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ASSESSMENT OF SETTLEMENTS' CENTRALITY IN BOTOŞANI COUNTY USING SHIMBEL INDEX[1]

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Abstract: *Having its origins in social sciences, the concept of centrality has gained an important role in studying the spatial networks at different spatial scales. This paper examines the different facets of centrality and analyses the degree of centrality for the settlements with administrative role in one of the least central counties in Romania, the Botoşani County. Starting from the road network in this county, the Shimbel index is calculated for road and straight line distances between the nodes in order to show the present centrality of the settlements and the potential one. The straightness centrality is calculated. All the indexes are mapped. The results show that the settlements with high centrality values are located around the geographical center of the county and that the settlements on the western side are "more central" than those located on the eastern and southern side. Another finding is that the Shimbel index depends on the road network that is majorly influenced by the elevation and the number of direct ties between the localities influences their general centrality and accessibility.*

Keywords*: accessibility, closeness, rural infrastructure, Shimbel Index, straightness centrality.*

1. Introduction

When it comes to the competitiveness of an enterprise, industry, city, region or country, among other factors, their location has a significant contribution in the competition between these actors, cities and regions competing with each other in convincing entrepreneurs, enterprises and industries to choose them for future expansions and relocations. But these locations must have a very important characteristic, it must be accessible and beyond that it must be central in relation to the location of other industries, suppliers or markets that are active in the horizontal and vertical industries.

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Centrality is a concept that has evolved from social sciences in the mid 1950's when it studied the relations in social networks and the individuals where seen as nodes in these networks and all of them had different degrees of centrality (Bavelas, A., 1950). This type of centrality was based on the fact that an individual with a high degree of centrality was closer to the other individuals in his social network and he would have access to information much easier or the information would get to him faster (Leavitt, H., 1951, Stephenson, K., Zelen, M., 1989)

The concept of centrality has become an important one in every science that is using a network in order to analyze or explain different situations. Centrality is used in graph-theory in order to identify new ways to calculate centrality (Freeman, L.C., et al., 1991; Klein, D. J., 2010; Farbey, B., et al., 1967; Freeman, L.C., 1978). Having this baseline, centrality began to be used in psychology (Mackenzie, K.D., 1966), telecommunications (Slater, P.J., 1981) , ecology (Timothy, C., Murray, A., 2009;Bauer, B., et al., 2009; Tian-xiang, Y., et al., 2002), biology (Keunwan, P., Dongsup, K., 2009), physics (Tarafdar, S., Citron, Z., Milov, Al., 2014), computer sciences (McLaughlin, A., Bader, D., 2014;Chehreghani, M. H., 2014; Qin Gao, C. S., Chunyan, Y., 2014) and even political studies (Sinclair, P. A., 2009; van der Wusten, H., 2004).

In geographical analysis, centrality is used for all scales, at global level to assess the world-city hierarchies (Neal, Z., 2010; Boyd, J. P., et al., 2013) where the largest cities in the world are the places where resources and flows concentrate because they are key-nodes in the world city-systems. The circulation of flows between these nodes is the main engine for globalization and in the global system it is important to locate in a central place.

Cities build infrastructure like roads, highways, railways, ports and airports in order to increase their hinterland and to be the central place to more people, money, information, power. At global scale different authors argue that ports (Cullinane, K., Wang, Y., 2009; González, F., et al., 2012), and airports (Shaw, S., et al., 2009; Bowen, J., 2004; Neal, Z., 2010) are the key infrastructure for achieving a good degree of centrality and power in the world city network.

Centrality is also used to analyze different spatial distribution of certain areas within the cities using the street network for determine the centrality of the economic activities (Porta, S., et al., 2012), of the public spaces (Porta et al., 2008), how it influences the land use of a city (Wang, F., et al., 2011). Given the fact that only a part of the population is using a personal vehicle in order to get to different places around the city the public transport networks can attribute to a place a certain degree of centrality. In the big cities, being close to a node where different types of public transport combine can make a place to be more central than the ones located in the center of the city (Derrible, S., 2009). Other authors used a combination between street network and public transport network (von Ferber, C., et al., 2009; YANG, C., ShuLin, H., 2010) or the cheap and ecological alternative for urban transportation, the bicycles lanes (Goodman, A., Cheshire, J., 2014)

There is a lot of literature exploring different methods to assess centrality at the city level due to the importance of central places inside a city and besides the two territorial

levels mentioned above, the regional level centrality is a characteristic that weighs a lot in the development of a city or of a network of cities, because their place as nodes in the regional settlements' network can give them a high or low degree of centrality. The advantage of a city that is close in relation with the other cities in his region can be transformed in an economic advantage, through new investments that creates new jobs and more money from tax revenues for the local authorities and this economic advantage will later turn in a social advantage.

2. Methodology

There is a tight connection between centrality and transportation systems and infrastructure; a good infrastructure can increase the accessibility of a city. The two terms, centrality and accessibility, share almost the same meanings. The "accessibility" concept is defined in relation with what is defined as "accessible", the most common definition is that accessibility is the property of a location to be easy to reach using a particular transportation system (Dalvi, M. Q., Martin, K. M., 1976) therefore, it is easy to understand the fact that both terms are often used to define the same concept.

The Shimbel index uses the topology of a network, in order to determine the degree of centrality of a certain node or for all the nodes in that network. This is considered an index that measures both, accessibility and centrality, due to the fact that, as it will be shown further in this paper, the most accessible nodes in a network are the one that are positioned in the center of the system. The Shimbel index is "the total number of edges needed to connect any one place with all the other places" (Waugh, D., 2000), but only using the minimum number of edges between the nodes of the network, so a smaller Shimbel index means that the node is more central and it has a better accessibility.

In time, different variations of this index have emerged. For example, the simple Shimbel index failed to take into consideration the notion of distance, the edges between the nodes have different lengths that must be traveled thorough. Therefore a value was given to the links between nodes and that value may differ, from the actual distance between the nodes, the time necessary to reach point A from point B or the cost of the travel can be the values that may serve as inputs in calculating the Shimbel index, expressing the minimum distance, the minimum time or the minimum cost. In a territorial system, if we consider the settlements nodes and the transport infrastructure the edges that links the nodes, the shortest route on road between two cities isn't necessary the one that takes the minimum amount of time to travel or it is the cheapest, because of different types of road infrastructure that have different legal speed limits or the modal options. The index is measured as follows:

$S_i = \sum d_{ij}$, where S_i is the Shimbel index for node *i*, and d_{ij} is the distance between nodes *i*and *j*. The inverse of this formula results in what is called the closeness centrality, the advantage of this being that it is expressed in values between 0 and 1.

The closeness centrality is, together with betweenness centrality, degree centrality, eigenvector and straightness centrality, one of the measures for assessing centrality. The degree centrality is a basic measure that consists in the idea that the most important nodes in a network have the largest number of ties with the other nodes. The

betweenness centrality was first introduced by Freeman, (Freeman, L.C., 1978) and was used for sociological studies like the connection between humans in social networks. This measure for centrality quantifies the number of times a node or an edge of a network was transited as the shortest path between other two nodes of the network, assuming that the flow of information or of the goods is done taking the shortest path (Chehreghani, M. H., 2014). The eigenvector measure (Bonacich, P., 1987)is most commonly used in social and computer sciences where it quantifies the influence of a node in a network by assigning relative values to all the nodes and a node with a high eigenvector score will be in the proximity of other nodes also with a high score (Borgatti, S. P., 2005).

The straightness centrality is a measure for efficiency assessing the ratio between the geodesic values of the Euclidean distance and the shortest path distance between two nodes. The straight line distance being the most efficient, this measure for centrality assesses the deviation of the road's layout from the straight line.

Botoşani County is located in the north-eastern side of Romania and it holds a population of 412.000 inhabitants. The settlements taken into consideration for centrality assessment are the 78 localities that have an administrative role, thus hold a major significance in the county's territorial system. From these 78, there are seven towns and 71 villages (figure 1) the small number of cities determines the rural population to travel more for the services and goods that are not available in the rural settlements. The reason why only the settlements with administrative role were taken into consideration for the present analysis is that these settlements have also a large number of inhabitants, relatively low or medium economic activities in the rural ones and if all the settlements were to be considered the calculus for accessibility-centrality would have taken a serious amount of time, given the fact that Botoşani County has a total number of 350 localities and the distance matrix would have been hard to build.

The road network that was used (figure 1), contains the national roads, the county roads and some communal roads. Not all the communal roads were used because most of them are dirt roads and the best case, are macadamized roads. Their role is to link the residence of a territorial administrative unit with the other localities contained in that administrative unit so they were quite irrelevant for this analysis. Even when it comes to the county roads, a vast majority have asphalt garment, though, there are some road segments that have a macadam garment. The road layer used was an open source dataset derived from Open Street Map that was projected in Romanian Stereo 70 using the ArcGIS 10 software.

For assessing the centrality of the cities and villages from Botoşani County, two measures for centrality were calculated: The Shimbel index for accessibility-centrality and the straightness centrality.

For this two matrices were built, each with a resolution of 78x78 cells that were populated with the names of the settlements. Matrix A is a valued matrix containing the road distances between each settlement and second matrix that is also a valued matrix, containing the Euclidian distances between each analyzed settlement.

***Figure 1**. The localization of the analyzed settlements and road network*

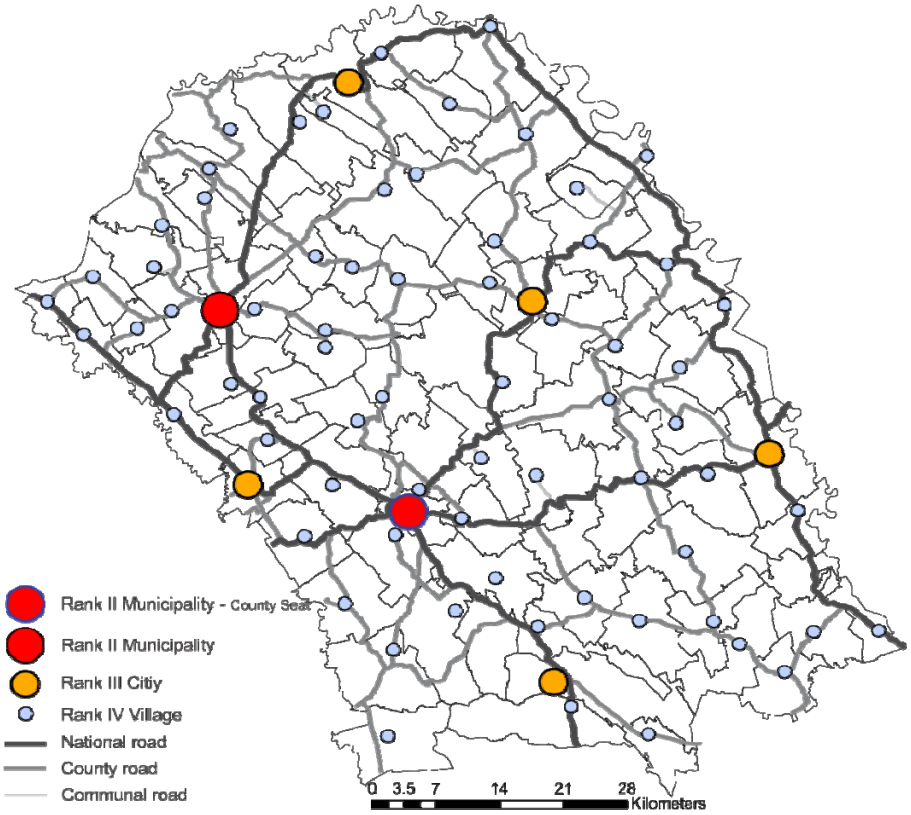


Table 1. Sample of the distance matrix using the road network (in kilometers)

	Botoşani	**Darabani**	**Dorohoi**	**Saveni**	**Adaseni**	**Albesti**	**Avrameni**	**Baluseni**	**…**	**Vorona**
Botoşani	0	70.6	35.9	35.7	58	44.7	47.9	17		20.8
Darabani	70.6	0	34.8	36.6	58.6	78.6	49.2	87.6		91.4
Dorohoi	35.9	34.8	0	43.8	66.2	79.9	55.9	52.7		56.5
Saveni	35.7	36.6	43.8	0	22.9	42.4	12.5	52.8		56.6
Adaseni	58	58.6	66.2	22.9	0	64.9	10.6	75.1		77.2
Albesti	44.3	78.6	79.8	42.4	64.9	0	54.7	40.3		63.1
Avrameni	47.9	49.2	55.9	12.5	10.6	54.7	0	65.1		68.9
Baluseni	17	87.6	52.7	52.8	75.1	40.3	65.1	0		23
⋮										
Vorona	20.8	91.4	56.5	56.6	77.2	63.1	68.9	23		0

The distances for both matrices were calculated in a GIS environment using the Closest Facility Tool for Arc Map that calculated the distances using the roads and in straight line.

For the Shimbel index a different formula than the consecrated one was used. The index is the sum of the sums of the distances between two nodes divided by the sum of the distances. The formula is this: $S_i = \Sigma\Sigma d_{ij} / \Sigma d_{ij}$. This variation for calculating the Shimbel index was first introduced by Ciceri et al (1977) and it was applied for the metro stations in Paris that were the nodes, and the subway lines were the edges. The difference between this method of calculation and the original one is that the node with the highest value is the most accessible/central one because it is reported to the sum of the distances for that node.

For the straightness centrality the value for Shimbel index resulted from the Euclidian distances was divided to the road distances index. The results of these formulas were mapped using the free software Philcarto 5.6 where the values for each node were triangulated in order to create areas with similar accessibility/centrality.

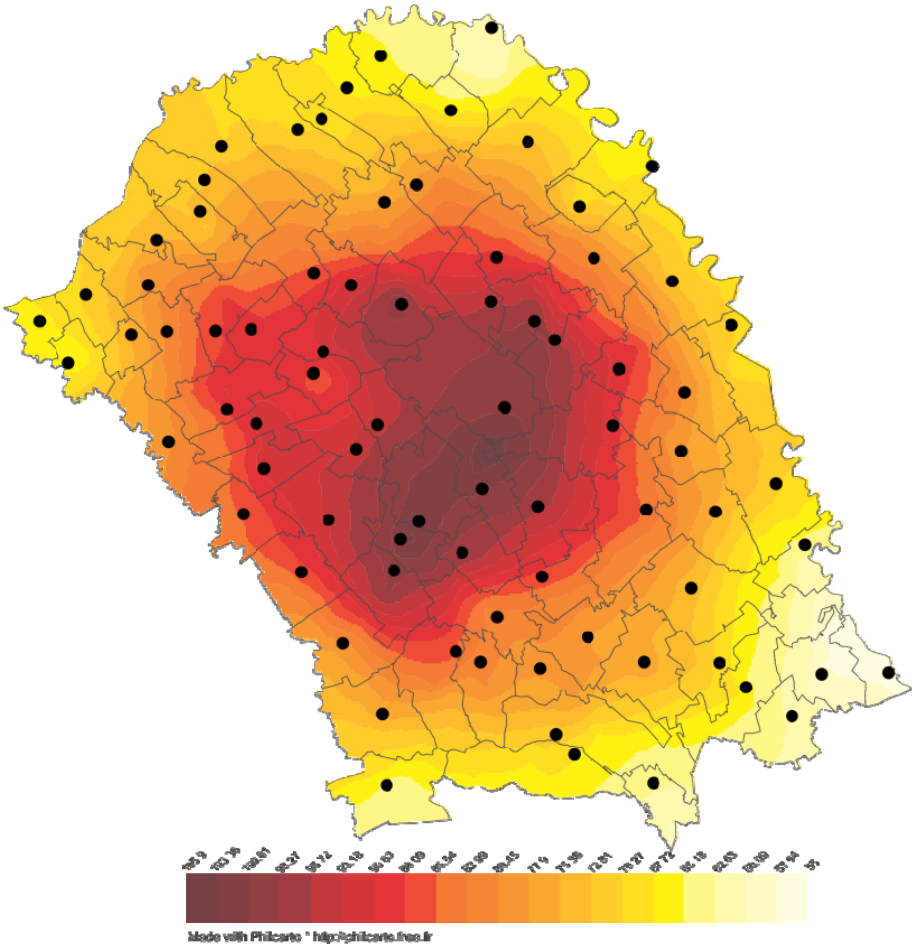
3. Results: The spatial distribution of centrality

The mapped Shimbel index for the localities in Botoşani County (figure 2) shows, first of all, that the high centrality area is localized around the geographical center of the territorial system. This is a common situation in the systems that have a good connectivity between its nodes. For Botoşani County the road network is relevant because it is the most used infrastructure and it has the best distribution, the rail has a low density network and it isn't used by the majority of the population.

The village that is most central in the county is Ungureni; also the closest to the geometrical central point it benefits from a good connectivity, this village is an intersection of four roads and it is transited by a national road. The high-centrality values are massed between this village and the county seat. The city of Botoşani is the largest city in the county and it has the most important and numerous economic activities. Its high degree of centrality is given by the fact that it has a large number of ties with the other villages and towns it is the most important node in the network. In the last two centuries the roads were built in order to ensure connectivity between the main city and the villages that provided agricultural goods for the urban population. At a smaller scale, the city of Botoşani had to be connected with the national and international road networks, due to its location at the border, therefore this city has a large hinterland and in the county system it has a high degree of centrality. There is a difference between the western side of the county and the eastern side in what concerns the centrality. The western side has bigger values for the Shimbel index justified by a bigger road density that makes the distances between cities become shorter.

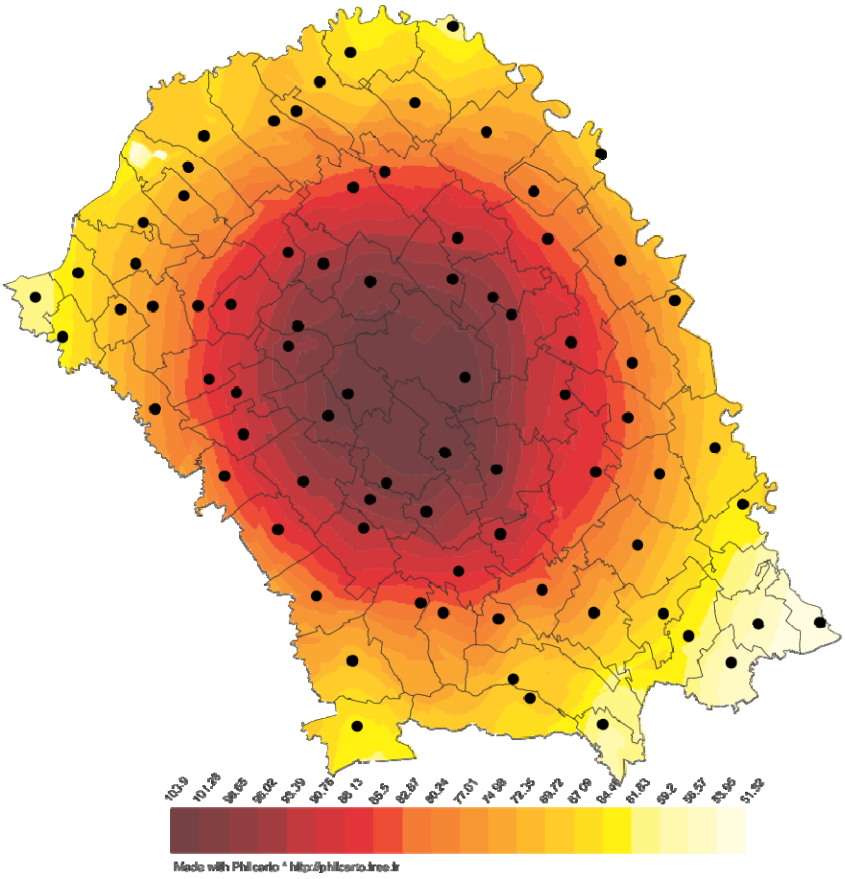
The low accessibility localities are positioned at the extremities of the county, the south-eastern part being the most remote. Besides the fact that they are far from the majority of villages, the road infrastructure isn't as dense as in other parts of the county and the links are oriented in a north-south direction, for the west-east direction there aren't any roads.

Figure 2. *The Shimbel Index distribution calculated using shortest road distances between the settlements*



The straight line distances matrix was built with the assumption of an ideal mobility or road infrastructure, where all the nodes in a network where directly connected with one another in straight line, the distances having the minimum possible values. This was the second step in the aim to compare the present accessibility with the maximum potential of accessibility if no changes in the localities system occur.

***Figure 3**. The Shimbel Index distribution calculated using the Euclidian distances between the settlements*

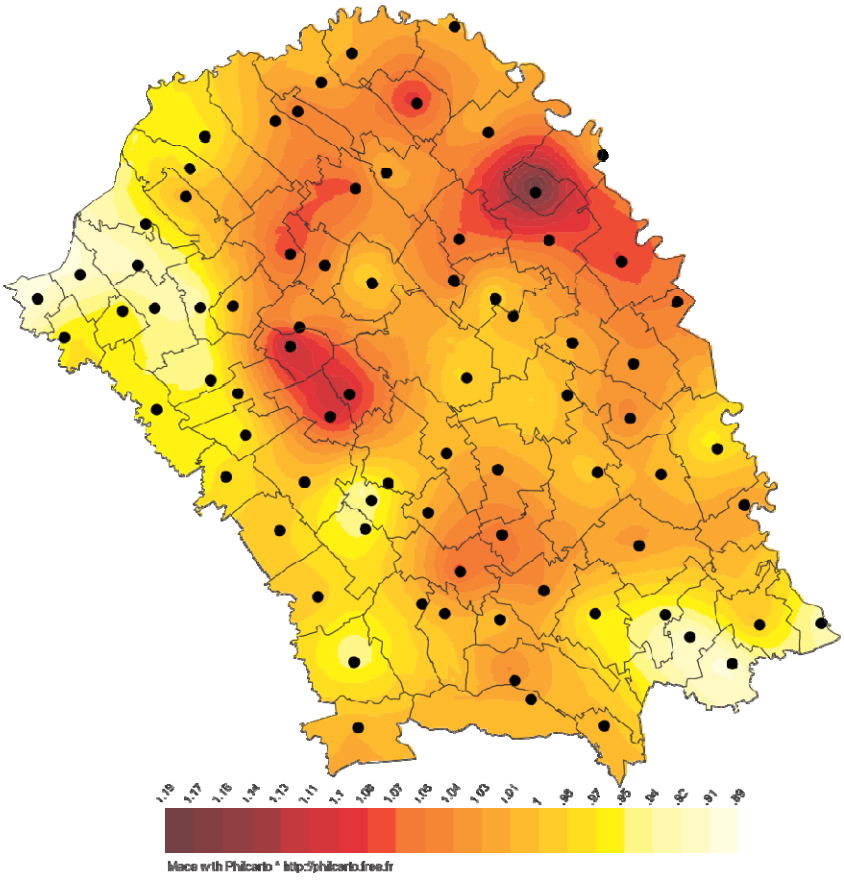


In figure 3 the mapping of the Shimbel index of accessibility/centrality using the straight line distances show an expected result. The most accessible villages and towns are the one that are the closest to the geometric center of the county, the values of the index decreasing towards the edges of the county in almost concentric circles. These circles aren't perfect concentric because of the positioning of the nodes, which are scattered inside the county and are not positioned on radial circles. Another factor that affects the spatial distribution of this index is the density of the settlements. If a certain part of the county holds more settlements the high centrality values will slide towards this side of the county and in Botoşani there are more nodes in the western and northern part, therefore those nodes are more central.

The straightness centrality for the settlements in Botoşani County was mapped using the same triangulation method (figure 4). This measure shows the differences between the maximum potential centrality and the present centrality, the map presenting in

shades of red with values greater than 1.03 the villages and towns that have good potential centrality but a bad existing one, in shades of orange and around the 1 value, the settlements that have almost similar centrality values both in road distance and in straight line distance and in a yellow gradient are the settlements that actually have a better existing centrality than the potential centrality.

***Figure 4**. The Straightness centrality measure distribution*



The low straightness centrality is registered only for a few villages from which the village of Adâşeni is the most evident. Located in the north-eastern side of the county, this village is far away from being a central and this isn't very surprising if we analyze the topology of the road network. With a straightness centrality value of 1.18, Adâşeni doesn't have direct access to a national or a county road and it is a „cul-de-sac" so the connection between other villages doesn't transit this node in the network. Also, the second „farthest away from the potential" village is Dimacheni who is also at the end of

a road that stops in that village. A pattern emerges at a close look: the nodes that have one or two links have low accessibility/centrality even though they are located in the central area of a spatial unit (city, region, country), the number of ties that a node has dictates its overall centrality values. This doesn't necessary mean that these settlements are inaccessible but they only few options in reaching other localities from Botoşani County and are vulnerable and can become isolated if the only road that provides connection with the rest of the territory breaks down during a major flood or during a blizzard in the winter, hence some investments must be done in the transport infrastructure in order to increase the resilience and to reduce the difference between the present centrality and the potential one.

The sub unitary values for straightness centrality are distributed in the settlements that are located at the county's extremities and the village of Vorona and the county seat, Botoşani are also in the same situation. The explanation is quite simple: like it was stated previously, the western side of the county benefits from a denser road network which gives a good present centrality to the settlements located in this area, but a lower centrality when it comes to straight line distances, due to the fact that are positioned at the edge of the county, so the shortcomings of being peripheral are reduced with a good road infrastructure.

Straightness centrality is used to assess the general detour of a road connection from the shortest path possible that is the straight line connection. So this measure for centrality can be higher or lower, depending on the layout of the road network, the number of curves and their amplitude. The path of a road is influenced by many factors, depending on the type of the road and we will shortly give some details on two of these factors: the relief and the historic legacy. The landform is influencing the layout of a road through costs of construction and reducing some risks related to landslides, so the roads must follow the most suitable routes in order to reduce costs of construction and maintenance. Botoşani County has a topography predominantly formed of succession of hills and valleys and most of the roads follow the valleys but there are some that pass across the hills and make very steep curves that increase the length of the roads making larger distances between settlements.

The nowadays roads' layout in Botoşani County is not so different than what it was a century ago. Because of the low investments in correcting the roads' alignment or building new, straight line roads, the distances remained the same between the county's settlements without freeways or expressways to eliminate the spatial impedance and encourage the exchanges between the cities and villages. The population that lives in Botoşani County inherited this road network from the previous generations, but this network isn't capable to connect properly some nodes to the cities that provide the goods and the services the rural people need and also don't allow to sell their products in the urban markets.

4. Conclusions

Centrality is a highly-desirable characteristic to all the companies or settlements that act as a node in a certain network. Often used in the research of the social scientists, the measure of centrality has revealed some great findings in other sciences too. The

Shimbel Index is a simple to calculate but very enlightening way to assess the centrality of a network's nodes or edges, but for a proper view of what's central and what is not, further research must be done using the other mentioned measures for centrality, the MCA (Multiple Centrality Assessment) (Crucitti, P., et al. 2006) being a very powerful tool in this sense.

Considering that the people of Botoşani County travel by using the shortest distance path and having a good spatial distribution, the road network in Botoşani County confers good centrality values to the settlements located in the geometric center of the county and they slide to the south-central part where the main urban center is located. The utilized measures for centrality are influenced by the nodes' location inside a network, the topology, the connectivity and the number of ties they have between them. Also, in a territorial system the results depend on the layout of the utilized network, in this case the road network that is also depending on many other factors like the topography of the terrain and the investments in the road infrastructure.

The current approach showed that there are some settlements with administrative attributes that have a low accessibility when they are related with all the other settlements in the county. This paper's results can be used by the authorities in order to prioritize the next investments in the road infrastructure. These results can also be used by the investors in order to identify proper location for their investments if they're in a search for central and accessible locations. This can mean jobs and a better life especially for the people in the rural area where agricultural activities are the main source of income. The assessment of centrality of the cities or villages has, therefore, a social dimension, besides the information that can be valuable for investors it shows how accessible are the main public services for the population, because if a city is accessible the services located in that city are also accessible, the quality and if they are affordable being different issues.

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short story, if not an entire novel in every family photo. And there is also a challenge in every painting.

The Balkan Conclusion

Expressionism Movement is just at its beginning. Time will tell whether this artistic movement will impact universal art as the previous art movements did.

The Balkan expressionism movement arose and is making the world aware that the artists from the Balkans are ought not to be forgotten or left aside. There is a culture that is in a continuous development without forgetting the tradition. There is a pure outcry: we are here; we are worthy!

The Balkan artists pride in the confidence they have in their creative ideas as they find their inspiration in the Balkan folklore, the surrounding stories in the urban areas. There is a story behind every Balkan expressionism painting and one can wonder if the world is prepared to witness the emergence of a new art that combines life in reality in such a way that it trespasses times and ages.

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