used and present the research methodology, structured around three components: demographic aging indicators and age pyramids, spatial autocorrelation (the Moran's I index and LISA maps) and the progressive construction of the econometric model. Finally, the fifth chapter presents and discusses the results obtained for each of these components, followed by a synthesis of the main research conclusions, the implications for public policy, the study's limitations and directions for future research.

2. Literature Review

The phenomenon of demographic aging represents one of the most significant structural transformations of contemporary societies, with profound implications for the configuration and financing of public services. Demographic projections carried out at the EU level indicate a radical change in the age structure of the population: the median age is estimated to rise from 40.4 years in 2008 to 47.9 years in 2060, while the share of the population aged 65 and over will increase from 17.1% to 30.0% of the total population, and the old-age dependency ratio will rise from 25.4% to 53.5%, which is equivalent to a shift from a ratio of four working-age persons per elderly person in 2008 to a ratio of two to one in 2060. For Romania, the same projections indicate a decline in the total population from 21.4 to 16.9 million inhabitants and an increase in the old-age dependency ratio from 21.3% to 65.3% over the same period (Giannakouris, 2008).

Jakovljević (2017) describes this process through a metaphor frequently used in the literature, the "Silver Tsunami," placing it in the context of an unprecedented demographic transformation driven by four converging factors: increased life expectancy, reduced infant mortality, the integration of women into the labor market, and declining fertility. The author draws attention to two dimensions often omitted from aggregate analyses: the accelerated expansion of the very elderly population (over 80 years old) and the "feminization" of aging, resulting from women's greater longevity—aspects also confirmed by Giannakouris's (2008) projections, which show that the population over 80 will triple at the EU27 level, from 21.8 to 61.4 million people.

A complementary perspective, at a global scale, is offered by Warner, Zhang, and Guillemot (2025), who show that most regions of the world will reach a peak in their total population before the end of the century, while the population aged over 75 will continue to grow until the end of the century in most regions. This combination generates what the authors call a "double crisis"—that of aging and that of demographic decline—which analytically distinguishes the problem of aging as such from the separate, but related, problem of total population contraction, with distinct implications for the organization and financing of public services.

The most consistently documented direction in the reviewed literature concerns the relationship between demographic aging and the growth of public health expenditure. Marešová, Mohelská, and Kuča (2015) show, based on OECD data, that the population aged over 65 is responsible for approximately 40-50% of total health expenditure across member states, with average per capita costs for this category being three to five times higher than for the population under 65, and that projections for the 2060 horizon indicate a substantial increase in this expenditure, with the demographic phenomenon identified as the main driving factor. The relationship between the pace of aging and the growth of health expenditure is also empirically confirmed at the regional level by Jakovljević (2017), who, analyzing the case of Serbia for the period 1995-2015, identifies a parallel and upward evolution: while the median age increased from 34.1 to 40.6 years and the old-age dependency ratio rose from 17.2 to 25.6 elderly persons per 100 working-age persons, health expenditure as a share of GDP increased from approximately 7% to 10%, and per capita expenditure more than quintupled. The author explains this dynamic through the contraction of the financing base of social insurance systems, the specific medical needs of the elderly population (chronic diseases, high frequency of hospitalizations, high costs in the last year of life), and the growing share of out-of-pocket payments, which contribute to the impoverishment of the elderly population through illness-related costs.

However, a recent analysis carried out by Niemcewicz and Ziółkowska (2025) at the level of four European regions introduces an important nuance: in 2023, although the share of the population aged 65 and over and the old-age dependency ratio recorded relatively similar values across the Nordic, Southern, Eastern, and Western regions, health financing levels differ considerably—the Nordic region allocates both the highest per capita expenditure and the largest share of investment in prevention (10-11%), in contrast to the Southern and Eastern regions, where investment in prevention is below 3%. Moreover, the correlation between the old-age dependency ratio and per capita expenditure is significantly positive only in the Nordic region, being negative in the other three regions—a result interpreted by the authors as a signal of budgetary constraints and inefficiencies in health systems. The central conclusion of this study, namely that differences in financing are not determined exclusively by demographic pressure but, to a large extent, by the way health systems are organized and by national policy priorities, suggests that demographic structure represents a necessary but not sufficient condition for explaining the level of health expenditure. An early but particularly relevant methodological contribution for nuancing this relationship is offered by Pearson, Smith, and White (1989). Analyzing the case of the United Kingdom, the authors estimate that the pure net demographic effect on health and social services expenditure is only 7-9% by 2001, a much more modest increase than that anticipated by simple models, while, paradoxically, the greatest pressure on public expenditure comes from the growth in pension spending (estimated at 25%), driven not by demographic structure as such, but by cohort differences in accumulated pension entitlements.

The conclusions of Pearson et al. (1989) are confirmed and extended by Kinnunen and Tuovinen (2008), in a unit-cost analysis dedicated to Finland, one of the European countries aging most rapidly. The authors project a doubling of the volume of social services for the elderly over the next 30 years and a one-third increase in health expenditure by the 2030s; however, the central element of their analysis is not demographic structure itself, but public sector productivity: a 1% annual decline in labor productivity in the provision of public services would require approximately 40,000 additional employees and would deteriorate the budgetary position by nearly 5% of GDP, while a symmetric 1% increase would almost entirely eliminate this need. Thus, Pearson et al. (1989) and Kinnunen and Tuovinen (2008) converge on the idea that non-demographic variables—such as system organization, productivity, and policy decisions—can significantly amplify or mitigate the purely demographic pressure on health expenditure, an idea also taken up by Niemcewicz and Ziółkowska (2025) at the European level.

Beyond the health sector, a series of econometric studies examine the impact of aging on the overall structure of public expenditure. The reference contribution in this regard is that of Sanz and Velázquez (2007), who, based on a dynamic panel data analysis for 26 OECD countries (1970-1997), show that the share of the elderly population represents the main explanatory factor for the growth in the size of the public sector: of the annual 1.02% increase in public expenditure as a share of GDP, 0.96 percentage points are attributed to the growing share of the elderly population. At the level of functional expenditure categories, the elderly population has a significant positive effect on five categories: social assistance, health, education, transport, communications, and defense, without significantly reducing any of the others. A notable result is that the effect on education is negative in the short term but cancels out in the long term, a phenomenon explained by the reaction of the working-age population, which, anticipating a longer retirement period, increases its own demand for public education.

However, the premise according to which a larger elderly population leads, through its increased political influence, to upward pressure on public expenditure is contested by part of the theoretical literature. Bryant (2003) revisits the "median voter" model with overlapping generations developed by Razin, Sadka, and Swagel (2002), who had obtained the counterintuitive result that a higher overall dependency ratio is negatively correlated with tax levels and social benefits, explained through "fiscal leakage" effects and reduced investment in education. By disaggregating the dependency ratio into its youth component (0-14 years) and elderly component (65 years and over), Bryant (2003) shows that the two have opposite effects: a larger share of the young population is associated with lower taxes and benefits, while a larger share of the elderly population is associated with a higher labor tax rate. Since demographic projections anticipate precisely the combination of a declining young population and a growing elderly population, Bryant (2003) arrives, contrary to the initial conclusion of Razin et al. (2002), at a position convergent with that of Sanz and Velázquez (2007): demographic aging will generate upward pressures on taxes and, possibly, on social benefits.

The implications of these fiscal pressures for the sustainability of public debt are also analyzed in depth by Jensen and Nielsen (1995), through a case study dedicated to Denmark. For the period 1994-2030, the authors identify a "demographic breathing space"—a temporary decrease in the old-age dependency ratio over the first 10-15 years, followed by a sharp increase as the baby-boom generations reach retirement age—and a "double aging" phenomenon after 2020, when the share of the senior population (80 years and over) increases simultaneously with that of the elderly population in general. Under a pay-as-you-go financing scheme, the tax rate required to finance expenditure for the elderly follows a "J-shaped" profile, with an increase of nearly 5 percentage points concentrated after 2005. An important result of the study is that, from the perspective of pure economic efficiency, the difference between a year-by-year balanced budget strategy and an anticipatory fiscal policy—involving the building up of reserves before the demographic pressure materializes—is minimal. The decisive argument for an anticipatory policy remains, instead, that of intergenerational equity, namely the distribution of the fiscal burden between the generations that are aging and the working generations during the period of intense aging.

A considerable body of recent research shifts the analysis from the macroeconomic level to that of local and regional public administration, where the effects of demographic aging on public services become visible with additional intensity and complexity. Andrews and Dollery (2021) propose a broad conceptual framework, showing that demographic decline is not a homogeneous phenomenon but results from the combination of natural population decline with negative net migration, manifesting itself with particular intensity in rural communities and small regions. The impact on local administration is, consequently, asymmetric: on the one hand, demand increases for health services, elderly care, and related infrastructure (care homes, care centers), while on the other hand, demographic decline erodes the viability of local labor markets and the fiscal capacity of local authorities, generating an increasing dependence on central government transfers.

Valkama and Oulasvirta (2021), analyzing the case of Finland, show that, among structural responses to demographic pressure, subsidized municipal mergers did not generate the anticipated cost savings, while intermunicipal cooperation and changes to the transfer equalization system proved more effective in reducing financial disparities between administrative units with different demographic profiles. Ferreira, Caldas, and Marques (2021), using a sample of 308 Portuguese municipalities, show that the longevity of residents and the share of pensioners have a significant negative effect on local socio-economic development and financial sustainability, even though the average age of the population explains a relatively small proportion of the variation in aggregate performance. De Widt (2021), based on a panel of 394 English local authorities, finds that administrations with aging populations managed their financial reserves cautiously in the post-2010 period, as a protective strategy, but warns that the combined impact of aging and the COVID-19 crisis represents a significant threat to the financial sustainability of local administration. Finally, Warner and Zhang (2021), based on data from the United States, show that a broader range of services for the elderly and for families with young children is determined primarily by interinstitutional collaboration and the active involvement of beneficiaries, a result that shifts the emphasis from fiscal constraints to collaborative governance capacity.

The relationship between demographic structure and the financial sustainability of public services is also rigorously examined by López Subires et al. (2019), through an analysis of 138 local administrations and 17 Spanish regions (2006-2014). The most relevant result for the topic of the present paper is the differentiated effect of the dependent population depending on the administrative level: the share of the population under 16 negatively affects exclusively the financial sustainability of local administrations, while the share of the population over 65 negatively affects exclusively the sustainability of regional governments—an asymmetry explained by the distribution of competencies (local administrations predominantly manage services for the young population—education, culture, sport—while regions manage health and social assistance). This distinction across administrative levels offers an essential interpretive key for the otherwise surprising results obtained by Kopańska (2023) on a sample of 2,414 Polish municipalities (2004-2019). Unlike Sanz and Velázquez (2007), who identify, at the aggregate OECD level, a positive relationship between population aging and the growth of public expenditure, Kopańska (2023) confirms, at the local level, exactly the opposite relationship: a 10% increase in the share of the elderly population is associated with a reduction in own revenues (particularly from income tax, as a result of the low pension replacement rate in Poland) and with a reduction in total and operational expenditure per capita, including social assistance expenditure. Moreover, the results regarding education and care homes contradict the author's initial hypotheses: per capita education expenditure increases in aging municipalities, due to the rigidity of teaching staff employment and the fixed maintenance costs of infrastructure amid declining student numbers, while expenditure on care homes for the elderly decreases—a result the author attributes to a possible chronic underfunding of this type of service. This also introduces the distinction between direct effects (changes in demand for age-group-specific services) and indirect effects (deterioration of the local economy, decline in the labor market and property values), which can reinforce one another through a "negative feedback loop" that accelerates both economic decline and youth migration.

Overall, the divergence between the results of Sanz and Velázquez (2007) and those of Kopańska (2023) illustrates that the effects of demographic aging on public finances cannot be generalized independently of the administrative level and the structure of competencies—a conclusion aligned with that of López Subires et al. (2019) and one that recommends caution in extrapolating results obtained at one level of government to another.

The effects of demographic aging on labor supply constitute another research direction with partially divergent results. Marešová, Mohelská, and Kuča (2015) argue that population aging tends to reduce both labor market participation rates and household savings rates, raising concerns about a possible long-term slowdown in economic growth. A different perspective is offered by Mariadas et al. (2023), who, through an ARDL-PMG panel data analysis for eight developing economies, obtain a contrary result: a 1% increase in the share of the elderly population is associated with an increase of approximately 1.03% in the labor market participation rate, a result confirmed by several estimators. The difference between the two results can be explained, at least in part, by the different economic context—developed versus developing economies—in which pension systems are less generous and the elderly population is forced to remain economically active. However, Mariadas et al. (2023) also identify a second, complementary mechanism: robustness tests show that health expenditure has a statistically significant negative effect on the labor market participation rate, suggesting that the financial pressure generated by medical costs can erode the resources available for economic participation—a link that connects this research direction to that concerning health expenditure, discussed earlier (Jakovljević, 2017; Niemcewicz & Ziółkowska, 2025).

A distinct and relatively rarely encountered perspective in the recent literature concerns the demographic effects on public sector employees. Wolf, Neves, Greenough, and Benton (1987) examine the staffing structure of local social assistance agencies in the United States, identifying the long-term effects of the baby-boom generation on the public services workforce: a median age of 40.2 years, a concentration of nearly 40% of positions in the 30-39 age group, and a widespread "career plateau" phenomenon, explained by the combination of the recruitment expansion of the 1960s-1970s and the contraction of promotion opportunities beginning in 1978. The authors warn of a structural paradox: stagnation at the middle and upper levels coexists with a potential staffing deficit at the entry level, generated by high turnover among young employees and the declining attractiveness of careers in public services. Although the study dates from 1987, its observations regarding job rotation and managerial succession planning remain relevant for contemporary public administrations facing similar waves of mass retirements—a phenomenon also mentioned by Kinnunen and Tuovinen (2008) for the Finnish case, where approximately one-third of local administration staff was estimated to retire within the decade following the analysis, thus generating a double pressure on administrative capacity: the need to replace existing staff and the need for additional staff to meet increased demand for services.

A less explored, but increasingly present, dimension in the recent literature concerns the adaptation of public services—particularly transport—to the specific needs of the elderly population. Tinella et al. (2023), through a literature synthesis from a psychological perspective, identify three essential requirements of an "age-friendly" public transport system: financial affordability, physical and informational accessibility, and safety. The authors document examples of policies that combine these dimensions, such as free or reduced travel passes for the elderly in the United Kingdom and Scotland, or the "transport for all" program in Hong Kong, with demonstrated effects on reducing the social exclusion of low-income elderly people. From a psychological perspective, the study structures the analysis around four axes:

independence and autonomy, comfort and convenience, social inclusion and combating age-based discrimination, and physical health and well-being. This perspective complements analyses centered on costs and financing (Sanz & Velázquez, 2007; Kopańska, 2023) with a dimension of service quality and accessibility, often absent from aggregate econometric models, and underscores that the effects of demographic aging on public services are not limited to the volume of allocated resources, but also include how these resources are used to address specific needs related to mobility, autonomy, and social inclusion.

Part of the reviewed literature explicitly rejects the predominant narrative framework—that of demographic aging as a "tsunami" or "crisis"—and proposes a reconceptualization of the phenomenon. Marešová, Mohelská, and Kuča (2015) emphasize that the change in age structure can also generate economic opportunities: the development of specialized markets for products and services aimed at the elderly, job creation in long-term care, and the expansion of the construction sector oriented toward adapted housing, as well as the role of migration as a partial solution to the labor shortage generated by the aging of the native population.

The critical analysis of the literature reveals both solid convergences and unresolved tensions. On the one hand, there is broad consensus regarding the general direction of the relationship between demographic aging and public health and social assistance expenditure: at the aggregate level, whether at the scale of a single country (Jakovljević, 2017; Kinnunen & Tuovinen, 2008), the OECD group (Sanz & Velázquez, 2007), or the European Union (Marešová et al., 2015; Niemcewicz & Ziółkowska, 2025), aging is associated with upward pressure on these expenditure categories. On the other hand, the magnitude and even the direction of this effect appear to depend critically on the level of aggregation and the structure of administrative competencies: what represents upward pressure at the national or OECD level (Sanz & Velázquez, 2007; Bryant, 2003) can turn into downward pressure on local budgets (Kopańska, 2023), an effect that can be explained by the asymmetric distribution of competencies between levels of government (López Subires et al., 2019; Andrews & Dollery, 2021).

A second line of analysis concerns the role of non-demographic factors. The methodologically more rigorous studies (Pearson et al., 1989; Kinnunen & Tuovinen, 2008; Niemcewicz & Ziółkowska, 2025) converge on the conclusion that demographic structure represents a necessary but not sufficient condition for explaining the level and evolution of public expenditure, with system organization, public sector productivity, cohort differences, and public policy decisions playing a role that is at least as important. Finally, a more recent strand of the literature proposes shifting the analytical framework from a predominantly fiscal and constraint-based logic—present in most of the cited econometric studies—toward a logic of adaptation and opportunity (Marešová et al., 2015; Warner et al., 2025), which integrates dimensions such as service quality and accessibility (Tinella et al., 2023), the structure of the public sector workforce (Wolf et al., 1987), and collaborative governance models (Warner & Zhang, 2021; Andrews & Dollery, 2021). This diversity of perspectives suggests that future analyses of the effects of demographic aging on public services will need integrated approaches, capable of combining the fiscal dimension with organizational, institutional, and service-quality dimensions, across multiple levels of governance.

3. Statistical Data

The data used in the research were obtained from the platform of the National Institute of Statistics (NIS), as well as from official documents published by the National Commission for Strategy and Prognosis, and cover the age and sex structure of the resident population, the natural population change, migration flows, the unemployment rate, public expenditure on social services, and the population of each county, used as a reporting base for calculating per capita indicators. Based on the demographic data, the demographic aging indicators used in the analysis were calculated for both reference years and disaggregated by sex: the share of young people, the share of the elderly, the average age, the median age, the demographic aging index, the youth dependency ratio, the old-age dependency ratio, and the total dependency ratio, as well as the net migration rate and the natural population change rate of the resident population, some of which are used as explanatory variables within the econometric model.

The statistical unit analyzed is the county, with the research covering all 41 counties of the country together with the Bucharest municipality, so that the sample comprises N = 42 territorial-administrative units. The choice of this level of disaggregation reflects both data availability and the administrative relevance of the county in the planning and provision of social services in Romania.

4. Research Methodology

4.1 Descriptive Analysis of Demographic Aging at the County Level

The age pyramid represents one of the most expressive graphical tools for visualizing the demographic structure of a population, allowing for the rapid identification of the stage of demographic aging and its evolutionary trends. In the present research, age pyramids of Romania's resident population were constructed for the years 1992, 2012, and 2025, based on NIS data on the age-group and sex structure, with the aim of illustrating the structural transformations that have occurred over more than three decades.

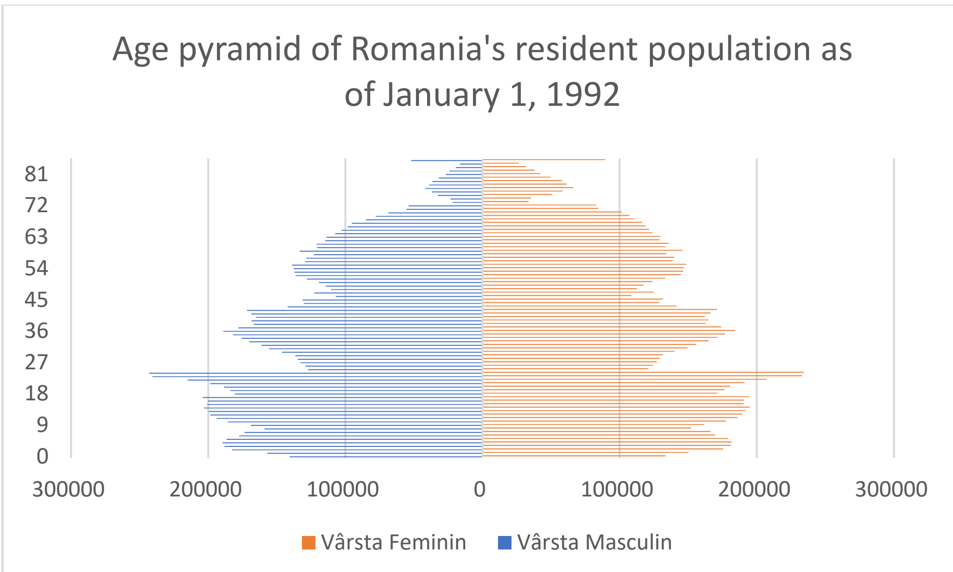

Fig. 1 - Age pyramid of Romania's resident population as of January 1, 1992

The 1992 pyramid (Figure 1) reveals a relatively young demographic structure, characterized by a still sufficiently broad base and by a population distribution that largely retains the shape of a triangle. At the same time, a pronounced bulge is observed in the age cohorts between 18 and 27 years old, reflecting the direct demographic effect of Decree No. 770 of 1966, through which the communist regime banned abortion and imposed an aggressive pronatalist policy, generating a wave of births during the period 1967-1989. This oversized cohort constitutes a persistent demographic imprint, visible across all three graphical representations.

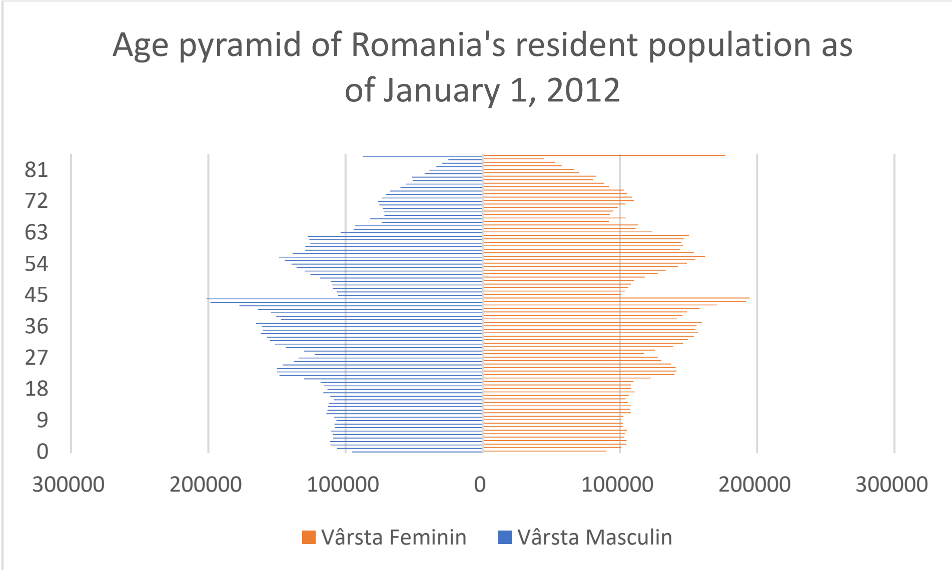

Fig. 2 - Age pyramid of Romania's resident population as of January 1, 2012

The 2012 pyramid (Figure 2) highlights the first clear signs of demographic aging. The base of the pyramid narrowed significantly compared to 1992, reflecting the sharp decline in the birth rate recorded after 1989, in the context of the liberalization of abortion and the deterioration of economic and social conditions. The Decree cohorts have now shifted to the 36-45 age segment, constituting the most numerous group within the population, while the younger age groups, under 18, are visibly underrepresented. The elderly age groups begin to occupy a more substantial share of the population structure, taking on a shape characteristic of populations in an advanced stage of demographic transition.

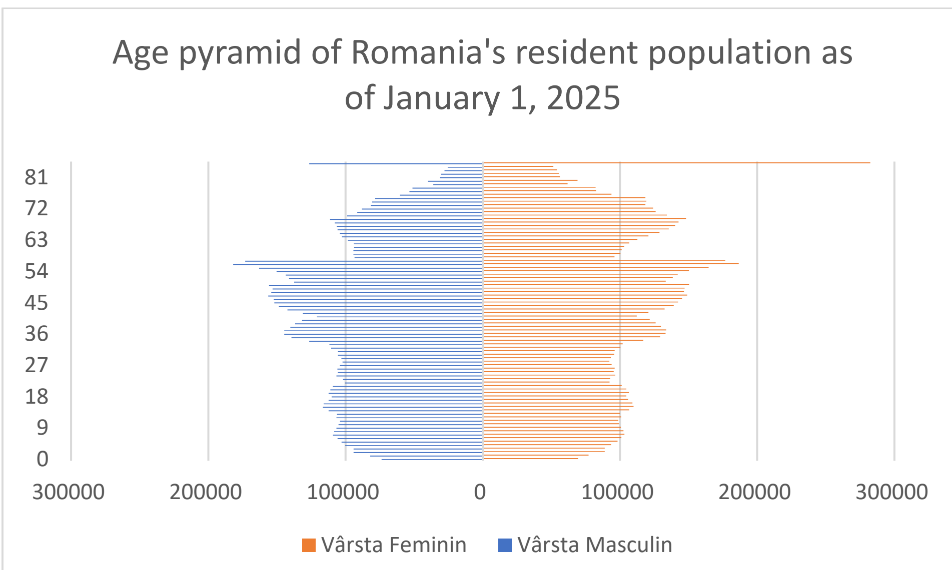

Fig. 3 - Age pyramid of Romania's resident population as of January 1, 2025

The 2025 pyramid (Figure 3) confirms and reinforces the trends identified previously. The base is considerably narrower than in any of the preceding years, signaling a birth rate too low to ensure generational replacement. The Decree cohorts have advanced to the 54-63 age group, becoming the most populous segments of the pyramid, which generates significant pressure on the pension system and on elderly care services. The top of the pyramid has elongated, particularly on the female side, as an expression of women's longevity advantage, and the overall shape of the demographic structure has shifted from a relatively balanced one to a markedly regressive one, with direct implications for the sustainability of social protection systems.

Beyond the visual component, through which the presence and intensity of the demographic aging process can be observed, quantifying this process requires the use of a set of statistical indicators capable of capturing both the structural changes in the population by age group and the intensity of the demographic pressure exerted by the two vulnerable social categories—the young and the elderly—on the working-age, adult population, aged 15 to 64. In the present research, eight demographic aging indicators were calculated at the national level for the years 2012 and 2025, disaggregated by sex, with the 1992 values included for historical reference purposes, in order to provide a broader comparative perspective on the magnitude of the structural transformations that occurred over the analyzed time period. In addition, the values obtained from county-level data allow for the identification of territorial disparities in the pace and intensity of these transformations specific to Romania's territory.

Indicator	01.01.1992			01.01.2012			01.01.2025		
	Masculin	Feminin	Ambele sexe	Masculin	Feminin	Ambele sexe	Masculin	Feminin	Ambele sexe
Pop tânără (0-14ani)	2704082	2590178	5294260	1635505	1548744	3184249	1511259	1429727	2940986
Pop adultă (15-64ani)	7660039	7664835	15324874	6837640	6831758	13669398	6242036	5997975	12240011
Pop vârstnică (65ani și peste)	1039961	1484765	2524726	1303962	1938387	3242349	1537239	2324915	3862154
Pop totală	11404082	11739778	23143860	9777107	10318889	20095996	9290534	9752617	19043151
yt (0-14ani)%	23,71	22,06	22,88	16,73	15,01	15,85	16,27	14,66	15,44
ya(15-64ani)%	67,17	65,29	66,22	69,94	66,21	68,02	67,19	61,5	64,28
yv(65ani și peste)%	9,12	12,65	10,91	13,34	18,78	16,13	16,55	23,84	20,28
xmediu (ani)	33,29	35,61	34,47	38,59	41,81	40,24	40,54	44,28	42,46
xmedian (ani)	31	34	33	38	41	40	41	46	44
iID (nr.vârstnici la 100 tineri)%	38,46	57,32	47,69	79,73	125,16	101,82	101,72	162,61	131,32
isen (vârstnici de 85 ani și peste la 100 vârstnici de 65 ani si peste)%	5,01	6,03	5,61	6,71	9,12	8,15	8,23	12,15	10,59
Kdt (tineri la 100 de adulți)	35,3	33,79	34,55	23,92	22,67	23,29	24,21	23,84	24,03
Kdv (vârstnici de 65 ani si peste la 100 de adulți)	13,58	19,37	16,47	19,07	28,37	23,72	24,63	38,76	31,55
Kdtot (tineri+vârstnici la 100 adulți)	48,88	53,16	51,02	42,99	51,04	47,01	48,84	62,6	55,58

Fig. 4 - Demographic aging indicators

The first group of indicators concerns the structure of the population by broad age groups. The share of young people (yt) expresses the proportion of the population aged 0 to 14 within the total population, while the share of the elderly (yv) reflects the proportion of persons aged 65 and over. In interpreting the latter indicator, the demographic literature operates with three reference thresholds: a yv value below 7% characterizes a demographically young population, a range between 7% and 12% signals a population undergoing demographic aging, and exceeding the 12% threshold indicates an already aged population. Measured against this interpretive grid, Romania's recorded values place the country in the category of aged populations as early as 1992, when the share of the elderly reached 10.91%, placing it at the upper limit of the transition range, and confirm the deepening of this process by 2025, when yv reached 20.28%, far exceeding the critical threshold of 12%. The evolution of these two indicators at the national level eloquently captures the dynamics of the demographic aging process: the share of young people fell from 22.88% in 1992 to 15.44% in 2025, while the share of the elderly followed the opposite trajectory, increasing continuously throughout the analyzed period. The gender discrepancy is significant in the case of the share of the elderly: in 2025, it reached 23.84% among women compared to 16.55% among men, reflecting the longevity advantage of the female population.

The second group of indicators concerns the central tendency of the age distribution. The average age of the resident population increased from 34.47 years in 1992 to 42.46 years in 2025, while the median age evolved from 33 years in 1992 to 44 years in 2025. For these indicators as well, gender differences are even more notable: in 2025, the median age of women was 46, compared to 41 for men, as an expression of the persistent gender differences in life expectancy, with women surviving in greater proportion to advanced ages.

The demographic aging index (Iid) relates the number of elderly persons (65 and over) to 100 young persons (0-14), constituting a synthetic indicator of the structural ratio between these two age groups. The conventional interpretive thresholds—below 20% for young populations, between 20% and 40% for aging populations, and above 40% for aged populations—place Romania, as early as 1992, beyond the demographic threshold of aging, with a value of 47.69%. This confirms that the phenomenon is not a novelty of recent decades, but a structural reality with origins predating the analyzed period. The subsequent evolution of the index considerably amplified this trend: in 2012, Iid reached a value of 101.82%, exceeding the threshold of numerical balance between generations and marking the moment when the elderly population began to numerically exceed the young population. By 2025, the index continued to increase, reaching 131.32%, with the gender breakdown significantly nuancing this picture: in 2025, the index reached a value of 162.61% among women, compared to 101.72% among men, a direct consequence of the higher life expectancy of the female population.

Demographic dependency ratios measure the potential economic burden that the dependent population categories—young people and the elderly—place on the working-age population (15-64 years). The youth dependency ratio (Kdt) decreased from 34.55% in 1992 to 24.03% in 2025, against the background of the declining share of the young population. Conversely, the old-age dependency ratio (Kdv) increased steadily, from 16.47% in 1992 to 31.55% in 2025, with significantly higher values for women (38.76% in 2025, compared to 24.63% for men). The total dependency ratio (Kdtot), which combines both components, recorded a slight decrease between 1992 (51.02%) and 2012 (47.01%), explained by the fact that the large generations born under the effect of pronatalist policies were, in 2012, in the midst of their working-age period, contributing to the increase of the ratio's denominator; however, this temporary decline reversed by 2025, when Kdtot increased to 55.58%, as these same generations began their transition toward retirement age.

The spatial distribution of the demographic aging index at the county level in 1992 reveals a heterogeneous territorial picture, in which disparities among counties reflect long-standing structural differences in the regional demographic behavior of Romania.

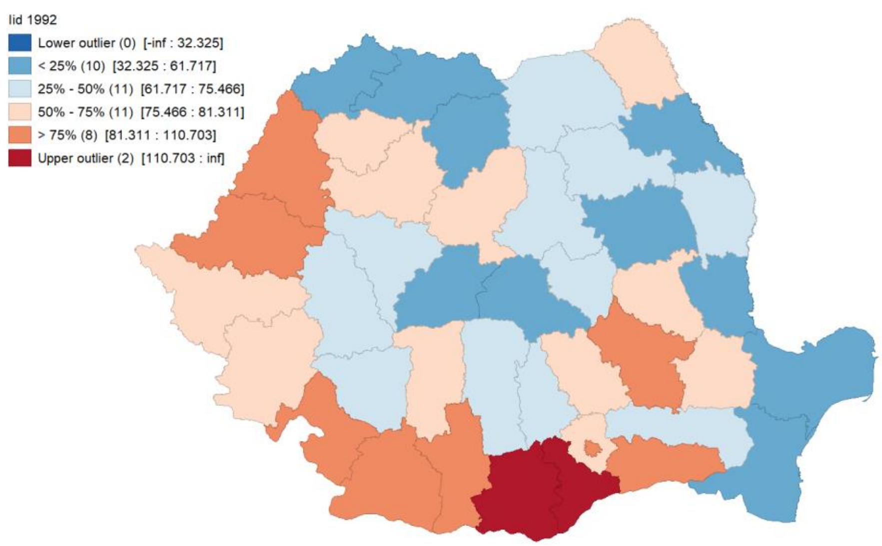

Fig. 5 – Box map for demographic aging index, 1992

Figure no. 5 makes it possible to identify the position of the counties relative to the statistical distribution of the index, highlighting outlier values. The analysis shows the absence of any values below the lower limit (32.325%), while at the upper extreme two counties stand out with values exceeding the threshold of 110.703%, classified as upper outliers. These counties, Teleorman and Giurgiu, located in the south of the country, had in 1992 a demographic aging index significantly higher than the rest of the territory, indicating a markedly aged demographic structure compared to the national average of 47.69%. The first quartile of the distribution (below the 25th percentile, with values ranging from 32.325% to

61.717%) groups 10 counties predominantly from the north and northeast of the country, regions historically characterized by higher birth rates and younger demographic structures. At the opposite end, the 8 counties with values above the 75th percentile (81.311%-110.703%) are concentrated in the west and southwest of Romania, reflecting a more advanced aging process, comparable to the demographic trends in neighboring Central European regions.

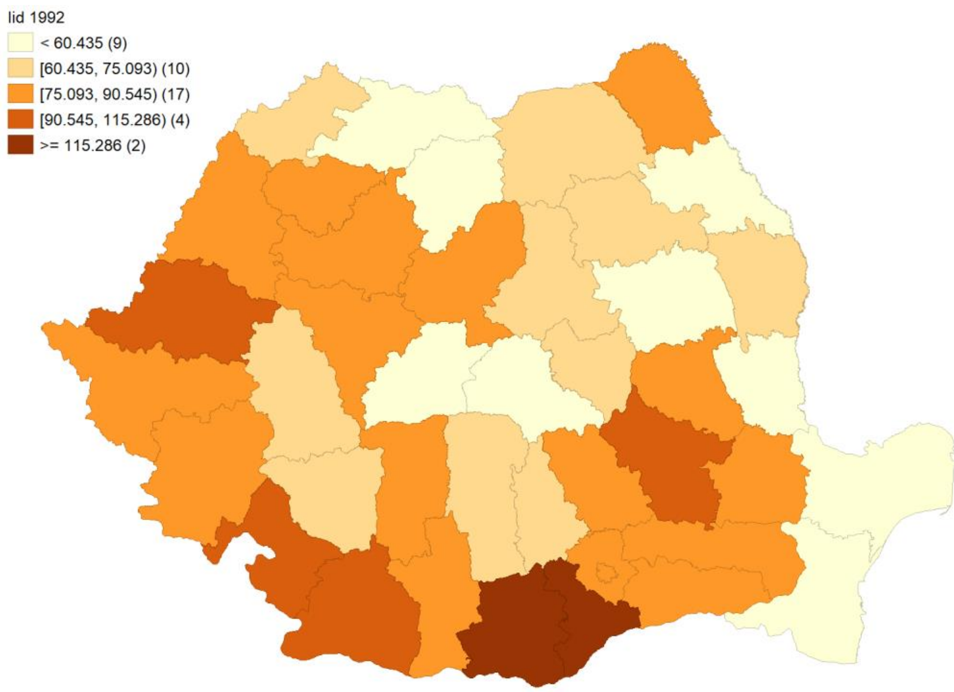

Fig. 6 - Natural Breaks Map for demographic aging index, 1992

The map produced using the Natural Breaks method (Figure 6) confirms these territorial patterns, while also providing a better visualization of the natural groupings within the data. The most numerous class, comprising 17 counties with values between 75.093% and 90.545%, occupies a central, transitional area, reflecting moderate demographic aging, in line with the national average. The nine counties with the lowest values (below 60.435%) are located predominantly in Moldova and northern Transylvania, while the same two counties in the upper class (above 115.286%), Teleorman and Giurgiu, again constitute, in this classification as well, the extreme cases of the distribution—a reality explainable through the convergence of several structural factors: a traditionally lower fertility pattern compared to the northeastern regions, an intense and selective rural-to-urban migration oriented toward Bucharest, facilitated by geographical proximity to the capital, a low degree of industrialization, and small-scale urban centers with weak capacity to retain or attract young population.

Taken together, the two cartographic representations outline an axis of demographic aging oriented roughly northeast-southwest, with the youngest counties concentrated in the Moldova area and the most aged ones located in the west and south of the country.

A comparison of the maps for 2012 with those for 1992 reveals a significant acceleration of the demographic aging process at the county level, reflected both in the generalized shift of values toward higher ranges and in the partial reconfiguration of the spatial distribution of the phenomenon.

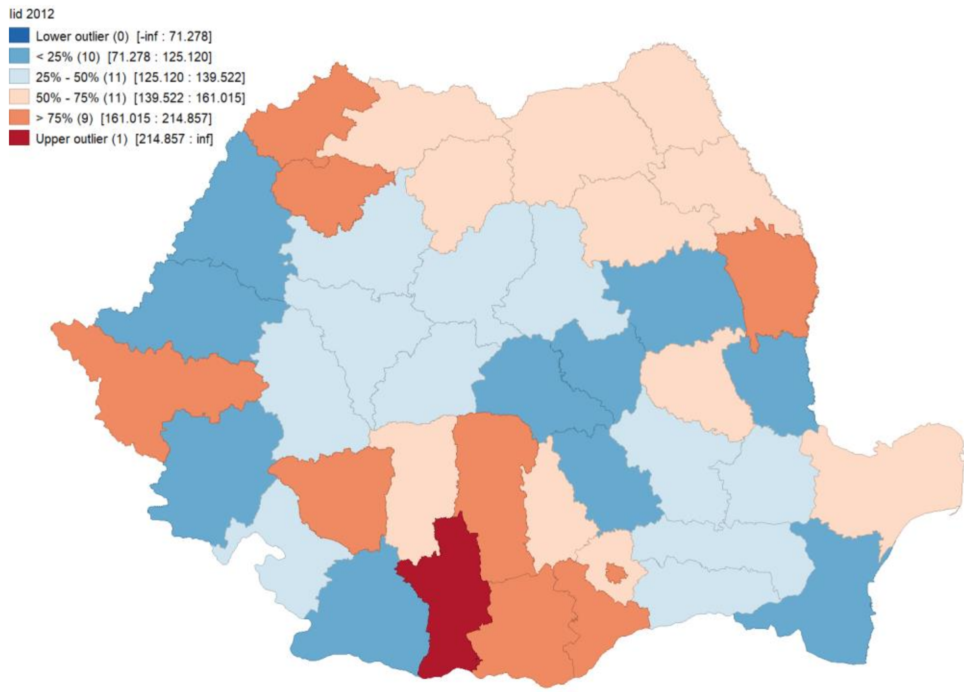

Fig. 7 –Box map for demographic aging index, 2012

Figure no. 7 captures a profound structural transformation of the index's distribution: the threshold of the first quartile rose from 61.717% in 1992 to 125.120% in 2012, the median shifted from 75.466% to 139.522%, and the upper quartile from 81.311% to 161.015%. This uniform shift of the entire distribution means that, by 2012, no county in the country still recorded values comparable to the lowest aging levels of 1992, with even counties having relatively young demographic structures exceeding, in 2012, the threshold of 71 elderly persons per 100 young persons. The number of upper outliers decreased from two to a single one, with values exceeding 214.857%, though this does not reflect a demographic improvement, but merely a relative compression of the dispersion, given that the entire sample had advanced toward higher levels of aging. The county classified as an upper outlier, Olt, located in the south of the country, recorded in 2012 an aging index exceeding the threshold of 221.599%, a value explainable through post-1990 industrial decline, particularly the restructuring of the aluminum sector in Slatina, massive emigration toward Western Europe, accelerated after the 2002 visa liberalization, extensive rural areas affected by chronic depopulation, and a southern-type demographic pattern, characterized by traditionally low fertility and selective migration of the young population.

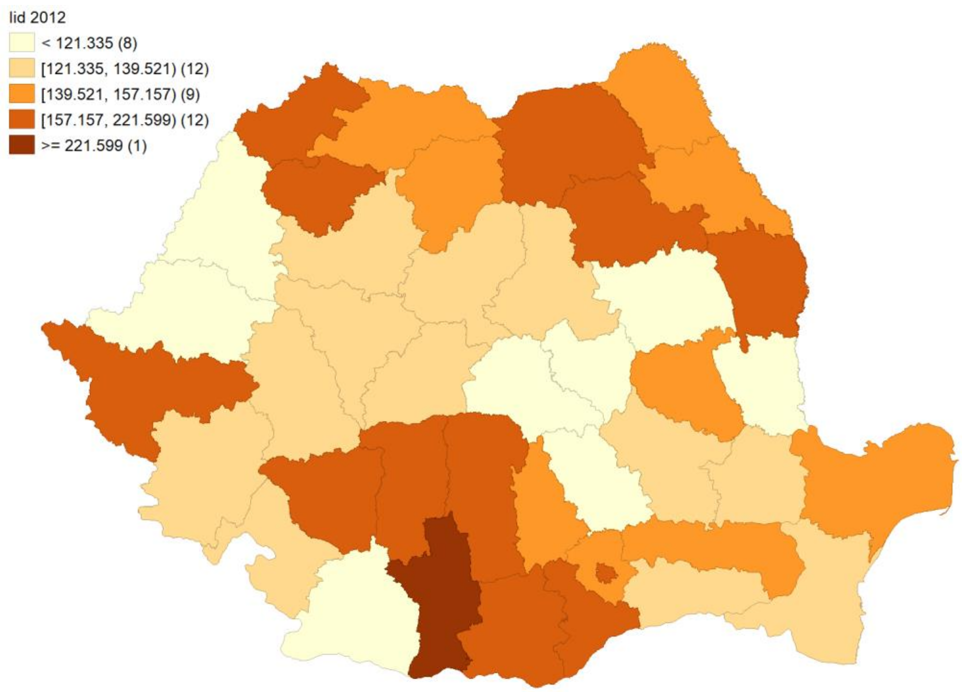

Fig. 8 - Natural Breaks Map for demographic aging index, 2012

The 2012 Natural Breaks map (Figure 8) reveals a more numerically balanced distribution among classes compared to 1992, with a concentration of counties in the intermediate and upper categories. The eight counties with the lowest values (below 121.335%) are no longer concentrated exclusively in the northeast of the country, but display a more geographically dispersed pattern, including in the central-western and southeastern areas, reflecting the effect of internal and external migration on the demographic structure. At the opposite end, the class with the highest values comprises a single county (Olt, with a value of 221.599%), while 12 counties fall into the immediately lower class (157.157%-221.599%), concentrated predominantly in the north and south of the country.

Compared to 1992, the spatial patterns of demographic aging are partially maintained, with the northeast-southwest axis remaining recognizable; however, the phenomenon has become generalized and intensified across the entire national territory, blurring some of the previous regional contrasts. This evolution is the direct consequence of the prolonged decline in the birth rate after 1989, the massive emigration of the young and working-age population, as well as the aging of the Decree cohorts, which by 2012 were already in the second half of their working-age life period.

The maps for 2025 (Figures 9 and 10) confirm the continuation and deepening of the demographic aging process, with notable changes both in the statistical structure of the distribution and in its spatial configuration.

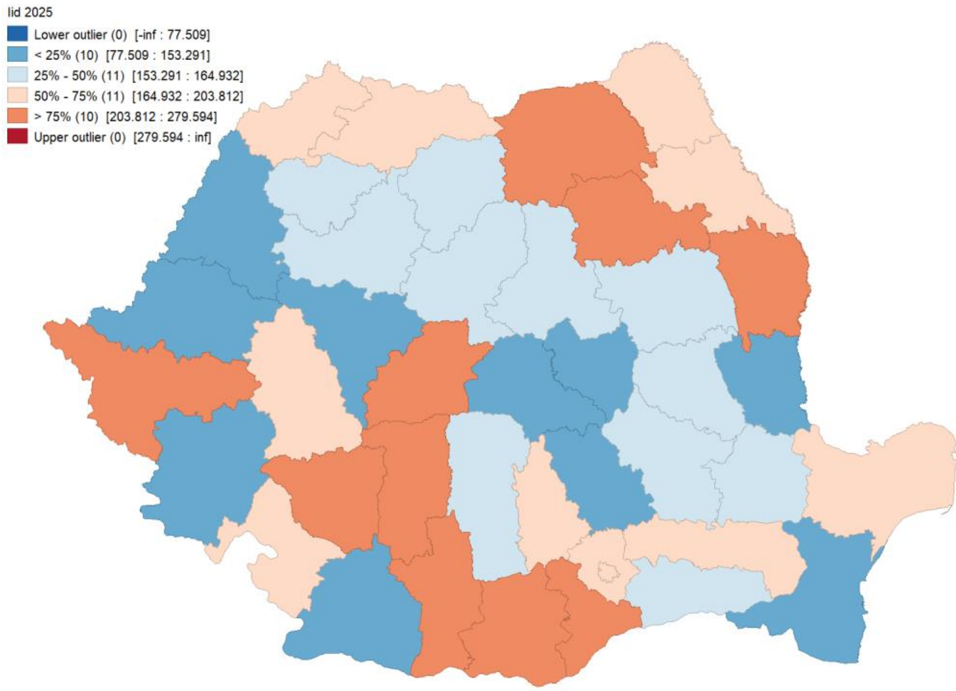

Fig. 9 – Box map for demographic aging index, 2025

The Box Map for 2025 reveals two simultaneous and seemingly contradictory trends. On the one hand, the distribution of the index has continued to shift toward higher values: the first quartile reached 153.291%, the median 164.932%, and the upper quartile 203.812%, with an upper outlier exclusion limit of 279.594%. On the other hand, and for the first time in the analyzed series, there is no county classified as an outlier. The absence of extreme values does not signal a positive convergence of county-level demographic trajectories, but rather a homogenization of the aging phenomenon: the process has become so widespread that even the counties with the highest values in 2012 have been absorbed into the current distribution, no longer representing statistical exceptions, but part of the demographic norm of contemporary Romania.

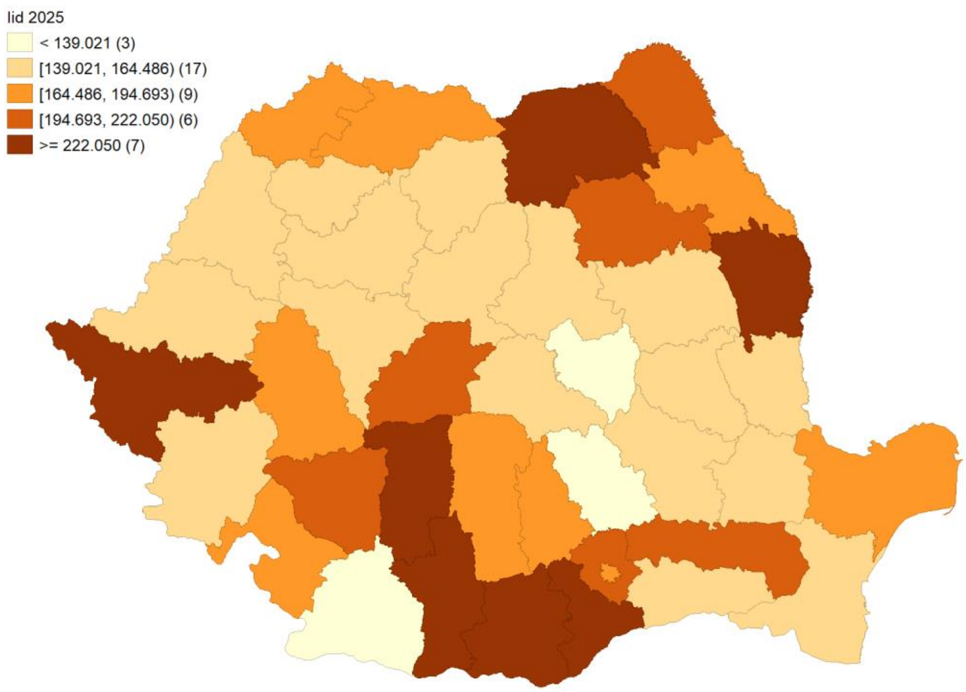

Fig. 10 - Natural Breaks Map for demographic aging index, 2025

Finally, the Natural Breaks map for 2025 illustrates the magnitude of this transformation. While in 2012 only one county exceeded the threshold of 221.599%, by 2025 no fewer than seven counties record values above 222.050%, falling into the highest class of the distribution. Among these counties are Vaslui and Suceava, located in the north and northeast of the country, which show a remarkable evolution compared to 1992, when they were among the demographically youngest, a transition that can be explained by the massive emigration of the young and working-age population, which has changed the demographic structure of the Moldova counties, rapidly transforming a region with historically high birth rates into a territory with one of the highest aging indices in the country. The same range also includes counties from the south of Romania, particularly from the Romanian Plain and Oltenia areas, regions with a predominantly agrarian profile and high rates of external emigration, as well as Timiș county, marked by emigration toward Western Europe. At the opposite end, only three counties still record values below the threshold of 139.021: Dolj, Prahova, and Covasna. Dolj benefits from the presence of Craiova as a university and industrial center, including through investments in the automotive industry that generate jobs for young people; Prahova combines economic diversity (petrochemical industry, tourism, proximity to Bucharest) with a high degree of urbanization; while Covasna represents a special case, explainable through the specific demographic behavior of the Székely Hungarian communities, characterized by stronger community cohesion and lower emigration rates compared to other rural counties in Romania.

Taken together, the three series of maps document a profound and irreversible demographic transformation of Romania's territory. The demographic aging index increased at the national level from 47.69% in 1992 to 131.32% in 2025, and its spatial distribution evolved from a pattern with clear contrasts between the young regions in the northeast and the aged regions in the west and south, toward an almost generalized picture of aging, in which differences among counties no longer reflect stable regional patterns, but the cumulative effects of emigration, declining birth rates, and the aging of the post-Decree cohorts. This territorial dynamic constitutes the descriptive foundation on which, in the following sections, formal spatial analysis tools are applied.

4.2. Spatial Autocorrelation

Spatial autocorrelation analysis seeks to determine to what extent the values of an indicator recorded at the level of territorial units are influenced by the values of the same indicator in neighboring units, thereby testing the hypothesis of random spatial distribution against that of territorial clustering. In the present research, the spatial autocorrelation of the demographic aging indicators was assessed using the global Moran's I index, calculated in GeoDa software, based on a queen contiguity neighborhood matrix, which defines as neighbors all counties sharing either an edge or a common point of their administrative boundaries.

Moran's I index takes values in the range [-1, 1], where positive values indicate a spatial clustering of similar values (clusters of counties with high or low indices), negative values suggest spatial dispersion (counties with high values tend to be surrounded by counties with low values and vice versa), and values close to zero indicate a random spatial distribution.

The statistical significance of the index was tested using the conditional permutation method (999 permutations), which randomly redistributes the observed values among counties and constructs an empirical distribution of Moran's I under the null hypothesis, avoiding the assumption of data normality. The observed value is compared with this distribution, yielding a pseudo p-value. Complementary to the global analysis, LISA (Local Indicators of Spatial Association) maps identify the type of local spatial association for each individual county, distinguishing four types of clusters: High-High (counties with high values surrounded by neighbors with high values), Low-Low, High-Low, and Low-High.

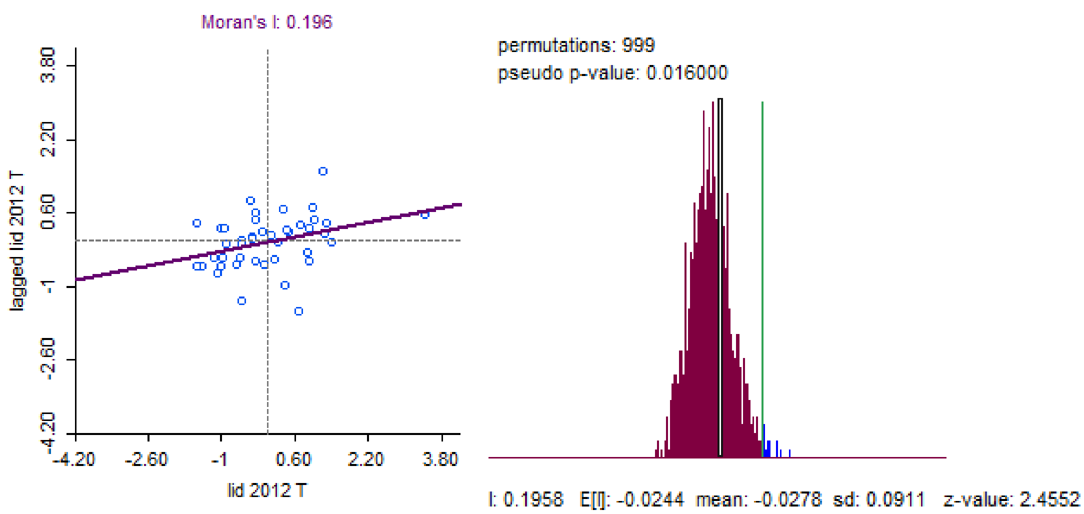

Fig. 11 - Moran's I Scatter Plot and Permutation Test for the Demographic Aging Index (2012)

The application of the global Moran's I index for the county-level demographic aging index in 2012 yielded a value of I = 0.1958, higher than the expected value under the null hypothesis of E[I] = -0.0244. The Monte Carlo permutation test with 999 randomizations generated a pseudo p-value of 0.016, below the 5% significance threshold, confirming that the spatial distribution is not random, while the z-value of 2.4552 exceeds the critical value of 1.96, confirming the statistical significance of the result. Therefore, the null hypothesis of a random spatial distribution of the demographic aging index at the county level in 2012 is rejected, with the data revealing the existence of a significant positive spatial autocorrelation, indicating that counties with high levels of the aging index tend to be located in proximity to other counties with similar values. The modest value of the index (0.196), however, suggests that this clustering is not of high intensity, with the aging phenomenon exhibiting considerable local variability beyond the overall clustering trend.

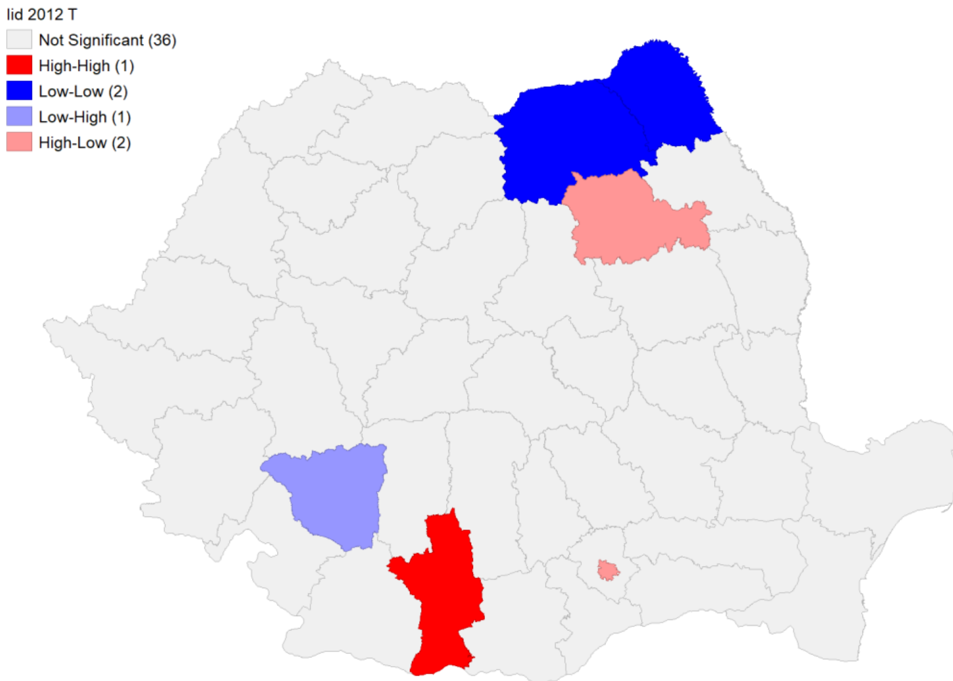

Fig. 12 – LISA Map for demographic aging index in 2012

The local LISA analysis for the demographic aging index in 2012 (Figure 12) reveals that, of the total 42 territorial units analyzed, 36 do not show a locally significant spatial association, confirming the moderate nature of the overall autocorrelation identified through Moran's I. Significant spatial clustering occurs in six counties, distributed across four distinct typologies.

Olt, the only county classified in the High-High category, located in the south of the country and consistently identified as an outlier in the previous descriptive analyses as well, displays a high demographic aging index and is surrounded by counties with similar values, constituting a genuine local hub of demographic aging in the Romanian Plain. The two counties in the Low-Low category, Suceava and Botoșani, located in the north of the country, in the Moldova region, form a cluster of relatively young demographic structures, confirming that in 2012 this region still retained, at least partially, the demographic advantage of a historically higher birth rate, although in accelerated decline compared to 1992.

In addition, the analysis revealed the presence of spatial outliers of the High-Low and Low-High types, suggesting the existence of local discrepancies relative to the dominant regional trend. Bucharest and Neamț, classified in the High-Low category, represent positive spatial anomalies: counties with higher aging indices than their neighbors, suggesting that the aging process has accelerated locally, possibly through more pronounced effects of emigration or declining birth rates compared to neighboring counties. Finally, Gorj, a county classified within the Low-High cluster, constitutes an island of relative demographic youth within a predominantly aged area, reflecting an urban attraction effect capable of retaining the young population, driven by the presence of the Oltenia Energy Complex, which maintained a higher proportion of the working-age population, limiting the emigration typical of counties with an exclusively agrarian profile in the region.

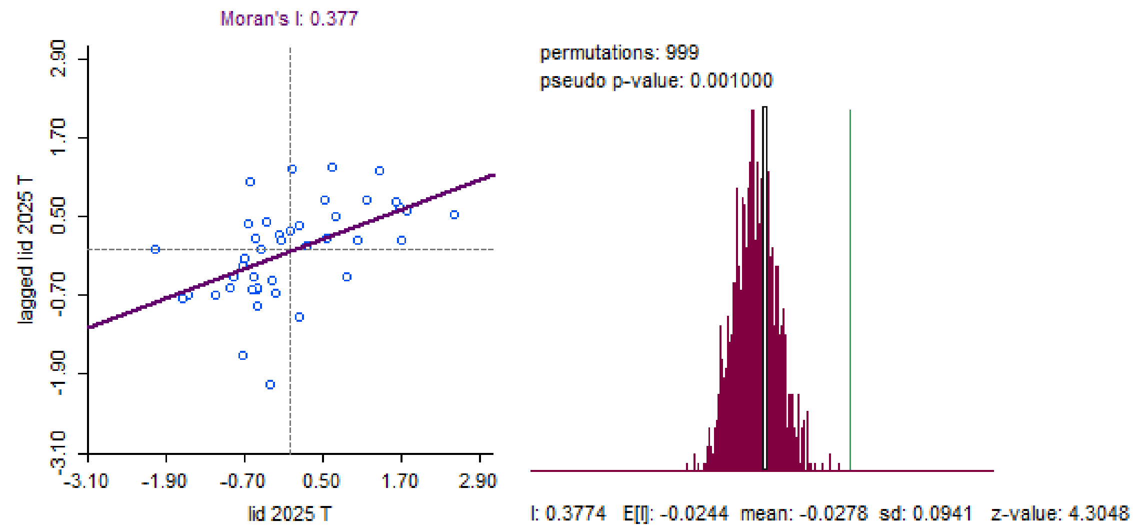

Fig. 13 - Moran's I Scatter Plot and Permutation Test for the Demographic Aging Index (2025)

The spatial autocorrelation analysis for 2025 reveals a substantial strengthening of the territorial clustering of the demographic aging index compared to 2012. Moran's I increased from 0.1958 in 2012 to 0.3774 in 2025, nearly doubling in value over the analyzed interval, which signals an intensification of the spatial clustering tendency of the aging phenomenon at the county level. The Monte Carlo simulation test based on 999 conditional permutations generated a pseudo p-value of 0.001, and the z-value of 4.3048 far exceeds the critical threshold of 1.96, confirming the high degree of statistical significance of the result, well above that recorded in 2012. The expected value under the null hypothesis remains $E[I] = -0.0244$, identical for both years, given that the number of analyzed units is constant ($N = 42$).

Nevertheless, the demographic aging process did not intensify uniformly across Romania's entire territory between 2012 and 2025; rather, existing regional disparities became more pronounced: counties with high indices evolved at a faster pace than those with low indices, generating more clearly delineated territorial clusters, with the reduced dispersion of points in the Moran scatter plot for 2025 compared to 2012 visually confirming this tendency toward spatial polarization.

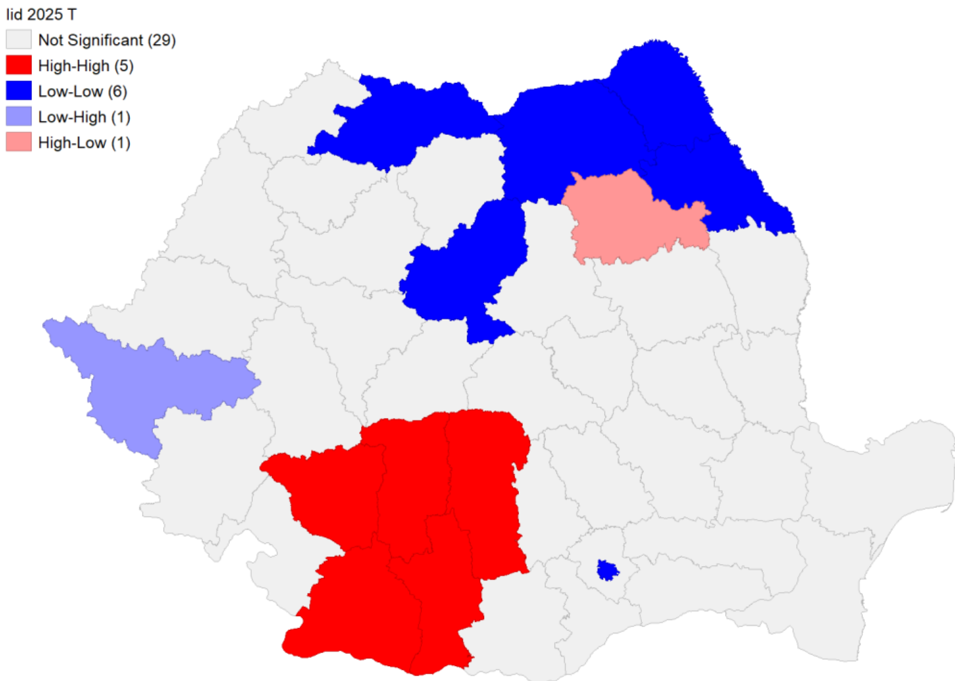

Fig. 14 – LISA Map for demographic aging index in 2025

The LISA map for 2025 (Figure 14) confirms and explains the jump recorded by the global Moran's I index, highlighting a considerable amplification and clarification of the spatial structure of demographic aging at the county level compared to 2012. The number of counties with a significant local spatial association increased from 6 to 13, reflecting the consolidation of spatial clusters. The most striking transformation is the expansion of the High-High cluster in the southwestern part of the country, in the historical region of Oltenia, which grew from a single county in 2012 to five counties in 2025. This compact cluster, located in the Romanian Plain, brings together counties with high demographic aging indices, mutually surrounded by neighbors with similar values, constituting in 2025 a genuine regional hub of demographic aging at the national level. Its territorial expansion compared to 2012 suggests that the process is no longer confined to a single isolated county but has spread to neighboring administrative units, consolidating an area of pronounced demographic aging in southern Romania.

The Low-Low cluster in the north of the country also underwent a significant expansion, growing from two to six counties, including the Bucharest municipality. This grouping of counties with relatively lower demographic aging indices reflects the greater capacity of urban centers to attract and retain young population, maintaining a more balanced demographic structure relative to the national average. Thus, Neamț county remains the only one in the High-Low cluster, while Timiș remained in the Low-High category, continuing to represent an island of relative demographic youth within a more aged regional context. The presence of such High-Low and Low-High clusters indicates the existence of counties with a demographic profile different from their immediate surroundings, highlighting local particularities that deviate from the dominant regional trends. Overall, the results confirm the consolidation of distinct territorial patterns of demographic aging and the sharpening of differences between Romania's historical regions.

Viewed comparatively, the evolution of the LISA maps between 2012 and 2025 documents a process of progressive spatial polarization of demographic aging in Romania: against the backdrop of a generalized increase in the index at the national level, the differences between aged territories and relatively young ones have intensified and become structured into increasingly well-defined geographic clusters, with direct implications for the territorial planning of social services. The approximate doubling of the index value over the analyzed period signals an intensification of the phenomenon over time, but also a progressive spatial polarization: counties with high indices and those with low indices tend to group increasingly coherently into distinct geographic clusters, against the background of diverging county-level demographic trajectories.

The spatial autocorrelation analysis was also applied to the "social expenditure per capita" variable, for both reference points in time analyzed, with the aim of assessing the extent to which it presents a non-random spatial structure at the county level.

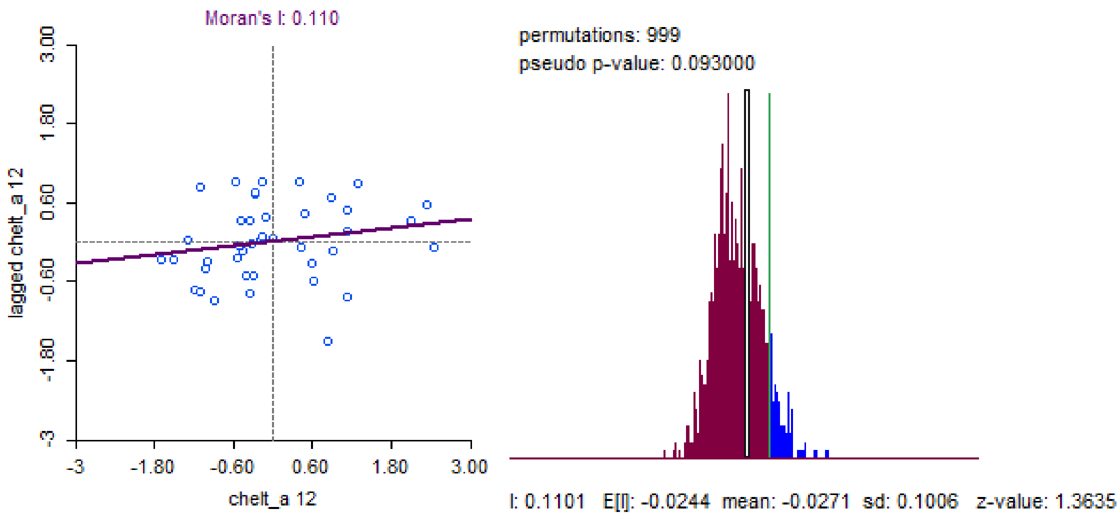

Fig. 15 - Moran's I Scatter Plot and Permutation Test for the social expenditure (2012)

The value of the global Moran's I index for social expenditure in 2012 was 0.110; however, given the recorded pseudo p-value of 0.093, above the conventional threshold of 0.05, the existence of a statistically significant spatial autocorrelation cannot be confirmed, with the territorial distribution of social expenditure being close to a random distribution.

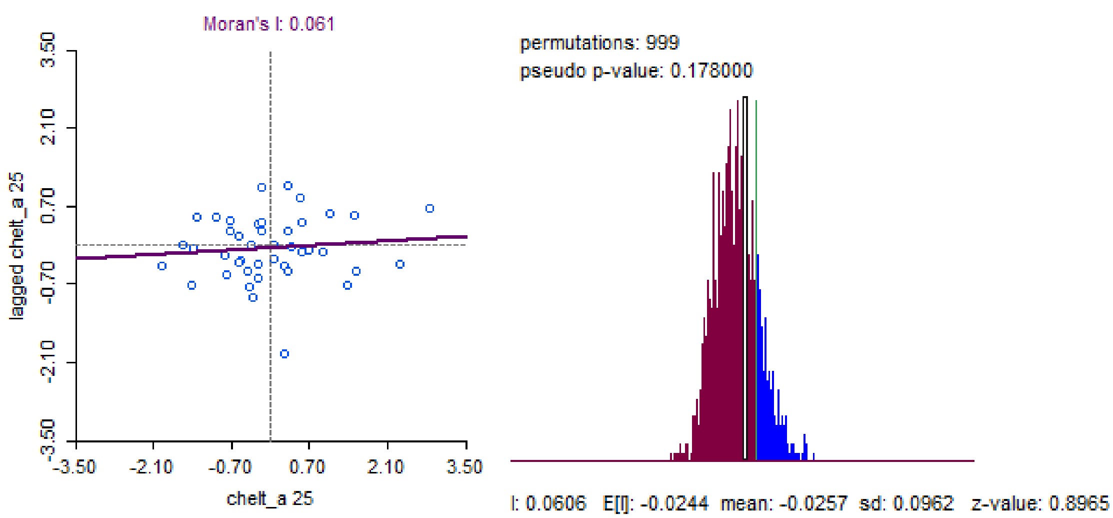

Fig. 16 - Moran's I Scatter Plot and Permutation Test for the social expenditure (2025)

Compared to 2012, the situation of social expenditure at the county level in 2025 shows a further weakening of any tendency toward spatial structuring. The global Moran's I index decreased from 0.110 in 2012 to 0.061 in 2025, while the pseudo p-value increased from 0.093 to 0.178, moving even further away from the conventional significance threshold of 0.05. Similarly, the z-value again remains below the critical threshold of 1.96 (0.8965), also confirming the absence of spatial autocorrelation. Therefore, the territorial distribution of per capita social expenditure remains, in both years, close to a random distribution, and the decreasing trend of Moran's I suggests that any territorial patterns in social expenditure, already weak in 2012, diminished further over the analyzed period, with no coherent spatial logic emerging in the allocation of budgetary resources—counties neither wishing nor managing to calibrate their social expenditure according to the levels of expenditure in neighboring counties.

Although the demographic aging process displays an increasingly pronounced spatial organization, the distribution of social expenditure does not reflect the same territorial structure and does not follow a similar spatial logic, outlining a contrasting picture. While the intensification of the spatial autocorrelation of demographic aging can be attributed to the consolidation of regions characterized by similar demographic profiles, generated by long-term processes such as the selective migration of the young population, declining fertility, or depopulation, the distribution of social expenditure does not present a statistically significant spatial structure, indicating that the allocation of public resources is influenced to a greater extent by institutional, budgetary, and administrative mechanisms than by geographic proximity. This result may suggest a low degree of territorial adaptation of social policies to the regional patterns of demographic aging.

Nevertheless, the divergence between the two variables remains analytically significant: while demographic aging follows an increasingly structured and spatially predictable territorial logic, social expenditure remains unstructured in space, suggesting that the local budgetary response to demographic pressures has not adapted to the territorial patterns of the phenomenon.

4.3. The Econometric Model

The econometric analysis of the relationship between demographic aging and public social expenditure at the county level was built progressively, starting from a simple specification and gradually enriching it, with each stage motivated by the results of the previous one.

Stage I — Simple Linear Regression

The first specification tested was a simple linear regression model in which per capita social expenditure represents the dependent variable, and the demographic aging index constitutes the sole explanatory variable, for each reference year separately.

```
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set            :  Judete
Dependent Variable  :  chelt_a 12  Number of Observations:   42
Mean dependent var  :     87.4803  Number of Variables   :    2
S.D. dependent var  :     27.4555  Degrees of Freedom    :   40

R-squared           :    0.009769  F-statistic           :    0.394614
Adjusted R-squared  :   -0.014987  Prob(F-statistic)     :    0.533455
Sum squared residual:     31350.5  Log likelihood        :    -198.517
Sigma-square        :     783.762  Akaike info criterion :     401.034
S.E. of regression  :     27.9957  Schwarz criterion     :     404.509
Sigma-square ML     :      746.44
S.E of regression ML:     27.3211

-----------------------------------------------------------------------------
       Variable      Coefficient      Std.Error    t-Statistic   Probability
-----------------------------------------------------------------------------
          CONSTANT       71.9849        25.0424        2.87452      0.00645
        Iid 2012 T       15.0618        23.9768       0.628183      0.53345
-----------------------------------------------------------------------------

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER   11.507238
TEST ON NORMALITY OF ERRORS
TEST                  DF           VALUE             PROB
Jarque-Bera            2             3.1471          0.20731

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                  DF           VALUE             PROB
Breusch-Pagan test     1             0.0815          0.77532
Koenker-Bassett test   1             0.0810          0.77588
SPECIFICATION ROBUST TEST
TEST                  DF           VALUE             PROB
White                  2             0.2590          0.87853

DIAGNOSTICS FOR SPATIAL DEPENDENCE
FOR WEIGHT MATRIX : Judete
   (row-standardized weights)
TEST                          MI/DF        VALUE          PROB
Moran's I (error)             0.1122         1.4872         0.13696
Lagrange Multiplier (lag)       1            1.1727         0.27885
Robust LM (lag)                 1            0.0016         0.96851
Lagrange Multiplier (error)     1            1.1876         0.27582
Robust LM (error)               1            0.0165         0.89792
Lagrange Multiplier (SARMA)     2            1.1891         0.55180
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Fig. 17 - OLS Regression Output, Simple Linear Regression Results 2012

For 2012, the model generated an extremely low coefficient of determination ($R^2 = 0.009$), indicating that the demographic aging index explains less than 1% of the variation in county-level social expenditure; moreover, the adjusted R^2 registers a negative value (-0.015), signaling that including this variable provides no explanatory benefit compared to a model with no predictors. The coefficient of the explanatory variable is statistically insignificant ($\beta = 15.06$; $p = 0.533$), as is the model as a whole ($F = 0.395$; $p = 0.533$), confirming that, in 2012, there was no significant linear relationship between the demographic aging index and the level of per capita social expenditure at the county level.

The diagnostic tests confirm the statistical validity of the model, without however remedying its lack of explanatory power. The Jarque-Bera test ($p = 0.207$) indicates that the assumption of residual normality is met, and the heteroscedasticity tests—Breusch-Pagan ($p = 0.775$), Koenker-Bassett ($p = 0.776$), and White ($p = 0.879$)—are all insignificant, confirming the homoscedasticity of the errors. The condition number (11.5) falls within normal limits, indicating the absence of multicollinearity issues, which is, moreover, to be expected in a model with a single explanatory variable.

The spatial dependence tests are likewise insignificant: Moran's I on residuals ($p = 0.137$), LM lag ($p = 0.279$), and LM error ($p = 0.276$) do not indicate any unexplained spatial structure, and the robust versions of these tests (Robust LM lag, $p = 0.969$; Robust LM error, $p = 0.898$) confirm the same conclusion. Therefore, the simple OLS model is statistically adequate for 2012, but explanatorily insufficient, with the relationship between demographic aging and social expenditure being, at this level of specification, statistically undetectable.

```
SUMMARY OF OUTPUT: ORDINARY LEAST SQUARES ESTIMATION
Data set            :  Judete
Dependent Variable  :  chelt_a 25  Number of Observations:   42
Mean dependent var  :     127.343  Number of Variables   :    2
S.D. dependent var  :     44.2524  Degrees of Freedom    :   40

R-squared           :    0.089136  F-statistic           :     3.91433
Adjusted R-squared  :    0.066364  Prob(F-statistic)     :   0.0547913
Sum squared residual:     74916.3  Log likelihood        :    -216.811
Sigma-square        :     1872.91  Akaike info criterion :     437.622
S.E. of regression  :     43.2771  Schwarz criterion     :     441.097
Sigma-square ML     :     1783.72
S.E of regression ML:     42.2341

-----------------------------------------------------------------------------
       Variable      Coefficient      Std.Error    t-Statistic   Probability
-----------------------------------------------------------------------------
          CONSTANT       64.0353         32.688        1.95899      0.05711
        Iid 2025 T       45.7146        23.1061        1.97847      0.05479
-----------------------------------------------------------------------------

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER   9.686808
TEST ON NORMALITY OF ERRORS
TEST                  DF           VALUE            PROB
Jarque-Bera            2             7.5395          0.02306

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                  DF           VALUE            PROB
Breusch-Pagan test     1             0.0020          0.96453
Koenker-Bassett test   1             0.0012          0.97274
SPECIFICATION ROBUST TEST
TEST                  DF           VALUE            PROB
White                  2             0.1605          0.92290

DIAGNOSTICS FOR SPATIAL DEPENDENCE
FOR WEIGHT MATRIX : Judete
   (row-standardized weights)
TEST                          MI/DF        VALUE          PROB
Moran's I (error)             0.0199        0.5740        0.56595
Lagrange Multiplier (lag)       1           0.0208        0.88539
Robust LM (lag)                 1           0.0215        0.88341
Lagrange Multiplier (error)     1           0.0374        0.84666
Robust LM (error)               1           0.0381        0.84519
Lagrange Multiplier (SARMA)     2           0.0589        0.97098
============================== END OF REPORT ================================
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Fig. 18 - OLS Regression Output, Simple Linear Regression Results 2025

For 2025, the simple model shows a higher explanatory power than that of 2012 ($R^2 = 0.089$; adjusted $R^2 = 0.066$), with the demographic aging index explaining approximately 9% of the variation in per capita social expenditure at the county level. The model as a whole is at the borderline of statistical significance ($F = 3.914$; $p = 0.055$), and the coefficient of the demographic aging index follows the same pattern ($\beta = 45.71$; $p = 0.055$), indicating a positive relationship between the two variables, marginally insignificant in strictly statistical terms, but with a tendency clear enough to justify further exploration through enriched specifications.

Unlike 2012, the Jarque-Bera test in this case signals a significant deviation from residual normality ($p = 0.023$), an aspect suggesting the presence of extreme values or an asymmetric distribution of errors, and which motivates, among other things, the subsequent recourse to a logarithmic transformation of the dependent variable. The heteroscedasticity tests remain insignificant, however: Breusch-Pagan ($p = 0.965$), Koenker-Bassett ($p = 0.973$), and White ($p = 0.923$), confirming the homoscedasticity of the errors, while the condition number (9.69) indicates the absence of multicollinearity issues.

Regarding spatial dependence, all tests remain insignificant: Moran's I on residuals ($p = 0.566$), LM lag ($p = 0.885$), LM error ($p = 0.847$), as well as their robust versions (Robust LM lag, $p = 0.883$; Robust LM error, $p = 0.845$), confirm the absence of any unexplained spatial structure in the residuals of the simple model for 2025. Thus, the main issue identified at this level of specification is not of a spatial nature, but relates to the normality of the residuals and the still-insufficient explanatory power of the model, aspects which will be addressed in the subsequent stages of the econometric analysis.

The results of the first stage indicate that the direct relationship between the demographic aging index and per capita social expenditure is weak and insufficiently captured by a univariate model, which motivates the enrichment of the specification through the inclusion of additional demographic variables with explanatory potential.

Stage II — Multiple Linear Regression

```
Data set            :  Judete
Dependent Variable  :    ln_chelt  Number of Observations:   40
Mean dependent var  :     4.78674  Number of Variables   :    4
S.D. dependent var  :    0.373717  Degrees of Freedom    :   36

R-squared           :    0.257655  F-statistic           :       4.165
Adjusted R-squared  :    0.195793  Prob(F-statistic)     :    0.012453
Sum squared residual:     4.14715  Log likelihood        :    -11.4284
Sigma-square        :    0.115199  Akaike info criterion :     30.8568
S.E. of regression  :    0.339409  Schwarz criterion     :     37.6123
Sigma-square ML     :    0.103679
S.E of regression ML:    0.321992

-----------------------------------------------------------------------------
       Variable      Coefficient      Std.Error    t-Statistic   Probability
-----------------------------------------------------------------------------
          CONSTANT       3.76661       0.313868       12.0006      0.00000
        rspornat24     0.0856974       0.038369       2.23351      0.03182
          rsomaj25     0.0682511      0.0282024       2.42005      0.02069
        Iid 2025 T      0.882327       0.309537       2.85048      0.00718
-----------------------------------------------------------------------------

REGRESSION DIAGNOSTICS
MULTICOLLINEARITY CONDITION NUMBER   20.285273
TEST ON NORMALITY OF ERRORS
TEST                  DF           VALUE            PROB
Jarque-Bera            2             1.3241          0.51578

DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                  DF           VALUE            PROB
Breusch-Pagan test     3             6.0871          0.10745
Koenker-Bassett test   3             4.3696          0.22422
SPECIFICATION ROBUST TEST
TEST                  DF           VALUE            PROB
White                  9            18.2614          0.03226

DIAGNOSTICS FOR SPATIAL DEPENDENCE
FOR WEIGHT MATRIX : Judete
   (row-standardized weights)
TEST                          MI/DF        VALUE          PROB
Moran's I (error)            -0.0962       -0.5559        0.57830
Lagrange Multiplier (lag)        1          0.1700        0.68012
Robust LM (lag)                  1          1.0779        0.29916
Lagrange Multiplier (error)      1          0.8433        0.35845
Robust LM (error)                1          1.7512        0.18572
Lagrange Multiplier (SARMA)      2          1.9212        0.38265
```

Fig. 19 - Regression Output: Multiple Linear Regression Results 2025

The multiple regression, in which the natural logarithm of per capita social expenditure serves as the dependent variable, and the demographic aging index, the natural population change rate, and the unemployment rate constitute the explanatory variables, marks a significant qualitative leap compared to the previously tested specifications, both in terms of explanatory power and overall statistical robustness. The model explains approximately 26% of the variation in social expenditure ($R^2 = 0.258$; adjusted $R^2 = 0.196$), a proportion considerably higher than that recorded in the simple specification, and the F-test confirms the statistical significance of the model as a whole ($F = 4.165$; $p = 0.012$), meaning that the set of explanatory variables, taken together, makes a real contribution to explaining the variation in county-level social expenditure.

All three explanatory variables prove to be statistically significant, which strengthens confidence in the relevance of the chosen specification. The demographic aging index retains the strongest effect among all the included variables ($\beta = 0.882$; $p = 0.007$), and in a log-linear model such as this, the corresponding coefficient can be interpreted as follows: a one-unit increase in the aging index is associated with an increase of approximately 88% in per capita social expenditure, thereby highlighting a pronounced link between a county's demographic structure and the budgetary effort allocated to social protection. The unemployment rate, in turn, contributes a positive and significant effect ($\beta = 0.068$; $p = 0.021$), confirming that counties facing higher unemployment pressure tend to allocate more substantial budgetary resources to social services, as a direct response to the social protection needs generated by the lack of jobs. It is important to note that this effect is not directly linked to the demographic aging process as such, since unemployment benefits target the working-age population, up to retirement age, rather than the elderly categories that are the central focus of the analysis; the significance of this variable rather reflects the aggregate nature of per capita social expenditure, which includes a wide range of social benefits beyond those addressed exclusively to the elderly population, an aspect also discussed in the section dedicated to the study's limitations. (It should also be noted that, in order to improve the model's explanatory power, the specification was extended by including the unemployment rate as an additional variable, in place of the net migration rate, which proved insignificant. This extension produced a substantial increase in the model's explanatory power, with the adjusted R^2 rising from 0.070 to 0.196.) The natural population change rate also displays a positive and significant coefficient ($\beta = 0.086$; $p = 0.032$), an effect that may reflect both the need for social services aimed at the young population in counties with a high natural population growth rate and possible indirect correlations with other regional socio-economic characteristics not explicitly included in the model.

The diagnostic tests broadly confirm the statistical validity of this specification, while also being useful for understanding the model's behavior relative to the previous ones. The Jarque-Bera test ($p = 0.516$) indicates that residual normality is satisfied, representing a notable improvement over the simple model and suggesting that the logarithmic transformation of the dependent variable contributed to a more balanced distribution of errors. The Breusch-Pagan ($p = 0.107$) and Koenker-Bassett ($p = 0.224$) tests do not signal heteroscedasticity issues; however, the White test ($p = 0.032$) is significant, suggesting possible deviations related to heteroscedasticity or unexplored nonlinear relationships among variables. Given that the other two heteroscedasticity tests remain insignificant, this discrepancy can more likely be attributed to interaction terms not included in the model than to a serious structural problem with the specification. Regarding the condition number (20.3), it falls at the upper limit of the range considered acceptable, indicating moderate multicollinearity among the independent variables, without significantly compromising the stability of the estimates obtained.

Regarding spatial dependence, all tests remain insignificant, producing a picture consistent with that observed in the previous specifications: Moran's I on residuals ($p = 0.578$), LM lag ($p = 0.680$), and LM error ($p = 0.358$), as well as the robust versions of these tests (Robust LM lag, $p = 0.299$; Robust LM error, $p = 0.186$), confirm the absence of any unexplained spatial structure in the model. This conclusion indicates that extending toward a spatial econometric model is not methodologically warranted, with the log-linear multiple regression constituting the final form for the analysis of the relationship between demographic aging and public social expenditure at the county level in Romania.

Before reaching the final specification, other variables potentially influencing the level of per capita social expenditure were also tested, including the net migration rate and local per capita gross domestic product, the latter included as a proxy for fiscal capacity and the level of economic development of the counties. The extended model, which simultaneously included the demographic aging index, the natural population change rate, the unemployment rate, the net migration rate, and local GDP, generated a slightly higher coefficient of determination than the final model ($R^2 = 0.267$ versus 0.258), but with a lower adjusted R^2 (0.159 versus 0.196), signaling that the inclusion of the two additional variables does not statistically justify the cost in degrees of freedom consumed. Both variables proved statistically insignificant: the net migration rate ($\beta = 0.013$; $p = 0.693$) and local GDP ($\beta \approx -7.33\times10^{-6}$; $p = 0.629$), the latter additionally displaying a virtually null coefficient and a counterintuitive negative sign, without clear theoretical support. The removal of these two variables from the final specification therefore led to a model in which all remaining variables are statistically significant, and the adjusted R^2 records a higher value, confirming that the variable selection process followed a rigorous criterion of statistical relevance rather than merely the formal maximization of the model's raw explanatory power.

5. Conclusions

5.1 Summary of Results

The analysis carried out in the present research has confirmed, through a complex set of statistical, demographic, spatial, and econometric tools, the magnitude and particularities of the demographic aging process in Romania, as well as its relationship with the level of public expenditure allocated to social services at the county level.

The descriptive analysis of demographic aging indicators revealed a profound structural transformation of the resident population over the period 1992-2025. The share of young people decreased from 22.88% to 15.44%, while the share of the elderly followed the opposite trajectory, reaching 20.28%, far above the 12% threshold that, according to conventional demographic criteria, marks the status of an aged population. The demographic aging index increased from 47.69% in 1992 to 131.32% in 2025, signifying that, at the national level, the elderly population exceeds the young population by more than 31%. The age pyramids visually illustrated this transformation, highlighting the progressive shift of the large generations of Decree 770/1966 toward advanced ages and the continuous narrowing of the pyramid's base, as a result of the prolonged decline in the birth rate.

The spatial analysis revealed that the demographic aging process is not uniformly distributed across Romania's territory, but tends to cluster into increasingly well-defined territorial groupings. The global Moran's I index for Iid increased from 0.196 in 2012 to 0.377 in 2025, indicating an intensification of positive spatial autocorrelation, also confirmed by the LISA maps, which highlighted the expansion of a High-High cluster in the south of the country, from a single county (Olt) in 2012 to five counties in 2025, and the expansion of a Low-Low cluster in the north of the country, from two to six counties. By contrast, per capita social expenditure did not display, in either of the two analyzed years, a statistically significant spatial structure, with Moran's I values remaining below the significance threshold (0.110 in 2012 and 0.061 in 2025, respectively), indicating an approximately random territorial distribution.

The econometric analysis confirmed the existence of a positive and statistically significant relationship between the demographic aging index and per capita social expenditure for 2025, a relationship that could not be statistically detected for 2012. The final model, built progressively by testing and removing insignificant variables (the net migration rate, local GDP) and by including the natural population change rate and the unemployment rate, alongside the logarithmic transformation of the dependent variable, explained approximately 26% of the variation in per capita social expenditure (adjusted $R^2 = 0.196$), with all three remaining variables being statistically significant. Testing of the spatial models, both with spatial lag and spatial error, did not reveal significant spatial dependencies in the residuals, confirming that the multiple OLS model represents the appropriate specification for the analyzed data.

5.2 Public Policy Implications

The main finding with relevance for public policy results from the contrast between the two spatial dimensions of the analyzed phenomenon: while demographic aging follows an increasingly pronounced and predictable territorial pattern, per capita social expenditure does not reflect this spatial structure. This disconnect suggests that the allocation of budgetary resources for social services at the county level is not, at present, calibrated according to territorially differentiated demographic pressures, but rather follows historical, administrative criteria or financing formulas that are insensitive to the actual dynamics of the population's age structure.

This observation has direct implications for informing budget allocation policies. The concentration of the demographic aging process into increasingly well-defined territorial clusters, particularly the High-High cluster in the south of the country, which evolved from a single county in 2012 to five counties in 2025, suggests the need for territorially differentiated financing mechanisms, capable of anticipating and responding proportionally to local demographic pressures, instead of uniform formulas applied at the national level. Specifically, the counties included in this cluster could constitute the target of pilot programs for the differentiated allocation of funds for long-term care services, home assistance, and social infrastructure aimed at the elderly population, with the results of these interventions subsequently evaluated and, potentially, extended at the national level.

The results of the econometric model, according to which the demographic aging index explains a significant but not majority share of the variation in social expenditure, indicate that demographic pressure represents a relevant but not determining factor of the social budgetary effort at the county level. This finding supports a recommendation for anticipatory budgetary planning, based on medium- and long-term demographic projections: given the predictable and short-term irreversible nature of the demographic trajectory, central and local authorities could integrate indicators such as the demographic aging index and the old-age dependency ratio directly into the formulas for allocating transfers to local budgets, thereby transforming a predictive variable into an active criterion for financial planning, rather than reacting ex-post to pressures that have already materialized.

The absence of significant spatial autocorrelation in social expenditure can also be interpreted as an opportunity: the lack of "fiscal competition"-type pressures among neighboring counties means that public authorities have room to introduce explicit allocation criteria based on demographic needs, without the risk of distortions generated by strategic behaviors of neighboring local administrations. In this sense, the periodic monitoring of demographic aging indicators at the county level could provide an objective basis for adjusting social service financing formulas, thereby anticipating the budgetary pressures generated by the already documented continuation of the demographic aging process in Romania.

6. Limitations of the Research

A first limitation of the research concerns the time horizon of the analysis. The initial approach aimed at an extended longitudinal perspective, covering the period 1990-2025; however, the limited availability of county-level disaggregated data for the period prior to 2000, coupled with the comparability difficulties generated by the monetary reform, since Romania used the old leu until 2005, with a value structure incomparable to the current one, required restricting the analysis to two reference years, 2012 and 2025. This choice nevertheless allows for capturing a significant evolution spanning over a decade, sufficient to highlight the demographic trends and their budgetary implications, but limits the ability to apply econometric methods specific to panel data, which would allow for controlling county-level fixed effects and a more robust statistical inference. Addressing this limitation could be achieved by retroactively reconstructing the series of social expenditure in comparable prices, using deflation methodologies appropriate for the monetary transition period. Another direction in this regard would require an effort on the part of the National Institute of Statistics to collect and make available historical series disaggregated at the county level for the period prior to 2012, data which are currently not publicly available at this level of detail. A second, complementary direction would consist of an additional effort to manually collect data directly from the budgetary executions of the counties for the years prior to 2012, documents which, despite the principle of transparency that governs public administration activity, are not available for most counties. It should be noted, however, that neither of these directions, not even combined, would fully reflect the actual scale of social expenditure, since part of it is borne directly by local budgets, while other parts, such as those related to the pension system or certain social benefits, are administered and financed at the national level, without being fully reflected in county budgetary executions.

A second important limitation also stems from the nature of the data used regarding public expenditure on social services. These have a general character, covering a broad range of social benefits and services, including, alongside those aimed at the elderly population, areas such as protection for the unemployed, and do not exclusively target expenditure associated with the demographic aging process. This limitation directly affects the interpretation of the econometric results, since part of the variation in per capita social expenditure is inherently explained by factors independent of the population's age structure, as also highlighted by the statistical significance of the unemployment rate in the final model. Addressing this limitation would require access to data disaggregated by category of social expenditure, allowing for the isolation of the components explicitly addressed to the elderly population, such as social assistance for the elderly, long-term care services, or expenditure on retirement homes, either by requesting detailed reports from local public administrations or through collaboration with the Ministry of Finance and the Ministry of Labor to obtain budgetary executions classified functionally at a more detailed level. Such disaggregation would allow for a more precise testing of the relationship between demographic aging and social expenditure, eliminating the disruptive influence of expenditure components unrelated to the analyzed process.

7. Future Research

A particularly promising future research direction would consist of reversing the analyzed relationship, by using the demographic aging index as the dependent variable, and per capita social expenditure, the net migration rate, and the natural population change rate as explanatory variables. Preliminary testing of such a specification, in the form of a spatial lag model, generated a considerably higher coefficient of determination ($R^2 = 0.737$), with a statistically significant spatial coefficient Rho (Rho = 0.295; $p = 0.013$) and a Likelihood Ratio test confirming the superiority of the spatial model over the OLS specification ($p = 0.010$). These results suggest the existence of significant territorial spillover effects in determining a county's level of demographic aging, with counties tending to display an aging index similar to that of their neighboring counties, beyond their own economic and demographic characteristics. Such an approach would allow for reformulating the research question, moving from the effects of demographic aging on social expenditure toward identifying the factors, including fiscal-budgetary ones, that contribute to shaping and spatially propagating demographic aging at the county level in Romania, thus constituting a complementary, but distinct, avenue for investigating the relationship between demography and public policy.

```
SUMMARY OF OUTPUT: SPATIAL LAG MODEL - MAXIMUM LIKELIHOOD ESTIMATION
Data set            : Judete
Spatial Weight      : Judete queen
Dependent Variable  :  Iid 2025 T  Number of Observations:   42
Mean dependent var  :     1.38486  Number of Variables   :    5
S.D. dependent var  :    0.289006  Degrees of Freedom    :   37
Lag coeff.   (Rho)  :     0.29491

R-squared           :    0.736695  Log likelihood        :     20.1516
Sq. Correlation     : -            Akaike info criterion :    -30.3032
Sigma-square        :   0.0219925  Schwarz criterion     :    -21.6148
S.E of regression   :    0.148299

-----------------------------------------------------------------------------
       Variable       Coefficient     Std.Error       z-value    Probability
-----------------------------------------------------------------------------
      W_Iid 2025 T      0.29491       0.119223        2.47361      0.01338
          CONSTANT     0.380453       0.166416        2.28615      0.02225
        chelt_a 25   0.00124003    0.000522674        2.37246      0.01767
        rspormig24    0.0118826      0.0130441       0.910958      0.36232
        rspornat24   -0.0781367     0.00952932       -8.19962      0.00000
-----------------------------------------------------------------------------

REGRESSION DIAGNOSTICS
DIAGNOSTICS FOR HETEROSKEDASTICITY
RANDOM COEFFICIENTS
TEST                                     DF      VALUE        PROB
Breusch-Pagan test                       3         3.3399     0.34213

DIAGNOSTICS FOR SPATIAL DEPENDENCE
SPATIAL LAG DEPENDENCE FOR WEIGHT MATRIX : Judete queen
TEST                                     DF      VALUE        PROB
Likelihood Ratio Test                    1         6.6216     0.01007
============================== END OF REPORT ================================
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Fig. 20 - Spatial Lag Model Output

10. References

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