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Maximizing city sizes or maximizing spatial interaction between cities. A look into the relative evolution of Romanian city regions from 1948 to 2021

Tomaz Ponce Dentinho[ab*], Gabriela Carmen Pascariu[c], Cristina Pantelica[a], Daniela Constantin[a], Patricio Aroca[d]

[a] Bucharest University of Economic Studies, Romania; [b] University of the Azores, Portugal; [c] Alexandru Ioan Cuza University of Iași, Romania; [d] University Adolfo Ibañez, Chile

Abstract
This paper aims to analyse the spatial interaction of Romanian Cities from 1948 to 2021 trying to perceive if, along seven decades of quite different political regimes – from Central Planning to Market Interaction–, there have been changes in the logic of spatial interaction between City Regions. The study looks into the economic-demographic evolution of Romanian city regions and tests whether, throughout time, adding to the role of the economic base, their evolution follows a logic of size maximization, or a logic of maximization of interaction flows subject to the spatial structure of Romanian cities. Results show that the logic of spatial interaction changed during the period. Except for the first periods from 1948-1956-1966, the spatial evolution of Romanian City Regions is better explained by a logic of size maximization, either in the period of Central Planning (1966-1992) or in the period of Market Interaction where the population of the previous period, or the logic of size maximization, has a strong effect in the relative performance of city-regions when compare with the logic of maximization of interaction flows. Furthermore, exports play a more reduced role in regional growth when space is appropriately integrated.

Keywords*:* spatial interaction, size maximization, flow maximization, regional development, Romania

Introduction

Cities are political entities (Cole & Payre, 2016) which, constrained by the spatial structure and by the economic, political, environmental, and technological context, compete with each other. The spatial structure of City-Regions (Pumain, 2021) is very much influenced by the intrinsic potential of places and locations shown by the resilience of the ranking of each city/region within the city/regions of a country

[*]Corresponding author: Tomaz Ponce Dentinho, PhD Professor at the University of the Azores, Portugal; e-mail: tomas.lc.dentinho@uac.pt.

(Pascariu et al., 2022; Banica et al., 2020; Reggiani & Nijkamp, 2015; Zipf, 1949) and synthesising not only the distance between and within cities but also their relative attractiveness implicit in the recurring concept of enduring proximities and resilience (Sandu et al., 2021; Sigler et al., 2021). Notwithstanding this, there are external impacts that also have a role in the profile of the system of city/regions: i) the political interference in the spatial redistribution of public money and the creation of barriers to the natural flow of people, goods and capital (Dentinho, 2017); the collapse of environmental or natural resources (Diamond, 2005); or technological changes related to mobility and communication (Reggiani & Nijkamp, 1998).

When interaction is free, each agent act generates impacts that modify the context for other agents. With many free agents, interactions become complex, leading to chaotic behaviours (Goldberger, 1996), new equilibriums (Gribbin, 2004) or self-organized dynamic equilibriums (Waldrop, 1992).

In ecology, organisms tend to maximize their stock and adapt through evolution (Pearce & Merletti, 2006) into spatially defined ecosystems (Müller-Schloer et al., 2011) eventually explained by network models (Riley et al., 2015). Nevertheless, when people and places interact freely within space they can choose to maximize their stock constrained by the context or, instead, opt to maximize the benefit from their interaction, constrained by available resources (Dentinho & Rodrigues, 2021).

Based on the maximization of land rent, Von Thünen (1826) analysed interactions between rural and urban areas. Assuming the minimization of transport and transaction costs of public goods, Chistaller (1966) understood the spatial structure of interaction between different city sizes. Losch (1954) added the role of rational behaviour and saw the possibility of spatial and economic equilibrium further included in the works of Bos (1965) and Paelinck and Nijkamp (1976). William Alonso (1964) reinforced the idea of spatial equilibrium and the role of land bid rent. Before, Hoteling (1929) perceived that the maximization of location benefits can be explained by using game theory, and the rationality of people and places was present in the works of Krugman (1991) and Sen and Smith (1995), then operationalized by the researchers inspired by the works of Wilson (1970) and Echenique et al. (2013), or econometric approaches to space, or spatial error as it is often called (Anselin et al., 1997). A step further was taken in trying to understand the evolution of the network of cities (Barthelemy, 2021).

The issue is whether places or city regions maximize interaction flows as assumed in regional economic models associated with gravity functions (Sen & Smith, 1995) or whether they maximize stock or size (Dentinho & Rodrigues, 2021). In the paper of Dentinho (2011), the argument is that a tragedy of the commons and urban non-sustainability will occur when cities try to maximize their size instead of managing size to maximize net benefits. According to Simões Lopes and Pontes (2010), size is maximized when the average cost of the city equals the average benefit,

whereas net benefits are maximized when the marginal cost of the city equals the marginal benefit as assumed in the bid rent of Alonso urban models (Alonso, 1964).

Using the reasoning explained in Dentinho and Rodrigues (2021), this paper aims to understand whether Romanian Cities have maximized their size or the benefits of their spatial interaction, from 1948 to 2021, during seven decades of quite different political regimes – from Central Planning to Market Interaction.

More specifically, the analysis looks into the economic-demographic evolution of Romanian City-Regions and tests whether, throughout time, the spatial interaction between City-Regions follows the maximization of their size, or the maximization of the interaction between them, all of this subject to the spatial structure of Romanian City-Regions and their economic base. The novelty derives from the application of the methodological approach proposed by Dentinho and Rodrigues (2021) on models of complex spatial interaction where the authors differentiate between rational spatial interaction that maximizes interaction flows between City-Regions, on the one hand and, on the other hand, organic spatial interaction that maximizes the size of each City-Region, both constrained by their spatial structure and economic base (Sirkin, 1959), suitable for small open economies of City-Regions.

In a previous work (Dentinho & Pantelica, 2020), it is shown that the Romanian integration in the socialist block followed by the integration in the European Union created winners in the North East and on the Coast and losers in the other parts of the country, but did not decisively change the path of increasing concentration in the capital region. Nevertheless, whereas Central Planning favoured City-Regions in the middle of the country, market interaction benefited the more populated City-Regions. This signals different logics of spatial interaction between City-Regions. What we would like to test is if the logic of spatial interaction is more organic, with the maximization of size, or more rational, with the maximization of interaction.

Point 2 presents the models of spatial interaction both for the case of maximization of City-Regions sizes and for the case when the logic is to maximize the interaction between the City-Regions. Section 3 estimates both models for the different periods by using the evolution of the population of Romanian City-Regions and assuming that, with free movement of people between City-Regions and rational fertility rates, the demographic evolution mirrors the economic change. Section 4 discusses the results regarding urban sustainability and Section 5 presents conclusions and recommendations.

1. Maximizing city sizes or maximizing spatial interaction

Organisms and humans adapt and evolve, adjusting to environmental, institutional, economic and technological contexts (Chadwick, 1978). The difference is that humans maximize interaction flows, whereas organisms tend to maximize the size of their communities. The difference between size maximization, or organic spatial

interaction, and maximization of spatial interaction, or rational spatial interaction, is the human perception of scarcity that signals the congestion and underuse of contextual resources expressed in prices and shadow prices (Scott & Pearse, 1992) stimulating technological and institutional evolution in the long-run.

The approach taken in this paper proposes the use of demographic data per City-Region of Romania and tests different models of spatial interaction. The organic spatial interaction, the rational spatial interaction and a combination of the two according to the period of the recent history of Romania: the period of Central Planning and the Period of Market Interaction. The approach proposed takes the Organic Spatial Interaction Model and the Rational Spatial Interaction Model developed by Dentinho and Rodrigues (2021) into account.

1.1. Organic spatial interaction model

The Organic Spatial Interaction Model presented in expression (1) highlights that F_{it} = the change of the population in the zone (i) and period (t) beyond a scaling factor (k) can be influenced by an endogenous entropic factor $\{-\sum_j^N [W_{ij}X_{jt}(\ln(1-\delta)X_{jt} - 1)]$ weighted by the parameter (α) and an exogenous impact $[(E_{it} - \sum_j^N (W_{ij}(1-\delta)X_{jt})]$, weighted by the parameters (ε_i), being W_{ij}= the potential interaction between zone (i) and zone (j); X_{it}= the population in zone (i) in period (t); $(1-\delta)$= depreciation, and E_{it} = basic activities in zone (i) in period (t); ε_i= the external weight of zone (i) in period (t) which is the regression coefficient of the external factor estimate per period.

$$F_{it} = k + \alpha\{-\sum_j^N [W_{ij}X_{jt}(\ln(1-\delta)X_{jt} - 1)]\} + \varepsilon_i[(E_{it} - \sum_j^N (W_{ij}(1-\delta)X_{jt})] \forall_i, \quad (1)$$

1.2. Rational spatial interaction model

Using expression (1) and substituting the term $[(1-\delta)X_{jt}]$ by the expression that maximizes the flows $[(1-\delta)X_{jt} = \exp(-\varepsilon_i - \nu_i - \gamma_j - W_{ij} - \beta c_{ij})]$ we obtain expression (2) (see Dentinho and Rodrigues, 2021) that represents the rational spatial interaction model:

$$F_{it} = k + \alpha(\varepsilon_i + \nu_i + 1)\exp(-\varepsilon_i - \nu_i)\{-\sum_j^N [(-W_{ij} + \ln(W_{ij}))W_{ij}^2 \exp(-W_{ij})]\} + \varepsilon_{ir} m E_{it} + \varepsilon_i\{\sum_j^N W_{ij}^2 - \sum_j^N W_{ij}\ln(W_{ij})\} + \varepsilon_i(\varepsilon_i + \nu_i)\sum_j^N W_{ij} \quad (2)$$

Where entropy effect $\{-(\varepsilon_i + \nu_i + 1)\exp(-\varepsilon_i - \nu_i)\sum_j^N [(-W_{ij} + \ln(W_{ij}))W_{ij}^2 \exp(-W_{ij})]\}$ on population change (F_{it}) is a function of the structural spatial interaction (W_{ij}), plus the effect of external influence with three components: 1) Exports (E_{it}), 2) spatial interaction associated with the exports' coefficient

$[\varepsilon_i(\varepsilon_i + \nu_i)\sum_j^N W_{ij}]$; and 3) a function of the entropy of structural spatial interaction $[\varepsilon_i\{\sum_j^N W_{ij}^2 - \sum_j^N W_{ij}\ln(W_{ij})\}]$.

1.3. Combined models

Table 1 presents the various models to be tested to perceive what spatial interaction logic drives in the evolution of the population across Romanian City –Regions from 1948 to 2021. First, we test the organic spatial interaction model for the periods (1948-1990), (1990-2020) and (1948-2020). Second, we test the rational spatial interaction model for the periods (1948-1990), (1990-2020) and (1948-2020). Finally, based on the previous results, we test spatial interaction growth models considering organic and rational interaction for different periods.[1]

Table 1. Coefficients and variables of organic and rational spatial interaction growth models

	Organic Spatial Interaction Urban Growth Model		**Rational Spatial Interaction Urban Growth Model**	
	Coefficient	Variable	Coefficient	Variable
Intercept	k_o		k_r	
Entropy	α_o	$\{-\sum_j^N[W_{ij}X_{jt}(\ln(1-\delta)X_{jt}-1)]\}$	$\alpha_r(\varepsilon_{ir}+\nu_{ir}+1)\exp(-\varepsilon_{ir}-\nu_{ir})$	$\{-\sum_j^N[(-W_{ij}+\ln(W_{ij}))W_{ij}^2\exp(-W_{ij})]\}$
Exports	ε_{io}	(E_{it})	ε_{ir}m	E_{it}
Exports correction	ε'_{io}	$-\sum_j^N(W_{ij}(1-\delta)X_{jt}$	ε_{ir}	$\{\sum_j^N W_{ij}^2 - \sum_j^N W_{ij}\ln(W_{ij})\}$
Spatial Interaction			$\varepsilon_{ir}(\varepsilon_{ir}+\nu_{ir})$	$\sum_j^N W_{ij}$

Source: Authors' representation

Notice that in the Organic Spatial Interaction Growth Model, growth depends on the existing population (X_{jt}) in the entropy variable and the export's correction variable. This does not happen in the Rational Spatial Interaction Growth Model, where the existing population does not have a role and growth is only explained by the exports and by the permanent features of the territory (W_{ij}).

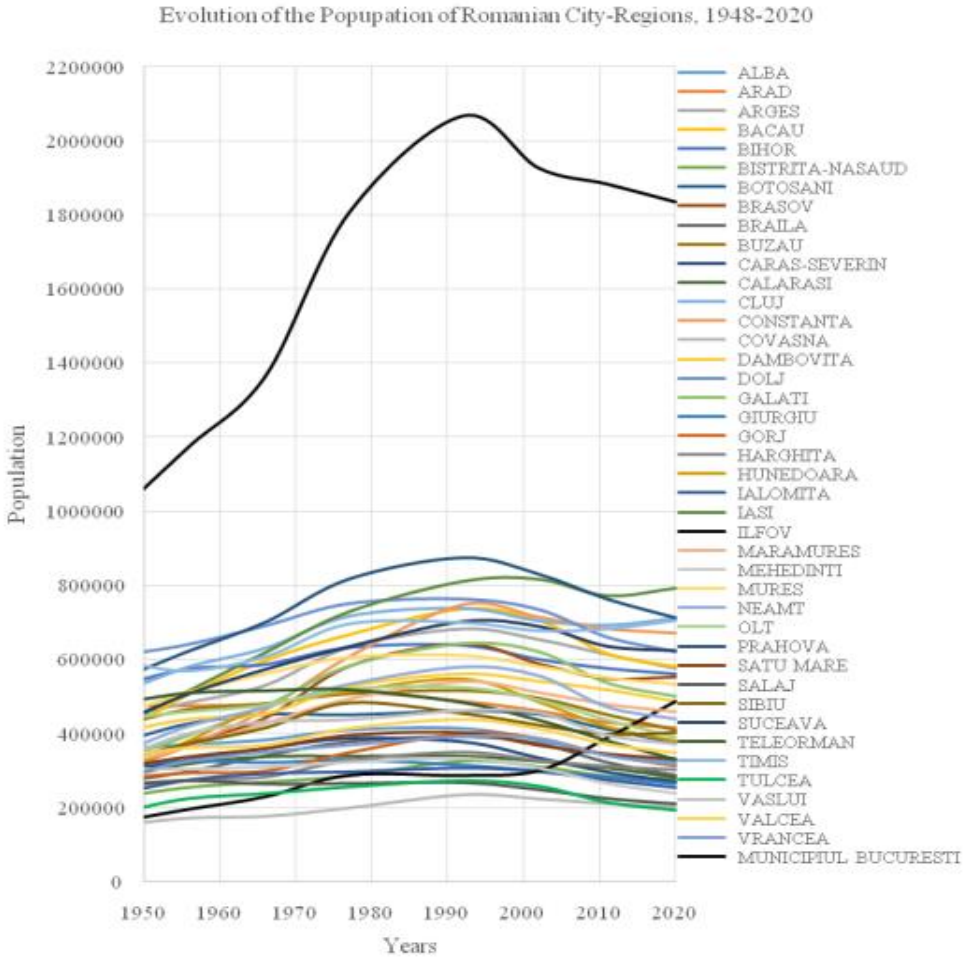
[1] The different forms of spatial interaction were explicit and theoretically justified variables in all models (Dentinho & Rodrigues, 2021).

2. Estimates for the organic and rational spatial interaction growth models

2.1. Data on population

Figure 1 shows the evolution of the population of the Romanian city regions. The fifties and the sixties of the twentieth century marked the relative take-off of Bucharest discernible in black and the surrounding regions, very connected to the establishment and reinforcement of the socialist regime in the country.

Figure 1. Evolution of the population of Romanian city-regions NUTS 3, 1948 – 2020



Source: Authors' representation

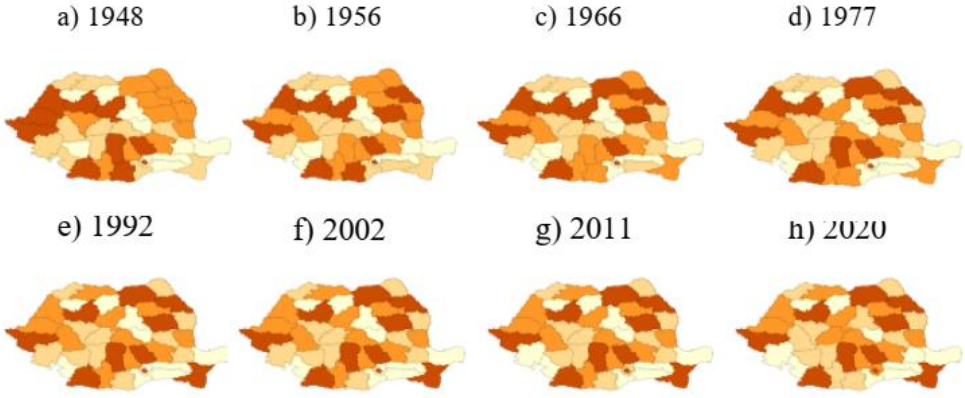
In the seventies and the eighties' growth, assessed by demography, decelerated, but some city regions were revealed to be more resilient than others.

The fall of the Berlin Wall and the Romanian integration into the European Union led to a strong decrease in the population in most of the regions (Holland et al., 2011; Ibanescu et al., 2020), except for the suburbs of Bucharest that increased sharply, revealing the growth of the metropolitan area of the capital. Contrary to what happens in most of the country, Iasi, Timisoara and a few others seemed to find their path along the last decade.

2.2. Data on population and spatial interaction

Figure 2 represents the quartiles of the distribution of the population of Romanian City-Regions from 1948 to 2020. It is clear that, just immediately the war, South-western regions concentrate the population and that most of the population is, on the one hand, more distributed throughout the country and, on the other hand, more concentrated in fewer city regions around the capital. Since we take the basic sector as 20% of the population assuming a population multiplier effect equal to 5 ($E_{it} = 0{,}2\ P_{it}$) the distribution shown in Figure 2 is a relevant explanatory proxy variable of the demographic and economic growth of the City-Regions.

Figure 2. Quartile Distribution of the Romanian Population from 1948 (a) to 2020 (h).

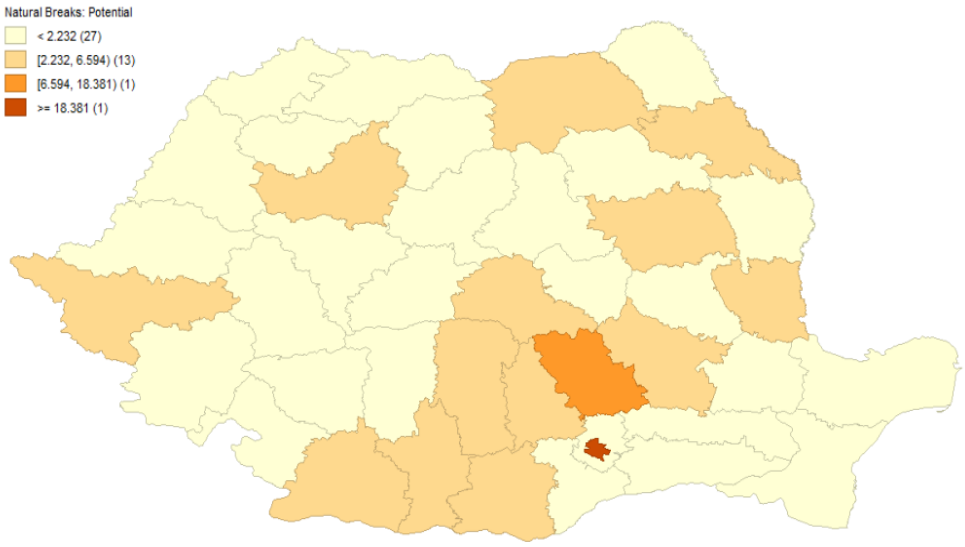


Source: Authors' representation

Figure 3 maps the Permanent Potential of Spatial Interaction $\{W_i = \sum_{j=1}^{n}[W_{ij}]\}$ and represents the estimates of the permanent spatial interaction factors $\{W_{ij} = P_i\ P_j exp^{(-\beta d_{ij})}\}$, where P_i= Population of (i), P_j= Population of (j), d_{ij} = distance between (i) and (j) and β= the impedance parameter calibrated to secure that the average interaction within each city-region is 50% of the average interaction with all City-Regions $\{\frac{\sum_{i=1}^{n}\{[W_{ii}]}{N}\} = 0{,}5\{\sum_{j=1}^{n}[W_{ij}]\ /N\}$. Figure 3 reveals the strong Potential of the capital Bucharest, the relative potential of Ploiesti centrality in the

country and the relative importance of some border regions because the distance between Kyiv and Vienna was also considered as edges of the network of Romanian City-Regions (Rozenblat & Neal, 2021). The Permanent Potential of Spatial Interaction is a proxy for the natural vocation of places, following the suggestion of Paul Krugman (1996) that nature or urban ranks flow along the hierarchy of river basins and that cities rooted in the natural capital also have a strong hierarchy.

Figure 3. Permanent Potential of Spatial Interaction



Source: Authors' representation

3. Estimates of the organic, rational and mix spatial interaction models

3.1 Model of organic spatial interaction growth

Table 2 presents the results of the Organic Spatial Interaction Growth Model that explains demographic-economic growth as a function of organic entropy, exports, and exports' correction factor.

The model with fixed effects presents an overall R^2=0.3725 with a within R^2=0.6865 and a between R^2=0.1913. Apart from the robust intercept, the only robust statistical indicators relate to exports in the periods (1992-2002) and (2002-2011), organic entropy for (1948-1956, 1956-1966, 2002-2011) and organic correction of exports for (1948-1956, 1966 -1977, 2002-2011).

Table 2a. Estimates of the organic spatial interaction growth model for Romanian regions

Fixed-effects	**within**
Group variable	Region
Number of observations	294
Number of groups	42
Observations per group minimum	7
Observations per group average	7
Observations per group maximum	7
R^2 Overall	0.3725
R^2 Within	0.6865
R^2 Between	0.1913
correlation(u_i, Xb)	-0.3495
F(18.234)	28.47
Prob > F	0.000

Source: Authors' representation

Table 2b. Estimates of the organic spatial interaction growth model for Romanian regions

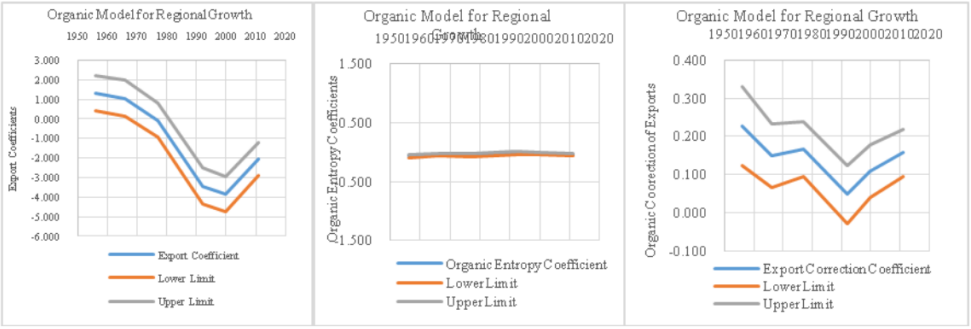
Popchange4820	**Coefficient**	**Std. Err.**	**t**	**P>t**
OrganicEntropy1956	-0.062	0.028	-2.180	0.030
OrganicEntropy1966	-0.041	0.024	-1.720	0.088
OrganicEntropy1977	-0.047	0.021	-2.220	0.028
OrganicEntropy1992	-0.011	0.022	-0.470	0.640
OrganicEntropy2002	-0.027	0.021	-1.300	0.195
OrganicEntropy2011	-0.043	0.018	-2.360	0.019
Exports1956	1.302	0.898	1.450	0.148
Exports1966	1.040	0.932	1.110	0.266
Exports1977	-0.064	0.892	-0.070	0.943
Exports1992	-3.434	0.926	-3.710	0.000
Exports2002	-3.856	0.916	-4.210	0.000
Exports2011	-2.053	0.818	-2.510	0.013
OrganicCorrection1956	0.228	0.104	2.190	0.030
OrganicCorrection1966	0.148	0.084	1.770	0.079
OrganicCorrection1977	0.166	0.072	2.300	0.022
OrganicCorrection1992	0.048	0.077	0.620	0.533
OrganicCorrection2002	0.109	0.069	1.570	0.117
OrganicCorrection2011	0.157	0.061	2.550	0.011
Constant	0.010	0.001	12.600	0.000

Source: Authors' representation

Figure 4 shows, for the Organic Model of Spatial Interaction Growth, the evolution of the Exports (a), Entropy (b) and Export Correction (c) coefficients and respective errors from 1956 to 2011. The importance of the economic base of the

regions in their growth decreased from 1948 until the end of the last century, to raise in the XXI century, compensated indicatively by the entropy of the territory and corrected by the Exports' Correction Factor.

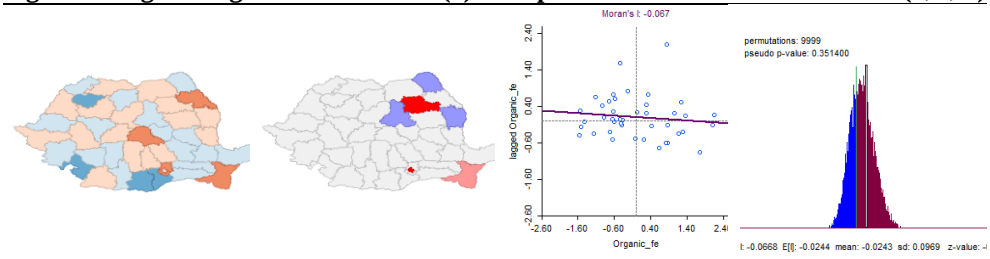
Figure 4. Evolution of the coefficients of the organic model (Exports (a), Entropy (b) and Exports Correction(c))



Source: Authors' representation

Figure 5 shows the percentile of the estimated Fixed Effects of the Organic Growth Model (a), with the LISA Maps and the spatial autocorrelation coefficients. The regions of Iasi, Constanta, Ilfov (surroundings of Bucharest) and Brasov have higher values indicating that, for the calibration of this Organic Model, the Permanent Potential of Spatial Interaction of Figure 3 should eventually be higher for these regions. Spatial Autocorrelation is negative and not strong, but it indicates a high-high correlation in the centre of Bucharest and, around Iasi, spread effects to the West and backwash effects to the South and North.

Figure 5. Organic regional fixed effects (a) and spatial autocorrelation indicators (b, c, d)



Source: Authors' representation

3.2 Model of rational spatial interaction growth

Table 3 presents the results of the Rational Spatial Interaction Growth Model that explains demographic-economic growth as a function of rational entropy, exports, exports correction factor and autonomous spatial interaction.

The model with fixed effects presents an overall R2=0.4591 with a within R2=0.7196 and a between R2=0.0803. Apart from the robust intercept, the only robust statistical indicators relate to exports in the periods (1992-2002) and (2002-2011), organic entropy for (1948-1956, 1956-1966, 2002-2011) and organic correction of exports for (1948-1956, 1966 -1977, 2002-2011).

Apart from the robustness of the intercept and the exports in the periods (1992-2002) and (2002-2011), there are relevant effects associated with rational entropy in the periods (1992-2002) and (2002-2011), for the exports' correction for the periods after 1966 and the autonomous spatial interaction both for the period after the war (1948-1956) and for the more recent periods since 1977.

Summing up, the interaction variable of the Rational Organic Spatial Interaction Growth Model seems to present a robust explanation for the economic and demographic evolution of the Romanian Regions from 1948 to 2020.

Table 3a. Estimates of the rational spatial interaction growth model for Romanian regions

Fixed-effects	**within**
Group variable	Region
Number of observations	294
Number of groups	42
Observations per group minimum	7
Observations per group average	7
Observations per group maximum	7
R^2 Overall	0.4591
R^2 Within	0.7196
R^2 Between	0.0803
correlation(u_i, Xb)	-0.2723
F(18.234)	24.38
Prob > F	0.000

Source: Authors' representation

Table 3b. Estimates of the rational spatial interaction growth model for Romanian Regions

Popchange4820	**Coefficient**	**Std. Err.**	**t**	**P>t**
RationalEntropy1956	-0.129	0.401	-0.320	0.748
RationalEntropy1966	0.530	0.401	1.320	0.188
RationalEntropy1977	0.395	0.401	0.980	0.326
RationalEntropy1992	-0.083	0.402	-0.210	0.837
RationalEntropy2000	-0.527	0.401	-1.310	0.190
RationalEntropy2011	-0.251	0.401	-0.620	0.533
Exports1956	1.399	0.754	1.860	0.065
Exports1966	0.715	0.788	0.910	0.365
Exports1977	-0.128	0.780	-0.160	0.869
Exports1992	-2.661	0.781	-3.410	0.001

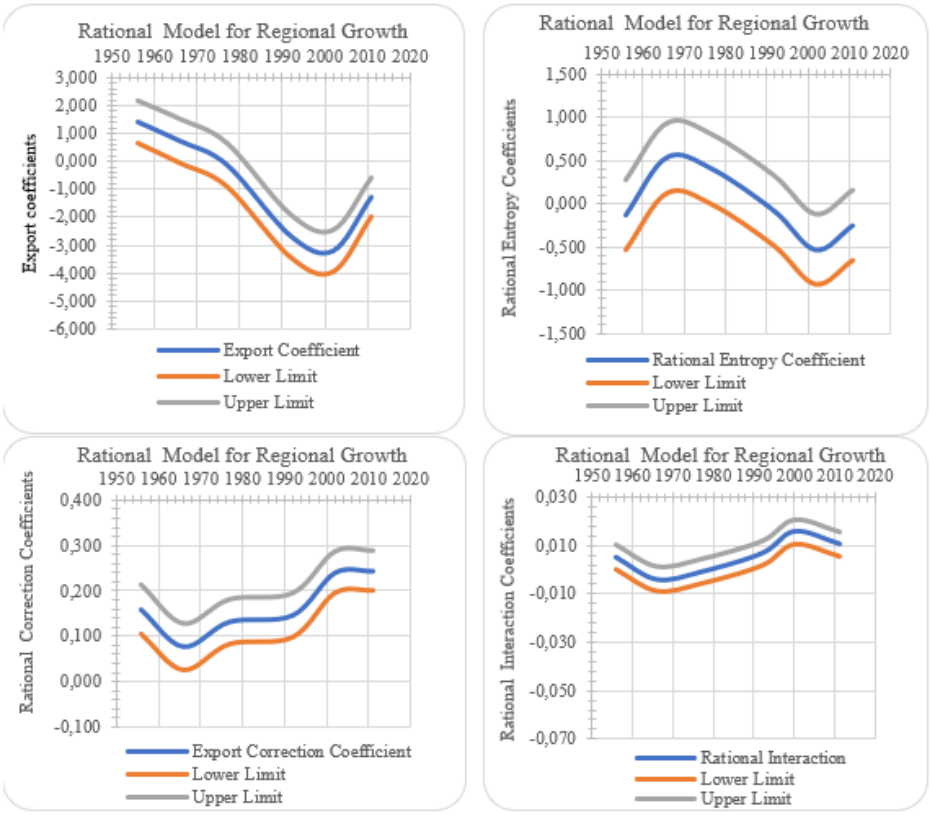
Exports2000	-3.196	0.766	-4.170	0.000
Exports2011	-1.285	0.705	-1.820	0.070
RationalCorrection1956	0.158	0.054	2.950	0.004
RationalCorrection1966	0.077	0.050	1.530	0.127
RationalCorrection1977	0.132	0.049	2.710	0.007
RationalCorrection1992	0.146	0.048	3.040	0.003
RationalCorrection2000	0.240	0.045	5.270	0.000
RationalCorrection2011	0.243	0.044	5.560	0.000
RationalInteraction1956	0.005	0.005	0.980	0.329
RationalInteraction1966	-0.004	0.005	-0.740	0.462
RationalInteraction1977	-0.001	0.005	-0.150	0.885
RationalInteraction1992	0.007	0.005	1.300	0.194
RationalInteraction2000	0.016	0.005	2.990	0.003
RationalInteraction2011	0.011	0.005	2.020	0.045
_cons	0.011	0.001	13.620	0.000

Source: Authors' representation

Figure 6 shows for the Rational Model the evolution of the Export (a), Entropy (b) Export Correction (c) and Spatial Interaction Exports Correction Coefficients and respective errors from 1956 to 2011. It is evident that the role of the economic base in regional growth decreased from 1948 until the end of the last century, to raise in the XXI century but, in the rational model, the entropy of the territory complemented the process with the correction of the Exports' Correction Factors.

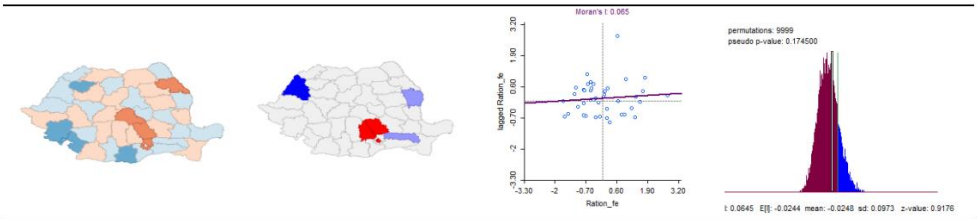
Figure 7 shows the percentile of the estimated Fixed Effects of the Rational Growth Model (a), with the LISA Maps and the spatial autocorrelation coefficients. With the Rational Growth Model, the regions of Iasi, Ilfov (surroundings of Bucharest), Ploiesti and Brasov have higher values indicating that, for the calibration of this Rational Model, the Permanent Potential of Spatial Interaction of Figure 3 should eventually be higher for these regions. Spatial Autocorrelation is positive and not strong, but it indicates a high-high correlation in the centre of Bucharest, Ploiesti and Targoviste.

Figure 6. Evolution of the Coefficients of the Rational Model (Exports (a), Entropy (b) Exports Correction(c) and Exports Spatial Interaction Correction (d))



Source: Authors' representation

Figure 7. Rational regional fixed effects (a) and spatial autocorrelation indicators (b,c,d)



Source: Authors' representation

3.3. Mixed model of spatial interaction growth

Finally, by joining the variables of the rational and organic spatial interaction growth and by selecting the ones that are more robust for each period, it is possible to see if, from the Second World War until 2020, there were periods when the demographic and economic growth of Romanian City-Regions followed a more organic or more rational logic. Table 4 presents the results of the Mixed Model of Spatial Interaction Growth.

The novelty of this approach is that, in the same regression, we can consider different functional theoretically rigorous expressions that, for different periods, better explain the economic and demographic growth of regions. The advantage is that it is possible to identify the logic of spatial interaction for a long period of time. The disadvantage is that selecting the best model requires a lot more time and, for this case, we additionally consider an expression of Interaction included in the rational interaction even when the period was better explained by the organic interaction - a reinforcement of the mixed model, but not a clear shift from rational to organic spatial interaction.

The model with fixed effects presents an overall R^2=0.5591 with a within R^2=0.7566 and a between R^2=0.0589. Apart from the robust intercept, the only robust statistical indicators relate to exports in the periods (1992-2002) and (2002-2011), organic entropy for (1948-1956, 1956-1966, 2002-2011) and organic correction of exports for (1948-1956, 1966 -1977, 2002-2011).

All presented coefficients are robust. The intercept, rational entropy from 1956 to 1966 and organic entropy onwards, exports from 1977 to 2011, organic correction of exports from 1977 to 2011, and Rational Interaction from 1948 to 2011. Summing up, the interaction variable of the Rational Organic Spatial Interaction Growth Model seems to present a robust explanation for the economic and demographic evolution of the Romanian Regions from 1948 to 2020.

Table 4a. Estimates of the mix spatial interaction growth model

Fixed-effects	**within**
Group variable	Region
Number of observations	294
Number of groups	42
Observations per group minimum	7
Observations per group average	7
Observations per group maximum	7
R^2 Overall	0.5591
R^2 Within	0.7566
R^2 Between	0.0589
correlation(u_i, Xb)	-0.1444
F(18.234)	40.41
Prob > F	0.000

Source: Authors' representation

Table 4b. Estimates of the mix spatial interaction growth model

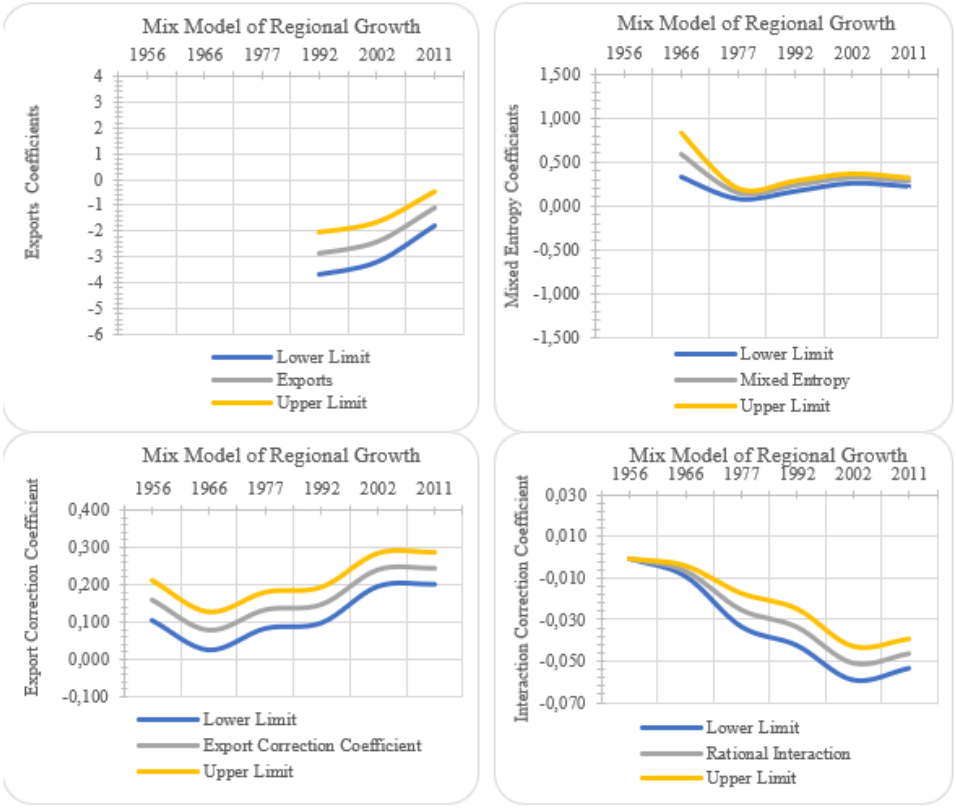
Popchange4820	Coefficient	Std. Err.	t	P>t
RationalEntropy1966	0.588	0.249	2.360	0.019
OrganicEntropy1977	0.145	0.060	2.410	0.017
OrganicEntropy1992	0.233	0.059	3.930	0.000
OrganicEntropy2002	0.320	0.054	5.980	0.000
OrganicEntropy2011	0.279	0.048	5.830	0.000
Exports1992	-2.862	0.825	-3.470	0.001
Exports2002	-2.423	0.782	-3.100	0.002
Exports2011	-1.124	0.678	-1.660	0.099
OrganicCorrection1977	-0.397	0.175	-2.270	0.024
OrganicCorrection1992	-0.660	0.171	-3.860	0.000
OrganicCorrection2000	-0.882	0.154	-5.740	0.000
OrganicCorrection2011	-0.762	0.137	-5.560	0.000
RationalInteraction1956	-0.001	0.000	-2.070	0.040
RationalInteraction1966	-0.006	0.003	-2.350	0.019
RationalInteraction1977	-0.025	0.008	-3.110	0.002
RationalInteraction1992	-0.034	0.009	-3.800	0.000
RationalInteraction2000	-0.051	0.008	-6.400	0.000
RationalInteraction2011	-0.046	0.007	-6.660	0.000
_cons	0.011	0.001	17.540	0.000

Source: Authors' representation

Figure 8 shows, for the Mix Model, the evolution of the Exports (a), Entropy (b) Export Correction (c) and Spatial Interaction Exports Correction Coefficients (d) and respective errors from 1956 to 2011. It is evident that the regions of the country evolved uniformly from 1948 to 1992 and, from then on, were supported by the economic base of the regions. Regarding the entropy factor, it is clear that, besides having no strong effect from 1948 until 1956, when the whole country was recovering from the war, they followed a rational pattern from 1956 to 1966 – balancing the North-eastern part of the country, more affected by World War II (see Figure 2), but then following an organic growth system with the increase of the surroundings of Bucharest and Constanta, with compensating effects from export correction factor and the spatial interaction factors.

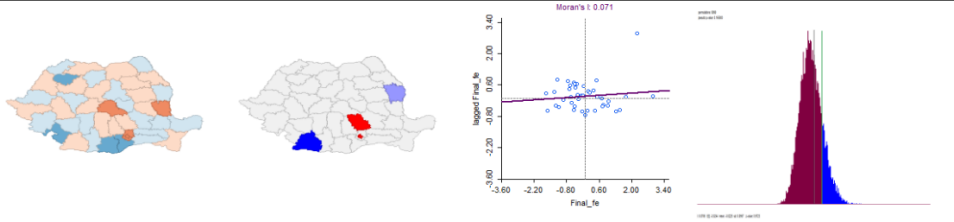
Figure 9 shows the percentile of the estimated Fixed Effects of the Mixed Growth Model (a), with the LISA Maps and the spatial autocorrelation coefficients. With the Mixed Growth Model, the regions of Bucharest and Ilfov (surroundings of Bucharest), Brasov and Galati have higher values, indicating that, for the calibration of this Mixed Model, the Permanent Potential of Spatial Interaction of Figure 3 could eventually be higher for these regions. Spatial Autocorrelation is positive but not strong, and it indicates a high-high correlation in the centre of Bucharest and Brasov.

Figure 8. Evolution of the coefficients of the mix model (exports (a), entropy (b) exports correction(c) and exports spatial interaction correction (d))



Source: Authors' representation

Figure 9. Mix model regional fixed effects (a) and spatial autocorrelation indicators (b,c,d)



Source: Authors' representation

4. Discussion

The scale of the Graphs of the model coefficients in Figure 4 is the same as the scale of the Graphs in Figure 6 and Figure 8. So, it is easy to compare and discuss the results of the three models. The mixed model is the best in terms of R2 and the one that shows better results for all the coefficients.

Looking at the export coefficients, it is interesting to notice that they play a crucial role in both the organic and rational models, whereas the only significant export coefficients for the mixed model are for 1992 onwards. And growing as happens for that period for the organic and rational model. It seems that, with the mixed model, spatial interaction features become more relevant. First, the organic entropy, with a residual impact in the organic model, reveals more of its importance in the mixed model. Second, the exports' correction factor that explains how the impact of exports in one area spreads across the territory becomes more relevant and of increasing importance. Finally, the autonomous interaction factor that appears in the theoretical formulation of the rational model (Rodrigues & Dentinho, 2021), appears with robust coefficients, mainly in the period of rational interaction (1948-1966), but with decreasing importance from 1966 to 2011. The best model, the Mix Model, refrains the role of exports, indicating that, beyond pushing exports, it is important to understand the role of each city within the network of city regions.

These changes in the logic of spatial interaction – from rational to organic from 1948 to 2020 - did have a role in the sustainability and resilience of Romanian cities assessed with reference to the Zipfs Curve (Zipf, 1949) for Romanian City-Regions (Dentinho & Pandelica, 2020): for resilience, by the vertical change of population share within the same rank; and for sustainability, by the horizontal change in the ranking for the same population share.

The analysis shows that space does not need to be threatened as homogenous with a centre as proposed by Von Thünen (1826) and William Alonso (1964), not even as distance throughout networks as assumed in the works of Chistaller (1966), Losch (1954), Paelinck and Nijkamp (1976). Space is, also, more than a game table where people and places compete with each other, as interestingly pointed out by Hoteling (1929) and later on by (Krugman, 1991). Following the works of Wilson (1970), Sen and Smith (1995) and Echenique et al. (2013), space can be operationalized by interaction networks and even more than the evolution of the networks (Barthelemy, 2021). Notwithstanding this, space is not an econometric error (Anselin et al., 1997) to be tentatively neutralized. As we try to show, the logic behind spatial interaction is crucial for understanding spatial interaction and the flows and channels it encompasses.

Conclusions

The question was to know if the evolution of Romanian City-Regions followed a logic of rational optimization of spatial interaction, a logic of organic maximization of spatial interaction or a mixed logic, with rational logic for some periods and organic logic for other periods. The paper shows that the mixed model is the best, indicating that the logic of spatial interaction changed over the period. Actually, except for the first periods, from 1948 to 1966, the evolution of the spatial structure of Romanian City Regions is better explained by the organic formulation, either in the period of Central Planning (1966-1992), or in the period of Market Interaction (1992-2020), where the previous period population has a strong effect indicating a maximization of the population of each city region rather than a maximization of the interaction between city regions.

On the other hand, comparing estimates for the various models, it is clear that exports play a less significant role in regional growth when space, represented by spatial interaction logics, is appropriately integrated. The Permanent Potential of Spatial Interaction, presented as a proxy representation of the permanent features of the territory, is a crucial factor to explain the demographic and economic performance of City Regions, meaning that the stable structure of the territory seems to be, together with exports, the main explanatory factor of city-regions growth. Future work will try to adjust the Permanent Potential of Spatial Interaction and relate it to the permanent features of the territory.

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Appendix A. Spatial Interaction Matrices

Table A1. Distances between City Regions of Romania [Dij]

	ALB	ARA	ARG	BAC	BIH	BIST	BOT	BRA	BRA	BUZ	CAR	CAL	CLU	CON	COV	DAM	DOL	GAL	GIU	GOR	HAR	HUN	IALO	IASI	ILFO	MAR	MEH	MUR	NEA	OLT	PRA	SAT	SAL	SIBI	SUC	TEL	TIMI	TUL	VAS	VAL	VRA	MUN
ALBA (Alba Iulia)	6	231	233	410	243	215	454	215	489	384	205	409	96	612	259	305	294	523	409	199	222	77	464	471	344	251	282	120	336	257	338	276	171	71	410	370	254	609	493	171	509	344
ARAD (Arad)	231	6	439	616	116	397	636	433	695	590	160	627	272	818	465	511	384	729	625	310	483	157	670	744	552	339	271	411	598	434	544	355	249	279	594	525	51	788	714	377	662	552
ARGES (Pitești)	233	439	6	321	489	409	481	141	299	194	408	230	333	379	173	72	121	333	178	174	242	282	249	452	113	484	244	292	382	71	123	509	404	160	473	143	454	394	409	62	266	113
BACAU (Bacău)	410	616	321	6	537	303	157	183	183	180	600	312	381	418	173	302	505	194	354	523	127	459	270	128	289	459	618	276	60	395	251	523	452	337	149	377	626	276	83	407	108	289
BIHOR (Oradea)	243	116	489	537	6	281	520	437	699	591	276	712	156	822	469	544	361	731	660	341	423	188	664	629	595	195	387	254	477	500	548	131	120	316	476	619	167	792	620	414	629	595
BISTRITA-NASAUD (Bistrița)	215	397	409	303	281	6	239	268	529	425	420	556	125	653	297	375	458	497	504	414	228	292	505	348	439	156	497	95	243	421	379	198	142	237	195	527	450	622	399	335	411	439
BOTOSANI (Botoșani)	454	636	481	157	520	239	6	340	340	337	659	473	364	575	330	459	605	351	514	662	264	531	427	122	446	396	725	334	148	552	408	437	364	476	42	534	687	433	207	564	265	446
BRASOV (Brașov)	215	433	141	183	437	268	340	6	246	141	417	288	261	395	32	107	265	260	236	315	101	276	237	326	171	404	395	173	241	212	111	420	352	144	332	284	444	382	281	224	213	171
BRAILA (Brăila)	489	695	299	183	699	529	340	246	6	105	679	134	543	182	294	227	444	34	275	477	302	538	92	261	210	682	557	459	243	370	176	682	635	416	332	298	753	93	196	361	96	210
BUZAU (Buzău)	384	590	194	180	591	425	337	141	105	6	574	136	438	238	189	122	325	139	175	368	258	433	90	300	109	561	456	330	240	265	71	577	509	311	329	197	658	198	215	261	72	109
CARAS-SEVERIN (Reșița)	205	160	408	600	276	420	659	417	679	574	6	526	305	777	449	480	277	713	511	231	518	161	629	728	511	456	164	396	663	327	531	415	409	263	617	416	109	774	683	361	646	511
CALARASI (Călărași)	409	627	230	312	712	556	473	288	134	136	526	6	563	142	320	200	351	432	135	410	389	512	42	415	117	712	454	461	472	301	177	730	634	390	461	188	684	242	345	212	204	117
CLUJ (Cluj Napoca)	96	272	333	381	156	125	364	261	543	438	305	563	6	666	313	388	394	575	511	306	267	177	518	456	445	151	382	108	321	357	392	176	71	173	320	476	323	636	455	271	498	445
CONSTANTA (Constanța)	612	818	379	418	822	653	575	395	182	238	777	142	666	6	417	325	500	217	278	563	486	661	148	507	266	809	613	558	478	450	274	805	737	539	567	354	833	123	379	441	310	266
COVASNA (Sfantu Gheorghe)	259	465	173	173	469	297	330	32	294	189	449	320	313	417	6	139	297	326	266	347	69	318	269	301	203	436	420	205	220	262	143	452	364	185	305	316	476	387	255	256	261	203
DAMBOVITA (Târgoviște)	305	511	72	302	544	375	459	107	227	122	480	200	388	325	139	6	203	261	148	245	208	354	177	433	83	511	316	260	348	143	51	527	459	232	451	156	525	322	337	134	194	83
DOLJ (Craiova)	294	384	121	505	361	458	605	265	444	325	277	351	394	500	297	203	6	464	233	104	366	267	384	533	234	545	113	363	503	50	254	594	465	221	612	141	333	529	540	123	397	234
GALATI (Galați)	523	729	333	194	731	497	351	260	34	139	713	432	575	217	326	261	464	6	309	516	321	572	135	267	244	701	577	457	254	404	210	701	646	450	343	332	797	80	162	400	92	244
GIURGIU (Giurgiu)	409	625	178	354	660	504	514	236	275	175	511	135	511	278	266	148	233	309	6	362	337	460	183	473	65	660	345	409	414	190	125	687	582	339	503	100	632	328	389	240	246	65
GORJ (Târgu-Jiu)	199	310	174	523	341	414	662	315	477	368	231	410	306	563	347	245	104	516	362	6	416	153	415	645	297	450	84	319	561	164	297	480	381	214	638	245	304	560	592	116	449	297
HARGHITA (Miercurea Ciuc)	222	483	242	127	423	228	264	101	302	258	518	389	267	486	69	208	366	321	337	416	6	299	336	277	276	390	486	159	140	313	212	405	336	204	276	328	467	369	210	325	206	276
HUNEDOARA (Deva)	77	157	282	459	188	292	531	276	538	433	161	512	177	661	318	354	267	572	460	153	299	6	513	548	395	328	241	197	413	306	387	327	248	122	487	386	162	631	542	220	505	395
IALOMITA (Slobozia)	464	670	249	270	664	505	427	237	92	90	629	42	518	148	269	177	384	135	183	415	336	513	6	373	118	661	465	410	330	302	126	657	589	391	419	206	685	145	305	293	162	118
IASI (Iași)	471	744	452	128	629	348	122	326	261	300	728	415	456	507	301	433	533	267	473	645	277	548	373	6	409	504	641	343	135	536	371	563	544	465	141	496	716	374	65	529	226	409
ILFOV	344	552	113	289	595	439	446	171	210	109	511	117	445	266	203	83	234	244	65	297	276	395	118	409	6	595	347	344	349	184	60	622	517	273	438	88	567	263	324	175	181	409
MARAMURES (Baia Mare)	251	339	484	459	195	156	396	404	682	561	456	712	151	809	436	511	545	701	660	450	390	328	661	504	595	6	533	231	399	508	535	68	96	324	361	627	390	759	542	422	567	595
MEHEDINTI (Drobetaa Turnu Severin)	282	271	244	618	387	497	725	395	557	456	164	454	382	613	420	316	113	577	345	84	486	241	465	641	347	533	6	430	631	163	367	526	453	298	725	254	220	610	671	200	526	347
MURES (Târgu Mureș)	120	411	292	276	254	95	334	173	459	330	396	461	108	558	205	260	363	457	409	319	159	197	410	343	344	231	430	6	216	363	264	247	179	132	290	435	365	562	348	230	365	344
NEAMT (Piatra Neamț)	336	598	382	60	477	243	148	241	243	240	663	472	321	478	220	348	503	254	414	561	140	413	330	135	349	399	631	216	6	453	311	441	392	319	101	437	581	336	143	470	168	349
OLT (Slatina)	257	434	71	395	500	421	552	212	370	265	327	301	357	450	262	143	50	404	190	164	313	306	302	536	184	508	163	363	453	6	194	533	428	184	595	107	363	447	480	87	337	184
PRAHOVA (Ploiești)	338	544	123	251	548	379	408	111	176	71	531	177	392	274	143	51	254	210	125	297	212	387	126	371	60	535	367	264	311	194	6	531	463	265	400	148	555	271	286	190	143	60
SATU MARE (Satu Mare)	276	355	509	523	131	198	437	420	682	577	415	730	176	805	452	527	594	701	687	480	405	327	657	563	622	68	526	247	441	533	531	6	87	349	395	652	306	802	606	447	609	622
SALAJ (Zalau)	171	249	404	452	120	142	364	352	635	509	409	634	71	737	364	459	465	646	582	381	336	248	589	544	517	96	453	179	392	428	463	87	6	244	336	574	300	707	526	342	560	517
SIBIU (Sibiu)	71	279	160	337	316	237	476	144	416	311	263	390	173	539	185	232	221	450	339	214	204	122	391	465	273	324	298	132	319	184	265	349	244	6	422	303	290	509	430	96	363	273
SUCEAVA (Suceava)	410	594	473	149	476	195	42	332	332	329	617	461	320	567	305	451	612	343	503	638	276	487	419	141	438	361	725	290	101	595	400	395	336	422	6	526	645	446	192	535	257	438
TELEORMAN (Alexndria)	370	525	143	377	619	527	534	284	298	197	416	188	476	354	316	156	141	332	100	245	328	386	206	496	88	627	254	435	437	107	148	652	574	303	526	6	474	351	412	193	269	88
TIMIS (Timișoara)	254	51	454	626	167	450	687	444	753	658	109	684	323	833	476	525	333	797	632	304	467	162	685	716	567	390	220	365	581	363	555	306	300	290	645	474	6	830	709	398	730	567
TULCEA (Tulcea)	609	788	394	276	792	622	433	382	93	198	774	242	636	123	387	322	529	80	328	560	369	631	145	374	263	759	610	562	336	447	271	802	707	509	446	351	830	6	242	436	172	263
VASLUI (Vaslui)	493	714	409	83	620	399	207	281	196	215	683	345	455	379	255	337	540	162	389	592	210	542	305	65	324	542	671	348	143	480	286	606	526	430	192	412	709	242	6	476	143	324
VALCEA (Rm. Vâlcea)	171	377	62	407	414	335	564	224	361	261	361	212	271	441	256	134	123	400	240	116	325	220	293	529	175	422	200	230	470	87	190	447	342	96	535	193	398	436	476	6	333	175
VRANCEA (Focșani)	509	662	266	108	629	411	265	213	96	72	646	204	498	310	261	194	397	92	246	449	206	505	162	226	181	567	526	365	168	337	143	609	560	363	257	269	730	172	143	333	6	181
MUNICIPIUL BUCURESTI	344	552	113	289	595	439	446	171	210	109	511	117	445	266	203	83	234	244	65	297	276	395	118	409	409	595	347	344	349	184	60	622	517	273	438	88	567	263	324	175	181	6

Source: Authors' representation

Table A2. Structural Spatial Interaction [Wij]

	ALI	AR	AR	BA	BIH	BIS	BO	BR	BR	BU	CA	CA	CLI	CO	CO	DA	DO	GA	GIU	GO	HA	HU	IAL	IAS	ILF	MA	ME	MU	NE	OL	PR	SA	SA	SIB	SU	TE	TIM	TU	VA	VA	VR	MU
ALBA (Alba Iulia)	1,9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,5	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0
ARAD (Arad)	0,0	3,0	0,0	0,0	0,4	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,7	0,0	0,0	0,0	0,0	0,0
ARGES (Pitești)	0,0	0,0	4,6	0,0	0,0	0,0	0,0	0,3	0,0	0,1	0,0	0,0	0,0	0,0	0,1	1,0	0,5	0,0	0,1	0,1	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,0	1,0	0,5	0,0	0,0	0,1	0,0	0,2	0,0	0,0	0,0	1,0	0,0	1,5
BACAU (Bacău)	0,0	0,0	0,0	5,1	0,0	0,0	0,2	0,1	0,1	0,1	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,1	0,0	0,0	0,2	0,0	0,0	0,5	0,0	0,0	0,0	0,0	1,3	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,7	0,0	0,4	0,0
BIHOR (Oradea)	0,0	0,4	0,0	0,0	4,8	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,2	0,2	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0
BISTRITA-NASAUD (Bistrița)	0,0	0,0	0,0	0,0	0,0	1,1	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,4	0,0	0,0	0,0	0,0	0,1	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0
BOTOSANI (Botoșani)	0,0	0,0	0,0	0,2	0,0	0,0	2,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,4	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	1,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0
BRASOV (Brașov)	0,0	0,0	0,3	0,1	0,0	0,0	0,0	3,5	0,0	0,2	0,0	0,0	0,0	0,0	0,8	0,4	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,1	0,0	0,0	0,1	0,0	0,1	0,6	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,4
BRAILA (Brăila)	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	1,5	0,3	0,0	0,1	0,0	0,1	0,0	0,0	0,0	1,3	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,3	0,1
BUZAU (Buzău)	0,0	0,0	0,1	0,1	0,0	0,0	0,0	0,2	0,3	3,1	0,0	0,1	0,0	0,0	0,0	0,3	0,0	0,2	0,1	0,0	0,0	0,0	0,3	0,0	0,2	0,0	0,0	0,0	0,0	0,0	1,3	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,6	1,3
CARAS-SEVERIN (Reșița)	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,4	0,0	0,0	0,0	0,0	0,0
CALARASI (Călărași)	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,1	0,0	1,4	0,0	0,2	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,6	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,8
CLUJ (Cluj Napoca)	0,6	0,0	0,0	0,0	0,3	0,2	0,0	0,0	0,0	0,0	0,0	0,0	6,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,2	0,0	0,6	0,0	0,0	0,0	0,1	0,6	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
CONSTANTA (Constanța)	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,2	0,0	4,5	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,1
COVASNA (Sfantu Gheorghe)	0,0	0,0	0,1	0,1	0,0	0,0	0,0	0,8	0,0	0,0	0,0	0,0	0,0	0,0	0,5	0,1	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1
DAMBOVITA (Târgoviște)	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,4	0,0	0,3	0,0	0,0	0,0	0,0	0,1	3,4	0,1	0,0	0,1	0,0	0,0	0,0	0,1	0,0	0,4	0,0	0,0	0,0	0,0	0,2	2,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,2	0,1	2,3
DOLJ (Craiova)	0,0	0,0	0,5	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	6,5	0,0	0,0	0,4	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0	1,8	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,3	0,0	0,2
GALATI (Galați)	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	1,3	0,2	0,0	0,0	0,0	0,1	0,0	0,0	0,0	3,6	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,4	0,1	0,0	0,4	0,1
GIURGIU (Giurgiu)	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,1	0,0	0,0	0,0	0,1	0,0	0,0	1,3	0,0	0,0	0,0	0,0	0,0	0,4	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,0	2,1
GORJ (Târgu-Jiu)	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,4	0,0	0,0	1,5	0,0	0,1	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0
HARGHITA (Miercurea Ciuc)	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	1,3	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
HUNEDOARA (Deva)	0,5	0,1	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	2,7	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0
IALOMITA (Slobozia)	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,3	0,0	0,6	0,0	0,1	0,0	0,1	0,0	0,1	0,0	0,0	0,0	0,0	1,1	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,1	0,7
IASI (Iași)	0,0	0,0	0,0	0,5	0,0	0,0	0,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	6,5	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,4	0,0	0,0	0,0	1,2	0,0	0,0	0,0
ILFOV	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,1	0,0	0,2	0,0	0,1	0,0	0,0	0,0	0,4	0,0	0,0	0,4	0,0	0,0	0,0	0,1	0,0	1,2	0,0	0,0	0,0	0,0	0,1	1,0	0,0	0,0	0,0	0,0	0,4	0,0	0,0	0,0	0,1	0,0	0,0
MARAMURES (Baia Mare)	0,0	0,0	0,0	0,0	0,1	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	2,8	0,0	0,0	0,0	0,0	0,0	0,6	0,3	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
MEHEDINTI (Drobetaa Turnu Severin)	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,0	1,2	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
MURES (Târgu Mureș)	0,3	0,0	0,0	0,0	0,0	0,4	0,0	0,1	0,0	0,0	0,0	0,0	0,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,1	0,0	0,0	0,0	0,0	0,0	4,2	0,1	0,0	0,0	0,0	0,1	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
NEAMT (Piatra Neamț)	0,0	0,0	0,0	1,3	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,3	0,0	0,0	0,0	0,1	3,2	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,0	0,0	0,2	0,0	0,1	0,0
OLT (Slatina)	0,0	0,0	1,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	1,8	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,1	0,0	0,1	0,0	0,0	3,0	0,1	0,0	0,0	0,1	0,0	0,4	0,0	0,0	0,0	0,5	0,0	0,3
PRAHOVA (Ploiești)	0,0	0,0	0,5	0,0	0,0	0,0	0,0	0,6	0,1	1,3	0,0	0,1	0,0	0,0	0,1	2,0	0,0	0,1	0,3	0,0	0,0	0,0	0,3	0,0	1,0	0,0	0,0	0,0	0,0	0,1	7,5	0,0	0,0	0,0	0,0	0,3	0,0	0,0	0,0	0,1	0,2	5,6
SATU MARE (Satu Mare)	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,0	0,0	0,0	0,0	1,8	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
SALAJ (Zalau)	0,0	0,0	0,0	0,0	0,2	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,6	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,3	0,0	0,1	0,0	0,0	0,0	0,2	0,9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
SIBIU (Sibiu)	0,6	0,0	0,1	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,1	0,0	0,0	0,0	2,3	0,0	0,0	0,0	0,0	0,0	0,4	0,0	0,0
SUCEAVA (Suceava)	0,0	0,0	0,0	0,3	0,0	0,1	1,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,4	0,0	0,0	0,0	0,0	0,6	0,0	0,0	0,0	0,0	0,0	5,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0
TELEORMAN (Alexndria)	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,1	0,0	0,0	0,0	0,1	0,3	0,0	0,3	0,0	0,0	0,0	0,0	0,0	0,4	0,0	0,0	0,0	0,0	0,4	0,3	0,0	0,0	0,0	0,0	2,9	0,0	0,0	0,0	0,1	0,0	2,0
TIMIS (Timișoara)	0,0	1,7	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,4	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	5,9	0,0	0,0	0,0	0,0	0,0
TULCEA (Tulcea)	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,4	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,7	0,0	0,0	0,0	0,0
VASLUI (Vaslui)	0,0	0,0	0,0	0,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	1,2	0,0	0,0	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	2,4	0,0	0,1	0,0
VALCEA (Rm. Vâlcea)	0,1	0,0	1,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,2	0,3	0,0	0,0	0,2	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,5	0,1	0,0	0,0	0,4	0,0	0,1	0,0	0,0	0,0	2,0	0,0	0,3
VRANCEA (Focșani)	0,0	0,0	0,0	0,4	0,0	0,0	0,0	0,0	0,3	0,6	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,4	0,0	0,0	0,0	0,0	0,1	0,0	0,0	0,0	0,0	0,0	0,1	0,0	0,2	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,1	0,0	1,7	0,2
MUNICIPIUL BUCURESTI	0,0	0,0	1,5	0,0	0,0	0,0	0,0	0,4	0,1	1,3	0,0	0,8	0,0	0,1	0,1	2,3	0,2	0,1	2,1	0,0	0,0	0,0	0,7	0,0	0,0	0,0	0,0	0,0	0,0	0,3	5,6	0,0	0,0	0,0	0,0	2,0	0,0	0,0	0,0	0,3	0,2	37,1

Source: Authors' representation