ORIENTATION OF COMMUNICATION ROUTES AND BALANCED REGIONAL DEVELOPMENT

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Abstract
Territorial development depends on territorial discontinuities, provided that the region is born of discontinuities, lives through them and is killed by them. Moreover, the equilibrium, as a goal of territorial cohesion, aims to reduce the gaps between regions, paying a special attention to deeply disadvantaged areas. The answer of the European Union consists of the concept of polycentricity, relying on many factors, including accessibility, which in its turn relates to the territorial development. In this context, the current study aims to analyze the connectivity of Romania to other European countries using a GIS-based methodology relying on determining the orientation of roads and railroads. The results indicate that the isolation of Romania is not due to a dominant overall orientation, but due to regional differences, resulted from the configuration of relief, and constituting possible explanations of disparities in regional development. The findings sustain the importance of Romanian strategic objectives of development.
Keywords: Territorial development, polycentricity, accessibility, GIS, disparities.

1. INTRODUCTION

Territorial development, a concept embedding **regional** and **local development**, originates in the spatial variability, materialized in the presence of discontinuities, which permits distinguishing several organizational levels. Starting from the idea that **discontinuities** are the most important materialization of spatial organization, the region can be regarded as a result of an interfering system of discontinuities (Ianoş and Heller, 2006). "*The region is born out of discontinuity processes, lives through dynamics found in qualitative breaks, projected spatially, and is also killed by discontinuities*" (Ianoş and Heller, 2006). Therefore, the territorial development emerges as a process of eliminating the discontinuities by translating them to the periphery and overlapping against the limits of the analyzed spaces: (1) territorial development appears as a consequence of the existence of gaps, (2) the gaps become evident as problematic areas are individualized, (3) the individualization results from the analysis of territorial disparities, (4) the disparities are based on finer scale cutoffs, (5) the disparities are underlined by aggregating the partitions based on specific indicators, and (6) the disparities are shaped by the emergence of spatial discontinuities as breaks of the territorial development gradients (Ianoş and Heller, 2006).

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Regional disparities can also be analyzed in the context of territorial cohesion, defined as "*balanced distribution of human activities in the territory*" (DG Regional Policy, 2004). The equilibrium is achieved by reducing existing disparities (*e.g.*, between urban networks), preventing territorial imbalances (*e.g.*, differences between the regions), by sectoral policies with spatial impact and more coherent regional policies; the active process resulting into cohesion is named convergence (van Well, 2006).

Four essential problems are recognized in regional development: (1) identification of regional resources and means for their wise use, (2) identification and analysis of barriers against the economic development, (3) choice of the regional development strategy and (4) choice of the methods and models for elaborating the programs of regional development. Three stages of the relationship between economic and regional development have been identified: (1) take off (emergence of first industrial nuclei), (2) autonomous and continuous growth, and (3) the post-industrial phase (Ianoş and Heller, 2006).

Regional development also grants a special attention to deeply disadvantaged areas, defined by the spatial contiguity of at least five base administrative units, an average of the global indicator of development 25% lesser than for the integrant region or 75% below the level of the region of development, values of at least one elementary indicators close to the minimum national or macro-regional level, and negative territorial impact on all neighboring areas. Such regions have been grouped in four classes: (1) weakly polarized area, without inner discontinuities, (2) rural mono-centric area, with slight inner discontinuities, (3) bi- or polycentric rural area with inner discontinuities, and (4) deeply rural area, not polarized. Regardless of their type, the treatment of such regions is based upon the production of discontinuities (Ianoş and Heller, 2006).

Territorial cohesion is ensured by a **polycentric** structure. The European Spatial Planning Observation Network (ESPON) defined the **polycentric urban system** as "*spatial organization of cities characterized by functional division of labor, economic and institutional integration, and political cooperation*" (Nordic Centre for Spatial Development, 2003), and based on two types of aspects: the **morphology** of the territory (number, hierarchy and distribution of human settlements) and **relationships** (fluxes and cooperation) of the elements (human settlements) within (Nordic Centre for Spatial Development, 2005). There are three levels of ***polycentricity***: macro – in Europe, an alternative to the "Pentagonal" London, Paris, Munich, Milan and Paris (14% of the EU27 area, 32% of population and 43% of the GDP), mezzo – regional, two or more cities are complementary offering people and companies from the common areas access to urban function that can usually appear only in higher rank cities, and micro – intra-regional, if the complementarities of urban and economic functions are strengthened by spatial clusters (Nordic Centre for Spatial Development, 2005).

The ESPON studies underline the role of accessibility in developing a polycentric structure (ESPON Monitoring Committee, 2004). In its turn, accessibility plays a key role in territorial development, since "*a good accessibility of European regions determines not only an enhancement of their hierarchical position, but an increased competitiveness of the entire continent*" (Spiekermann & Wegener Urban and Regional Research, 2007). The accessibility indicators describe the location of a region in relationship with the opportunities, activities or resources existing in other regions and in the region itself, where the concept of "region" could be used for cities and corridors as well (Wegener *et al*., 2002).

Approaching accessibility seems to have no borders, meaning that booth the American continent (National Capital Region Transportation Planning Board, 2006) and European Union (Nordic Centre for Spatial Development, 2005) define accessibility using the 45 minutes isochrones. Nevertheless, due to problems related to the relief (*e.g.*, hardly accessible mountain areas – Popescu, 2008), poor infrastructure or traffic issues (Bucharest), using this definition in Romania leads to paradoxical situations, which make Romania to appear as isolated from the remaining part of the continent. For such regions, definitions of accessibility based on spatial proximity have been criticized, several authors proposing their replacement with approaches based on long distance connections between cities and regions (ESPON Monitoring Committee, 2007).

For such reasons, one of the common objectives of the National Development Plan, National Strategic Concept of Spatial Development for 2025 and National Strategic Reference Framework is the "connection to the European and intercontinental network of spatial development poles and corridors" (*Figure 1*). The latest two documents ad the "*consolidation of trans-Carpathian connection in support of regional development*" (Petrişor, 2008). All these objectives are motivated by the fact that different European projects do not include Romania, due to poor accessibility, resulting from the lack of motorway and railway connections with Europe – *e.g.*, the METREX network (partnership for balanced development), founded at the Glasgow Conference of Metropolitan Regions (*Figure 2*).

In this context, the study proposes to analyze the situation of the most important categories of roads and railways in Romania, using an original methodology based on determining their orientation, in order to reveal eventual disparities in providing the connectivity of development regions.

2. DATA AND ANALYSIS

The study uses data owned by the Interdisciplinary Center of Advanced Research on Territorial Dynamics on Romanian roads (accounting for the county and national highways and express roads, including the auto-routes), and railroads (*Figure 3*). The road database contains 8463 records,

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specifying their type, indicative (internal and national), name of track and its length (in meters and kilometers). The railroad database has 1088 records, specifying the indicative and length (in meters and kilometers) of tracks.

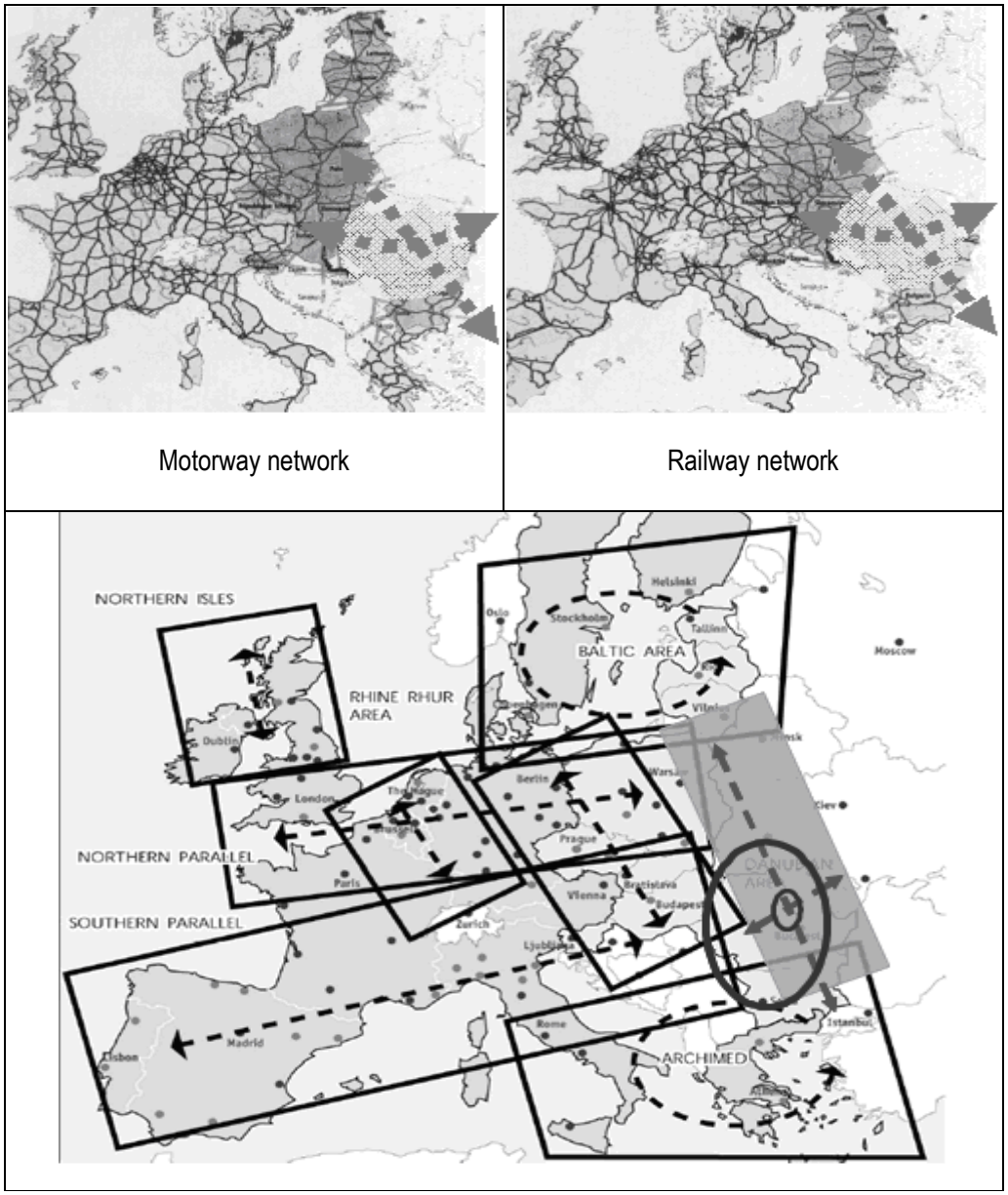

FIGURE 1 - CONNECTING ROMANIA TO THE EUROPEAN AND INTERCONTINENTAL NETWORK OF SPATIAL DEVELOPMENT POLES AND CORRIDORS – OBJECTIVE OF DEVELOPMENT (BORBÉLY, 2005)

The method used in the study consisted of replicating the algorithm proposed by Petrişor and Decho for the study of the orientation of cyanobacteria in marine stromatolites (Petrişor and Decho, 2006). The method is based on the CalcAngle extension, version 1.0, of ArcGIS 9, developed by Mike Sweeney from ESRI (Charlotte, NC, USA) for their project. The application computes the angle formed by any segment with the North axis (0^0-360^0). In the next step, the orientation was classified in two manners

(*Figure 4*): binary (N-S, for angles between 0^0-45^0, 135^0-225^0 and 315^0-360^0, and E-W – 45^0-135^0 and 225^0-315^0) and using four intervals (N-S – 0^0-22.5^0 and 157.5^0-202.5^0, NE-SW – 22.5^0-67.5^0 and 202.5^0-247.5^0, E-WV – 67.5^0-112.5^0 and 247.5^0-292.5^0, NW-SE – 112.5^0-157.5^0 and 292.5^0-337.5^0).

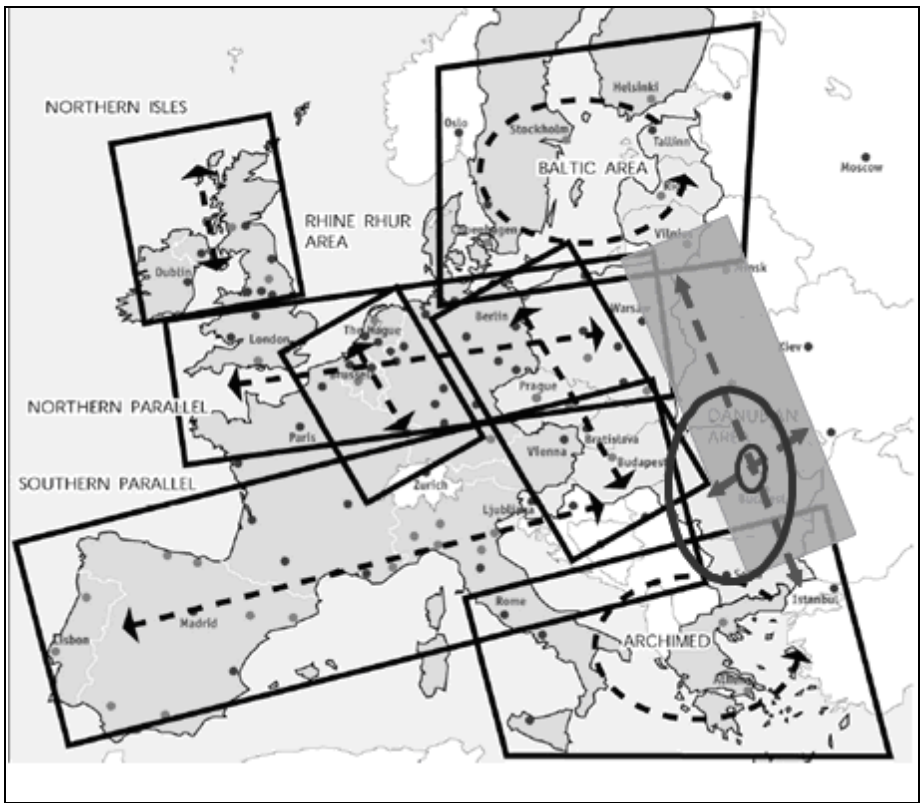

FIGURE 2 - THE METREX NETWORK (VRABETE, 2005)

Regional analyses (county and region of development) were based on the following steps, involving the program ArcView, version 3.2: (1) intersect the road/railroad with the limits of the regions, splitting them in sub-tracks corresponding to each region, and (2) join the databases of split tracks and regions, resulting into the assignment in the table of attributes corresponding to the tracks of a new field, indicating their location.

The classifications and numeric analyses were performed using Microsoft Excel. Computations were used to sum tracks with certain orientations based on their type (for roads), region, or their combination. However, the density was preferred, and defined as the ratio of the total length per region and area of the region. County-level analyses represented an application of multi-scale approaches. The regions of development, corresponding to the Nomenclature of Territorial Units for Statistics (NUTS) level 2, represent the macro-scale, while counties (NUTS 3) are the mezzo-scale.

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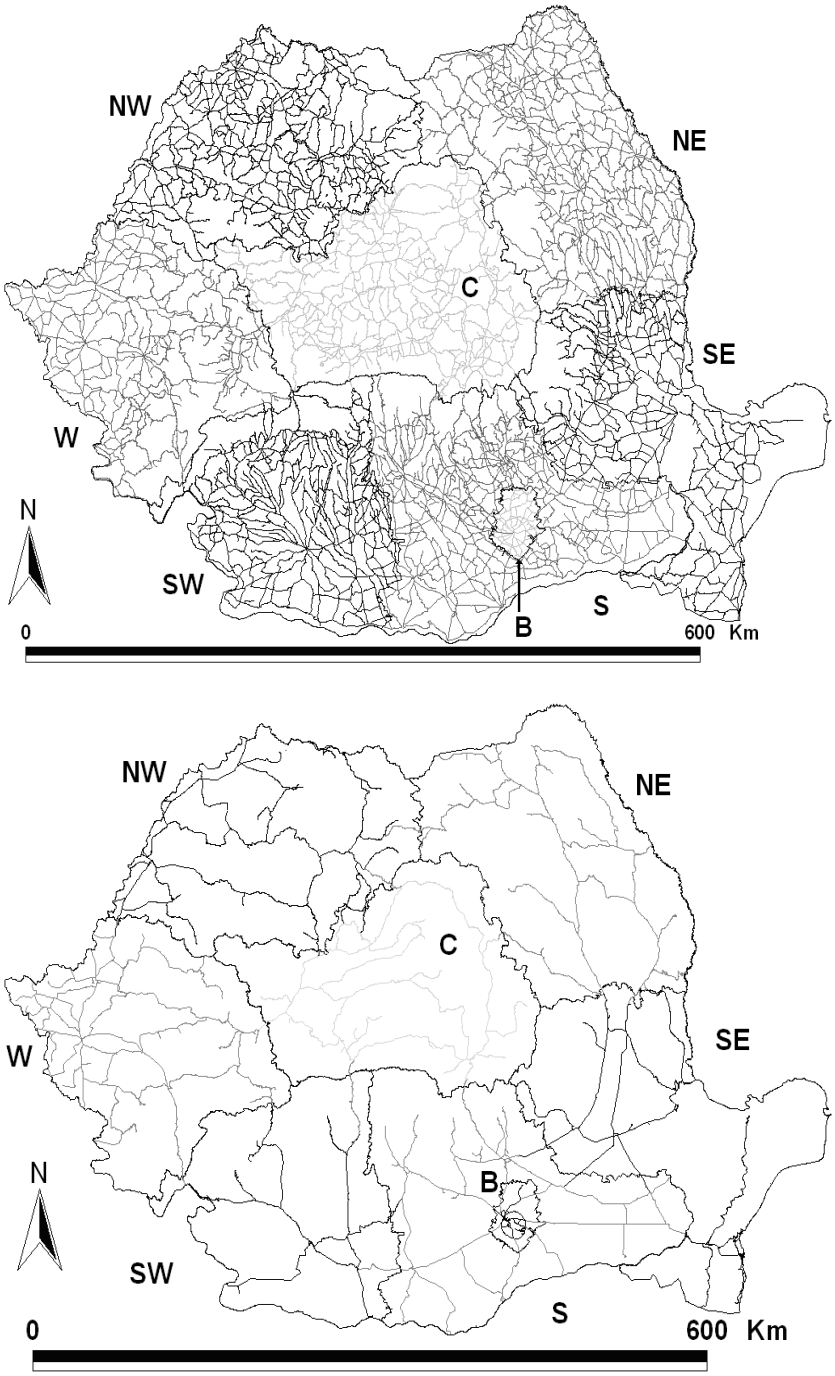
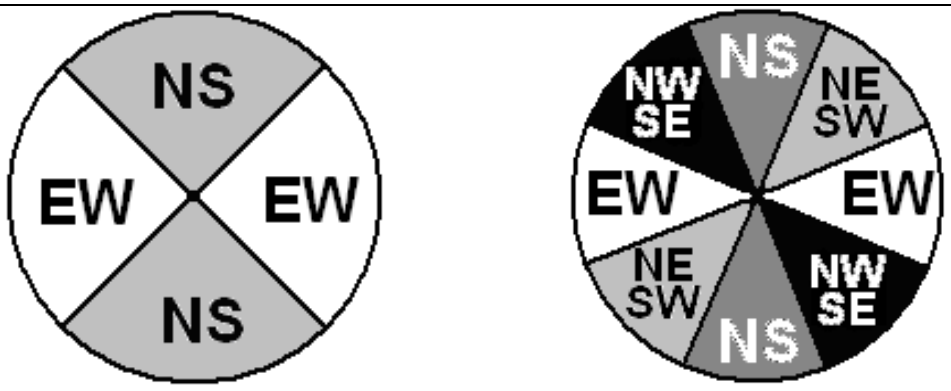


FIGURE 3 - COUNTY AND NATIONAL HIGHWAYS, AND EXPRESS ROADS, INCLUDING AUTO-ROUTES (A), AND RAILROADS (B) IN THE ROMANIAN REGIONS OF DEVELOPMENT (C - CENTER, B - BUCHAREST-ILFOV)



A B

FIGURE 4 - CLASSIFICATION OF THE ORIENTATION OF ROAD/RAILROAD TRACKS IN ROMANIA: (A) BINARY, (B) FOUR CLASSES

3. RESULTS AND DISCUSSIONS

3.1. Roads

The results of the Analysis of Variance (ANOVA) used to detect eventual differences of the density summed by of roads summed by type, orientation, region of development, and all possible interactions are displayed in *Table 1*. Since significant differences were detected, three post-hoc comparison tests were used (Duncan, Bonferroni, and Scheffé). The differences in density by the region of development area analyzed in *Table 2*, the influence of the type of road in *Table*), and the influence of orientation classified on four levels in *Table 4*.

TABLE 1 - ANALYSIS OF VARIANCE (ANOVA) FOR COMPARING THE DENSITY OF ROADS SUMMED BY TYPE, ORIENTATION, REGION OF DEVELOPMENT, AND ALL POSSIBLE INTERACTIONS.
(Gray shading indicates the classification of orientation on four levels, and white shading indicates the binary classification. Italic values are statistically significant)

	Orientation N-S or E-W					**Orientation N-S, NE-SW, E-W, NW-SE**				
Source	**DF**	**SS**	**MS**	**F**	**p**	**DF**	**SS**	**MS**	**F**	**p**
Model	33	0.039	0.0012	*13.23*	*<0.001*	53	0.012	0.00037	*11.66*	*<0.001*
Error	14	0.001	0.0001			42	0.001	0.00003		
Total	47	0.040				95	0.021			
Parameters of the model										
R^2	0.97					0.94				
CV	27.48					33.13				
Significance of variables										
Variable	**DF**	**SS**	**MS**	**F**	**p**	**DF**	**SS**	**MS**	**F**	**p**
Reg. of develop. (R)	*7*	*0.0018*	*0.0002*	*2.94*	*0.041*	*7*	*0.0009*	*0.00013*	*4.04*	*0.0018*
Type of road (T)	*2*	*0.0332*	*0.0166*	*187.67*	*<0.001*	*2*	*0.0166*	*0.00831*	*258.19*	*<.0001*
Orientation (O)	1	0.0000	0.0000	0.01	0.926	3	0.0002	0.00008	2.41	0.0803
Interaction R-T	14	0.0027	0.0002	2.19	0.078	*14*	*0.0014*	*0.00010*	*3.01*	*0.0029*
Interaction R-O	7	0.0007	0.0001	1.19	0.367	21	0.0005	0.00002	0.74	0.7702
Interaction T-O	2	0.0001	0.0001	0.83	0.455	6	0.0003	0.00004	1.45	0.2203

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TABLE 2 - POST-HOC COMPARISON OF THE DENSITY OF ROADS SUMMED BY REGION OF DEVELOPMENT
(Regions with the same letter (Duncan, Bonferroni, Scheffé) are not statistically different)

Density	N	Region of development	Orientation N-S or E-W				Orientation N-S, NE-SW, E-W, NW-SE					
			Duncan		Bonferroni	Scheffé	Duncan		Bonferroni		Scheffé	
0.048	6	Bucharest-Ilfov		A	A	A	A			A		A
				A	A	A				A		A
0.038	6	North-East	B	A	A	A	B		B	A	B	A
			B	A	A	A	B		B	A	B	A
0.036	6	South	B	A	A	A	B	C	B	A	B	A
			B		A	A	B	C	B	A	B	A
0.034	6	South-West	B		A	A	B	C	B	A	B	A
			B		A	A	B	C	B	A	B	A
0.032	6	North-West	B		A	A	B	C	B	A	B	A
			B		A	A	B	C	B		B	A
0.030	6	Center	B		A	A	B	C	B		B	A
			B		A	A	B	C	B		B	
0.029	6	West	B		A	A	B	C	B		B	
			B		A	A		C	B		B	
0.027	6	South-East	B		A	A		C	B		B	

TABLE 3 - POST-HOC COMPARISON OF THE DENSITY OF ROADS SUMMED BY TYPE.
(Groups with the same letter (Duncan, Bonferroni, Scheffé) are not statistically different)

Density	N	Type of road	Groups (all tests, orientation classified binary or using four levels)
0.071	16	County	A
0.021	16	National	B
0.010	16	Express	C

TABLE 4 - POST-HOC COMPARISON OF THE DENSITY OF ROADS SUMMED BY ORIENTATION (NS, NE-SW, EW, OR NW-SE).
(Orientations with the same letter (Duncan, Bonferroni, Scheffé) are not statistically different)

Density	N	Orientation	Duncan		Bonferroni	Scheffé
0.019	24	NW-SE		A	A	A
				A	A	A
0.018	25	N-S	B	A	A	A
			B	A	A	A
0.017	25	E-W	B	A	A	A
			B		A	A
0.015	24	NE-SW	B		A	A

3.2. Railroads

The density of railroads was compared among the regions of development (*Table 5*). The results indicate that N-S orientation dominates the binary classification in southern Romania (regions of development South, South-East, and South-West, except for Bucharest Ilfov), and E-V dominates the other regions, even though the differences are not statistically significant when using the t (Student) test. When orientation is classified using four levels, all railroads appear to have a North-South

orientation. Even though ANOVA was used for the railroads as well, the results are not significant due to the reduced sample size (8 regions times 2/4 orientation levels, respectively 16 or 32).

TABLE 5 - DENSITY OF RAILROADS BY ORIENTATION AND REGION OF DEVELOPMENT.
(Gray shading indicates the dominant orientation, indicated by the greatest value of density)

Region	Orientation N-S or E-W		Orientation N-S, NE-SW, E-W, NW-SE				Romania
	N-S	E-W	N-S	NE-SW	E-W	NW-SE	
Bucharest-Ilfov	0.0436	0.1121	0.0683	0.0069	0.0240	0.0565	0.1557
Center	0.0159	0.0302	0.0217	0.0103	0.0078	0.0063	0.0461
North-East	0.0195	0.0226	0.0145	0.0035	0.0108	0.0133	0.0421
North-West	0.0236	0.0264	0.0326	0.0030	0.0087	0.0058	0.0501
South	0.0283	0.0226	0.0270	0.0030	0.0113	0.0096	0.0509
South-East	0.0244	0.0143	0.0242	0.0015	0.0049	0.0081	0.0387
South-West	0.0161	0.0133	0.0234	0.0034	0.0011	0.0015	0.0294
West	0.0291	0.0360	0.0288	0.0046	0.0212	0.0104	0.0651
Romania	0.0227	0.0243	0.0248	0.0042	0.0096	0.0084	0.0470

Figure 5 shows the comparison by regions of development of the orientation (NS, NE-SW, EW, or NW-SE) and type of roads, using the total length for each combination of categories. The image indicates a significant gap between the region of development Bucharest-Ilfov and the others, indicating the high level of development of the capital compared to other regions of the country. The second place is taken by the North-East region; regardless of its high density of roads, poor connections toward Europe, indicated by the E-W orientation of roads, diminish its connectivity (*Figure 6*).

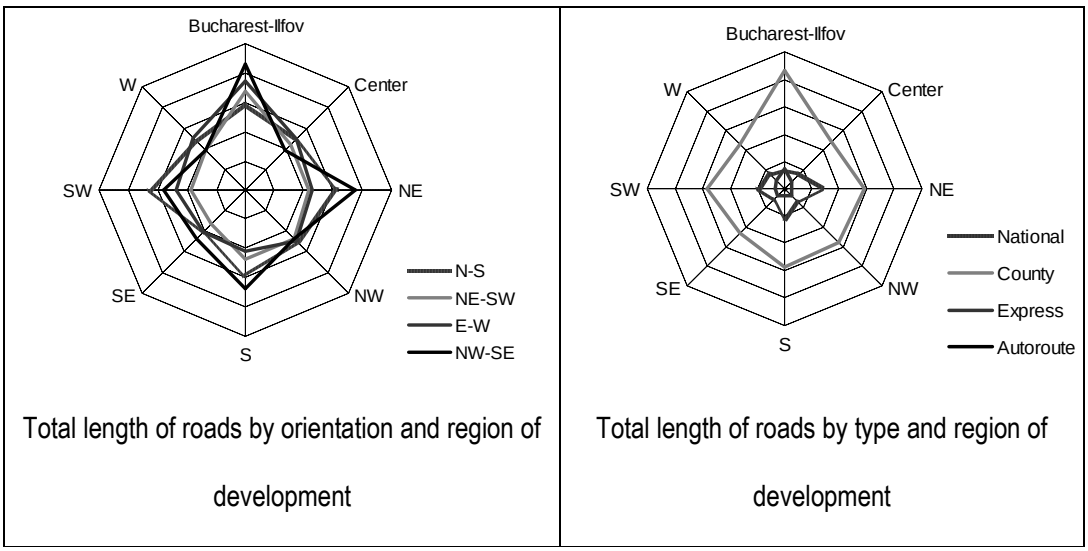

FIGURE 5 - COMPARISON BY REGIONS OF DEVELOPMENT OF THE ORIENTATION (NS, NE-SW, EW, OR NW-SE) AND TYPE OF ROADS.

County-level analyses allowed for the construction of maps displaying the dominant orientation of roads and railroads, computed based on the maximum value; the results are displayed in *Figure 6*. The figure

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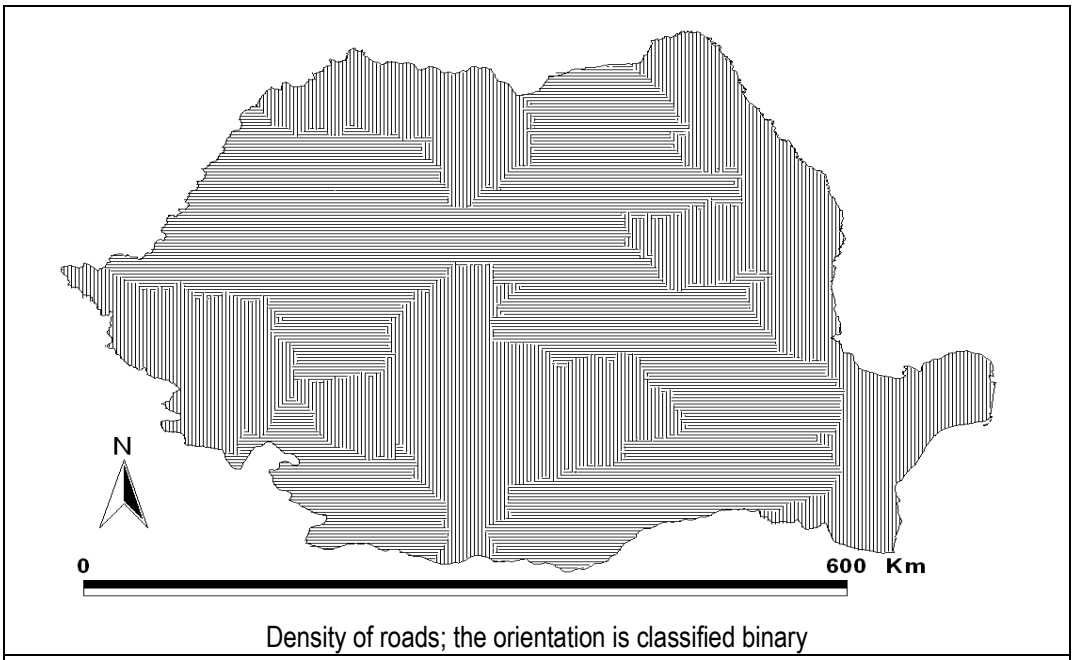
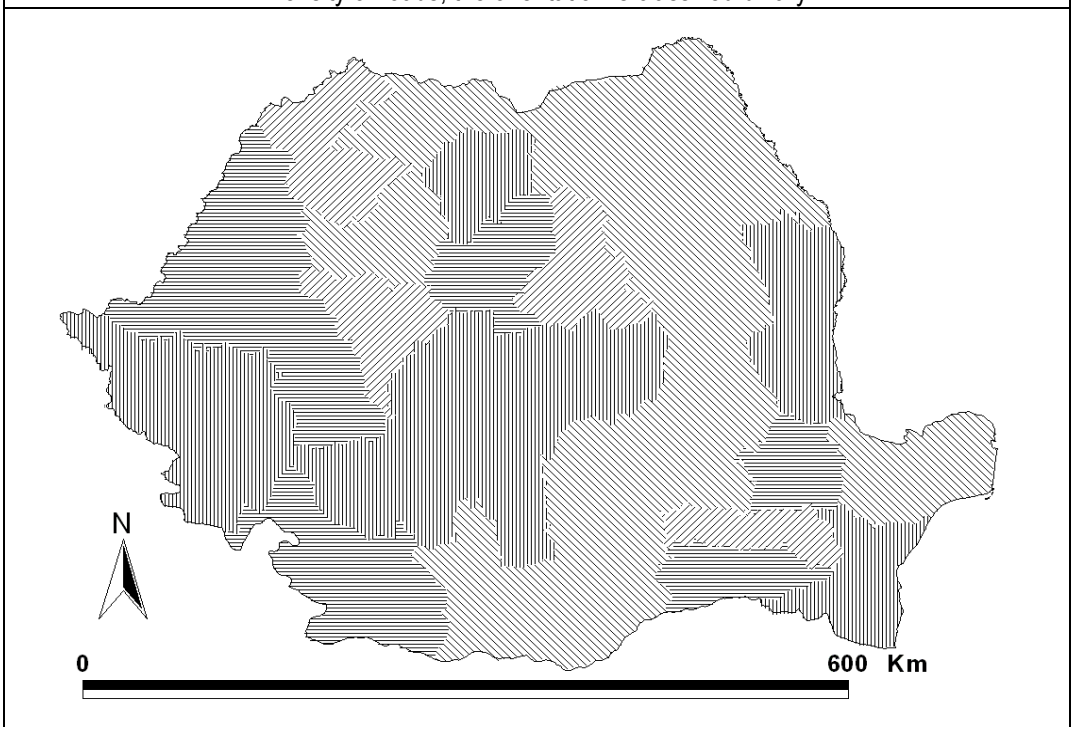
indicates that when the orientation is classified binary, the relief appears to determine the orientation of roads and railroads, leading to a separation of areas where the E-W orientation is dominant by areas where roads and railroads are oriented N-S, and to poor accessibility of some regions, sustaining the strategic objectives of the National Development Plan, National Strategic Concept of Spatial Development for 2025 and National Strategic Reference Framework. This situation is particularly important for the North-East region, since it could explain its reduced general level of development.



Density of roads; the orientation is classified binary



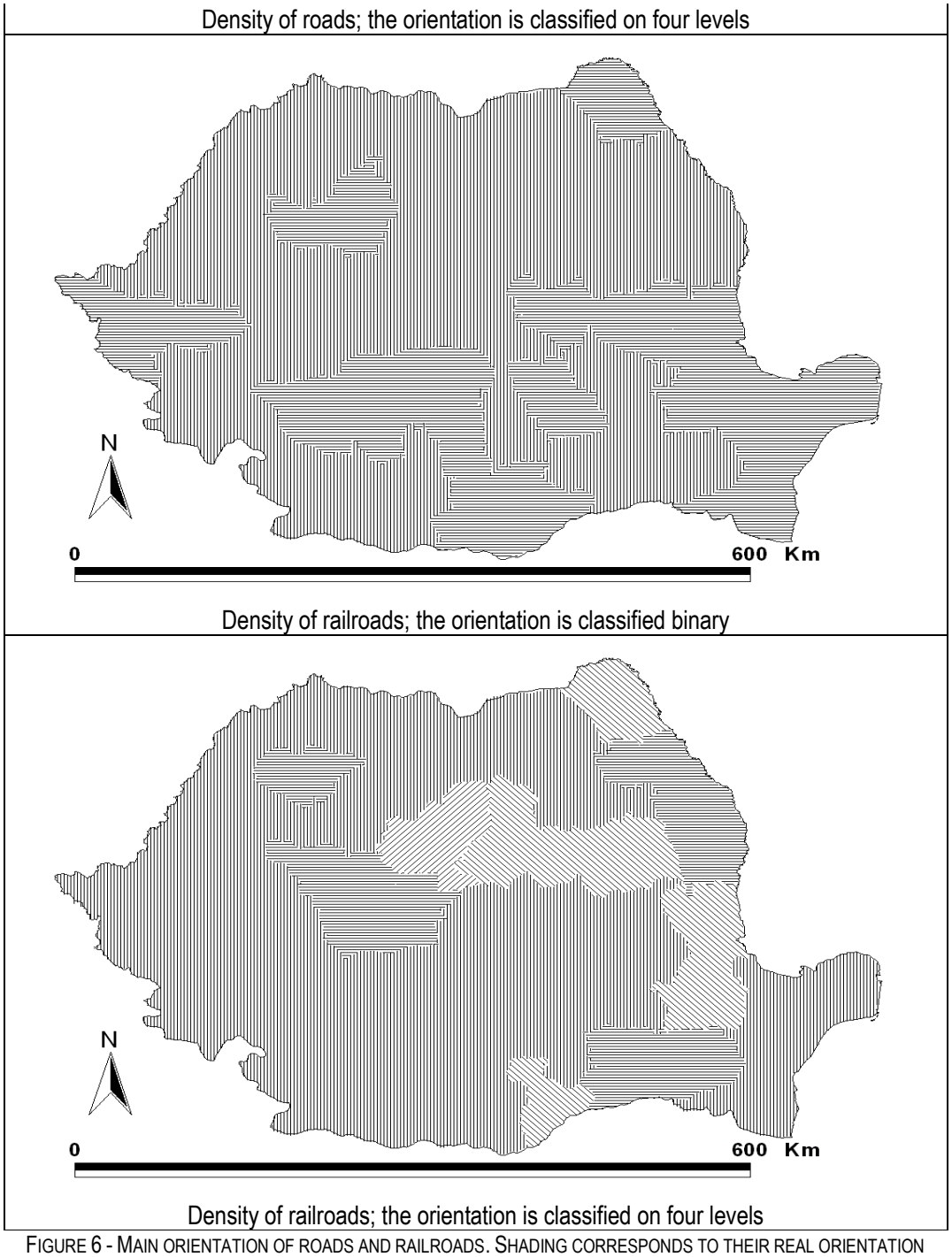


FIGURE 6 - MAIN ORIENTATION OF ROADS AND RAILROADS. SHADING CORRESPONDS TO THEIR REAL ORIENTATION

4. LIMITS OF THE STUDY

The main limitation is the lack of data reflecting, in addition, the technical status of roads, and/or traffic data. Even though unfortunately unavailable, particularly at the national level, such data could offer a more realistic image of the accessibility.

5. CONCLUSIONS

Accounting for the multitude of analyses, the conclusions must be based on a synthetic display of partial results of the situation of roads and railroads, by type (if applicable), region, and orientation, displayed in *Table 6*.

TABLE 6 - SYNTHESIS OF THE RESULTS

Type of de comparison	By region	By type	By N-S or E-W orientation	By NS, NE-SW, EW, NW-SE orientation
Road density by region of development	Bucharest-Ilfov> NE> S> SW> NW> Center> W> SE	County> National> Express	Differences not significant	NW-SE> N-S> E-W> NE-SW
Railroad density by region of development	Differences not significant	Differences not significant	N-S	Differences not significant
Railroad density by county	Hierarchy of 42 counties	County> National> Express	Differences not significant	NW-SE> N-S> E-W> NE-SW
Railroad density by county	Differences not significant	Differences not significant	E-W	Differences not significant

The results underline the disparities among regions. If orientation is classified binary, the alternating regions with predominant N-S and E-W orientation leads to the separation of some parts of the county from the continent. When four levels are used to classify the orientation, the lack of tracks oriented NW-SE, E-W and NE-SW, corresponding to the connections with the European and intercontinental network of spatial development poles and corridors underlines the importance of the development objective related to the connection of Romania to the other countries. Furthermore, the isolation of the North-East region could explain its low level of development.

In summary, the isolation of Romania from the continent is not due to an overall orientation of transport routes, but due to the differences in orientation between regions, determined by the configuration of relief, and leading to the poor connectivity among regions and with other countries, which could explain some disparities of regional development.

Methodologically, the analyses reveal the potential of geostatistical methods to sustain the conclusions on existing disparities, and be used in support of the political decisions on the national and regional development.

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