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Spatial Integration in Explaining the Accessibility to Residential Areas: Bandirma Case

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SPATIAL INTEGRATION IN EXPLAINING THE ACCESSIBILITY TO RESIDENTIAL AREAS: BANDIRMA CASE

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ABSTRACT:

In this research the topological accessibility values have been used as an alternative parameter to accessibility in order to examine whether it provides any advantages to the evaluation of the differences in spatial environment across an urban area that is unconventional to acquire with the geometrical distance measurement.

The topological accessibility has been calculated via space syntax analysis, and, called “spatial integration”. The basic principle of the space syntax methodology is based on the strict relationship between topological structure of urban environment and human behavior. With the method, the physical structure is represented as built space by three dimensional objects such as buildings and non-built space as a base for movements in urban space. Topological structure by itself affects the movement in space; this is called as “natural movement”, and this relationship also affects the other sub systems such as land use, land values, etc.

As the previous researches prove, topological structure and other urban systems are strongly correlated. Therefore, the spatial integration value is expected to explain the spatial variations of physical environment. In this research, this relationship is analyzed in Bandırma case. The analysis have been carried out with three factors based on spatial analyses and questionnaires of 795 households; the satisfaction from built environment, housing prices and Euclidean distances to the port, highways, city center, seashore, schools, and industrial areas.

Regression results show that there is a complex relationship between spatial structure and topological accessibility. According to the residual values, the spatial integration values through the main arterials fit better than that the other areas' values. Moreover, results reflect three distinct groups in the Bandırma case: The area near the main arterials, lately developed planned areas and old city part. Comparison of the last two areas show that spatial integration values in the old city part are more meaningful in explaining the other factors than the lately developed planned areas. This difference may be the result of the differences between two types of spatial development reflecting the opposite perspectives which are bottom-up and top-down approaches.

This research shows that the spatial integration values can be used as an alternative variable to measure accessibility; it may also help to explain the physical differentiation of space in an urban area..

Keywords: Space syntax; accessibility; spatial integration value; Bandırma

Introduction

The spatial distance between the components of the urban system is one of the widely used parameter in spatial researches. The network distance and Euclidean distance are among the few methods that define the distance in order to analyze the level of interaction. Although those methods use the geometrical measurement and compares the differences of physical distances between two components of an urban system, and the shortest path in the system is defined, the effect or the network of all routes is not included into the system.

In this research, the space syntax method has been used to analyze the relationship between topological network and physical spatial characteristics in Bandırma case. Based on the theory of space syntax, it can be argued that the heterogeneity of physical space can be reflected by the spatial configuration.

Bandırma is a small settlement in the Marmara Region. A 'Household Research' survey, which is conducted by Alkay and Kaya in 2010, based on the questionnaires of 795 households. The socio-demographic structure of households, the socio-economic structure of households, housing characteristics, the residential mobility pattern of households, social relations/interactions in the society, and the satisfaction with housing and housing environment are the main modules of the survey. The survey analyses have proved the heterogeneous socio-spatial structure in the city (Alkay & Kaya, 2011a, 2011b).

In the Bandırma case, the spatial integration values, which are the primary parameter of space syntax, have been used to analyze spatial configuration. The built structure of Bandırma has different characteristics (Kaya & Alkay, 2013). The spatial environment can be classified into few distinct regions as, historical area-organic pattern, central core-grid pattern, housing areas of 1960s-grid pattern, and newly developed housing areas-mixed pattern. The following analysis aims to find a bunch of remarkable results showing the physical-spatial variations via space syntax methodology.

Methodology

In this research, physical spatial variations have been analyzed by applying the space syntax methodology. Space syntax is a method which has developed based on the strong correlation between human behavior and topological structure of the urban space (Hillier & Hanson, 1984; Hillier, Leaman, Stansall, & Bedford, 1976).

The main argument of Space Syntax is that spatial configuration is the primary generator of activities, and urban systems have emerged based on the spatial configuration. The pedestrian movement that determined by the urban configuration rather than other movement generators - such as land use - is called as "natural movement".

Previous researches prove the existence of strong relationship between spatial integration and several urban issues such as land use, land values, crime and pedestrian movement. In the space syntax method, urban space is represented as built and non-built areas and two kinds of maps are produced from the existing spatial structure: axial map and convex map (Figure 1 **Error! Reference source not found.**).

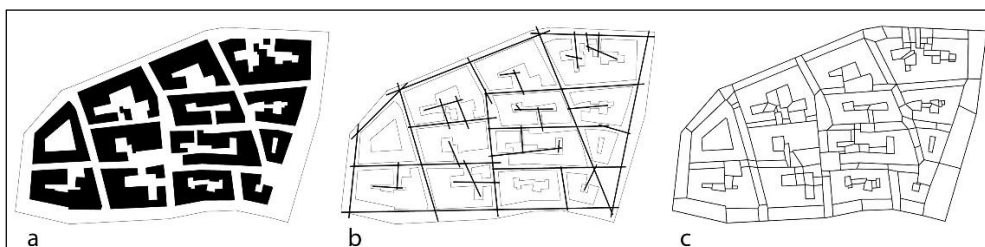


Figure 1. Figure-ground map (a), axial map (b), and convex map (c)

The axial map is a topological representation of urban configuration to measure the level of accessibility which is defined as “spatial integration”. Integration concept contains several measures that emphasized in following paragraphs:

Step: As the axial map is a kind of topological network, movement between different locations occurred via steps. Step is the movement from one axial line to another line. While each axial line is not curve each step is the change of direction in an axial map.

Depth: It is a measurement which counts the steps that are necessary to pass in order to reach from any space to all other spaces (Klarqvist, 1993). In other words, “it is a topological distance between nodes” (Volchenkov & Blanchard, 2008).

Radius: The maximum number of accessible steps defined to calculate the graph measure from a segment x to all other segments. If the whole map included to the calculation, it is called as Radius “n” (R_n) while it is Radius 10 (R₁₀) if the maximum allowed distance is 10 steps from any axial line (Turner, 2007).

Integration: The degree of accessibility from the whole system. “It describes the average depth of a space to all other spaces in the system” (Klarqvist, 1993). The integration values are measured for each axial line with all system (R_n: global integration) or with a specified distance smaller than the whole axial map (local integration).

Basically, the integration is the level of depth in the system but as the axial system grows, the depth values will change. To be able to compare different sized axial systems, the mean depth value has been used as a standardized value.

Spatial integration is the most widely used parameter in space syntax method. The distribution of integration values reflects the spatial variations. The first step is the calculation of depth of each axial line, in the other words, each node in the network.

$$D_i = \sum_{j=1}^N d_{ij}$$

D: Total depth for the given node i

d_{ij}: depth between two spaces of i and j (Volchenkov & Blanchard, 2008)

N is the total number of nodes in the axial map

The average number of syntactic steps from a given node i to any other node is called as “mean depth” (MD):

$$MD = \frac{D_i}{N - 1}$$

Mean depth of each node gives information about the accessibility or integration of nodes, however, since the size of the axial map effects the MD value, it is not possible to compare different networks thoroughly which have unequal number of nodes. To solve this problem, two concepts have been developed: Relative asymmetry (RA) and Real Relative Asymmetry (RRA).

The relative asymmetry or relative mean depth expressed as a “fraction of the maximum possible range of depth values for any node in a graph with the same number of nodes as the system” (Bafna, 2003):

$$RA = 2 \frac{MD - 1}{(N - 2)}$$

Real Relative Asymmetry is calculated by adding a normalization parameter (D_N) to the formula of RA for each node i (Volchenkov & Blanchard, 2008):

$$RRA = 2 \frac{MD - 1}{D_N(N - 2)}$$

Basically, D_N in this formula is the RA values of the central node of a diamond graph (or the normal distribution of nodes) with the same number of nodes as the system and it is extended as (Volchenkov & Blanchard, 2008):
$$D_N = 2 \frac{N(\log_2 \left(\frac{N+2}{3}\right) - 1) + 1}{(N-1)(N-2)}$$

The spatial integration value is measured as the inverse of the RRA values. Therefore the higher integration (1/RRA) values indicate that the particular node is more accessible than the other nodes. In the urban system, some locations are more accessible or have high integration than that the other areas are. The hierarchy of the transportation system and the road pattern affects the level of spatial integration. As the variations of integration is evaluated as one of the major driving forces changing the settlement structure in space syntax theory, it can be hypothesized that the spatial integration map also represent the spatial variations. Consequently, the relationship between physical-spatial variations and the spatial distribution of integration values have been analyzed together in the case of Bandırma.

The 'Household Research' survey which covering 789 households, consists of six main modules (1) the socio-demographic structure of households (2) the socio-economic structure of households (3) housing characteristics (4) the residential mobility pattern of households (5) the pattern of social relations in the society (6) the satisfaction with housing and housing environment. The analyzes results of 'Household Research' survey reflect both physical characteristics and social environment is distributed heterogeneously across the city (Alkay & Kaya, 2011b).

In this research spatial integration results compared with the results gathered from the Household research survey to analyze whether spatial integration values are capable of explaining the spatial variation of physical environment.

The main variables of multivariate linear regression are global integration (R_n), Distance to the important functions ($Dist$) such as port, schools and city centre, Housing and environmental quality ($Henv$) and Hosing Prices (Hp). Based on these variables, the linear regression formula can be written as follows:

$$R_n = k + \alpha * Dist + \beta * Henv + \gamma * Hp + \varepsilon$$

Further, the residuals, the unestimated part of the regression, are analyzed in order to discuss the characteristics of different areas that are well explained or unexplained in the linear model.

Case study

Bandırma is a small seashore settlement located in the city of Balıkesir. The Bursa-Çanakkale highway (D200 motorway) passed through the city and two main arterials join the D200 and the center and the port of Bandırma. The main road pattern in the central area is grid system which brings together high integration values. On the other hand, newly developed housing areas has different road pattern and in general, they are not highly integrated to the city.

The highest integration value is 0,28 that belongs to the Atatürk street and the extension of D200 from the intersection with Atatürk street (the rectangular area, number 9 in the Figure 2). The integration values in the commercial center (5) are very high. The grid system with small city blocks results in increasing integration values in this area.

The planned housing areas in the periphery of the Bandırma (1, 2, and 7) and unplanned developments (6 and 8) are not well integrated to the city. Those areas are spatially far from the city center. Although the areas 3 and 4 are relatively close to the city center, their integration values are still not high enough. However, since these areas are close to central area or surrounded by relatively high integration values, their attractiveness are relatively high than that the remaining parts.

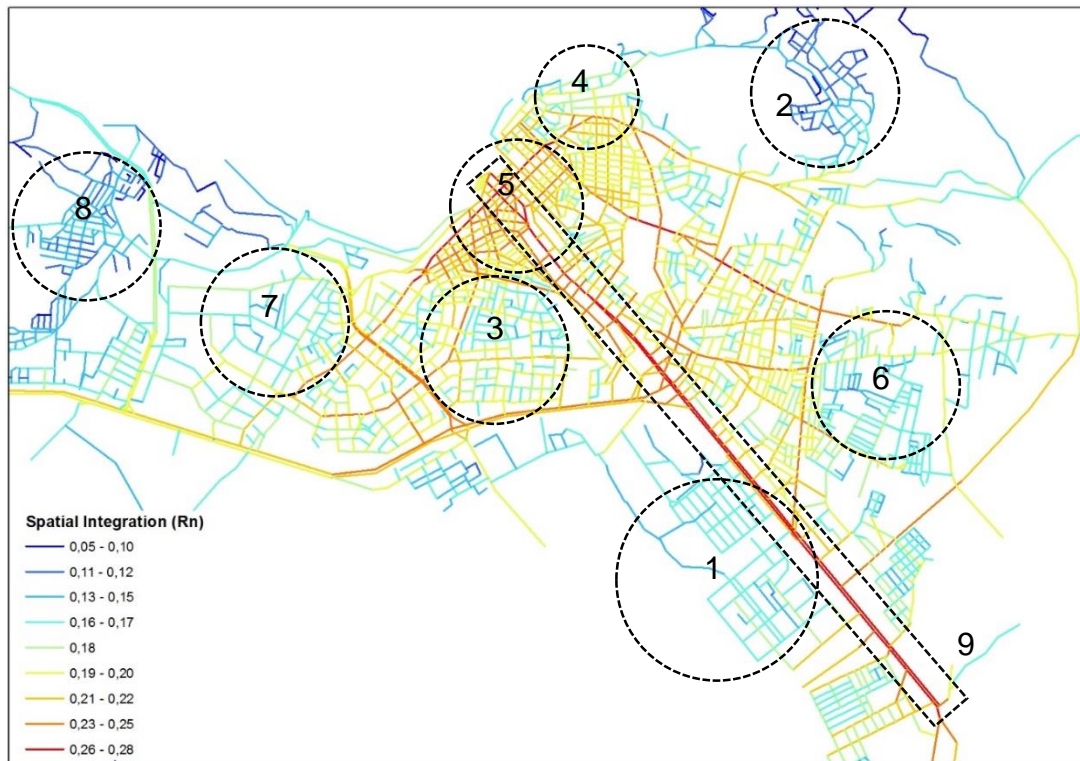


Figure 2. Global integration (Rn) values

The differences in spatial integration values have been analyzed by implementing the regression analysis. Although the r^2 value is relatively low, the coefficients of the independent variables indicate the importance of the centrality and the distribution of public facilities across the city. The r^2 of the best linear regression model is found as 0,412. The variables measuring the distance to the center and urban facilities have highest coefficient values (Table 1).

Table 1 Independent variables and their coefficients of regression model

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.	Collinearity Statistics		
		B	Std. Error	Beta			Tolerance	VIF	
Dependent Variable: intrns									
	(Constant)	,136	,041		3,298	,001			
	Distance to center	Dc	-,014	,003	-,309	-,5259	,000	,218	4,590
	Distance to shopping areas	Ds	,009	,001	,296	7,399	,000	,469	2,134
	Housing Price	Hp	,035	,004	,268	7,730	,000	,623	1,604
	Measured density	Md	-,008	,001	-,250	-,6444	,000	,497	2,010
	Perceived density	Pd	,004	,001	,145	4,319	,000	,662	1,510
	Urban green areas	Gr	-,004	,001	-,142	-,4864	,000	,887	1,127
	Distance to highway	Dh	-,006	,002	-,140	-,2995	,003	,342	2,923
	Distance to port	Dp	,006	,003	,079	1,900	,058	,430	2,324
	High pedestrian friendliness	Pf	-,002	,001	-,067	-,1951	,051	,641	1,561
	Distance to industry	Di	-,001	,002	-,016	-,329	,742	,309	3,231
	Distance to school	Dsc	,001	,001	,019	,483	,629	,502	1,991

The main variables of multivariate linear regression is global integration (Rn), Distance to the important functions (Dist) such as port, schools and city centre, Housing and environmental quality (Henv) and Housing Prices (Hp). Based on these variables, the linear regression formula is as follows:

$$Rn = 0,136 - 0,014 * Dc + 0,09 * Ds + 0,035 * Hp - 0,08 * Md + 0,04 * Pd - 0,04 * Gr - 0,06 * Dh + 0,06 * Dp - 0,02 * Pf - 0,01 * Di + 0,01 * Dsc$$

Since the r^2 value is not high enough, the importance of residual values increase to understand and evaluate the spatial pattern of changing variables. Therefore, the spatial distribution of residual values (ε) have been analyzed to see the characteristics of different areas that are well explained or unexplained in the linear model. Since residual values are distributed heterogeneously over the area, it is obvious that the regression equation does not correspond to the whole properly. Within this heterogeneous distribution, there are some noticeable homogeneous clusters of residuals (Figure 3).

These homogeneous clusters can be classified into the two main groups as “low integration and low physical characteristic values” and “high integration and low physical characteristic values”. Consequently, those four clusters common character is their low physical quality.

In the first group, both the integration values and physical quality, distance to the public facilities and housing prices are low, (1 and 2 in the Figure 3). Although those areas are planned housing areas, they are not well integrated with the city and lacked of sufficient urban facilities. The second group is located (3 and 4 in the Figure 3) close to the commercial center and main characteristics of these areas are high accessibility to the urban facilities. The age of housing stock and the distance to the railway that divide the city into two parts (particularly for the 3rd cluster) may be among reasons of low environmental quality. However, these clusters have high potential for urban renewal depending on their locational distribution across the city. They are in the vicinity of the central area; land values are high; on the contrary, property values are low.

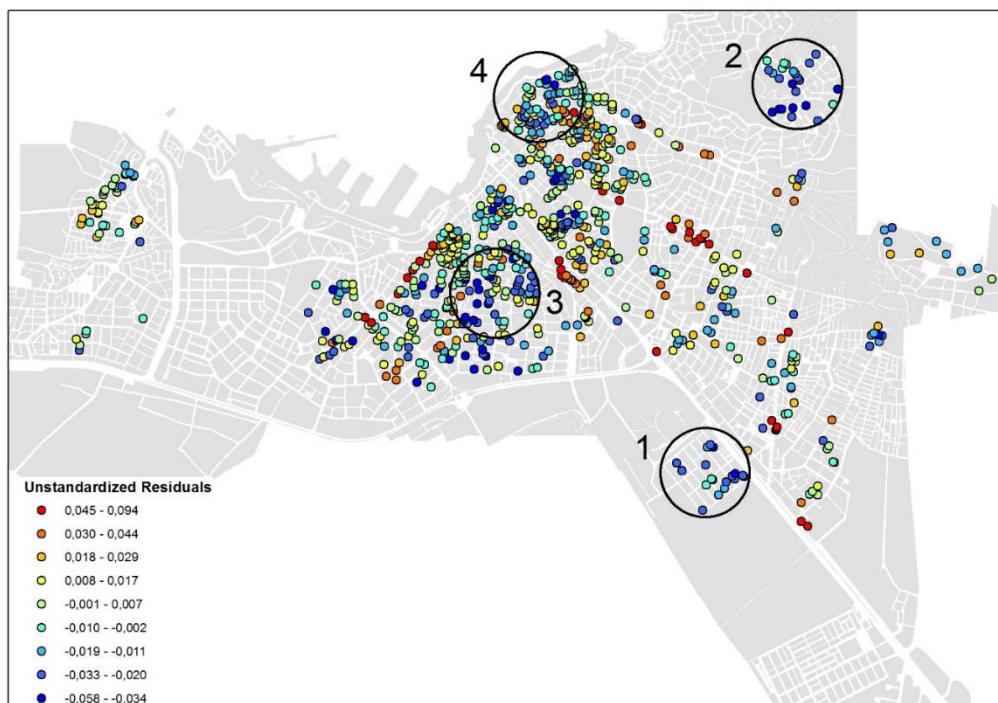


Figure 3. Spatial distribution of residual values

The residual values are similar in the four areas, however, each area has unique physical characteristic: The area 1 (Figure 3) is the low rise housing area with two storey buildings and small gardens. The area 2 (Figure 3) is the new housing development with apartment blocks

with 5 to 11 storey. The area 4 (Figure 3) is the old housing areas in the central zone. This area has the advantage of the sea view and green areas. The area 3 (Figure 3) is the new development area for housing. The main advantage of this area is being very close to the central activities.

The spatial distribution of residual values over the integration map shows that these four clusters of unexplained areas have low integration values than their surroundings (Figure 4). There are also high residual values close to the highly integrated roads but they aren't comes together to create clusters.

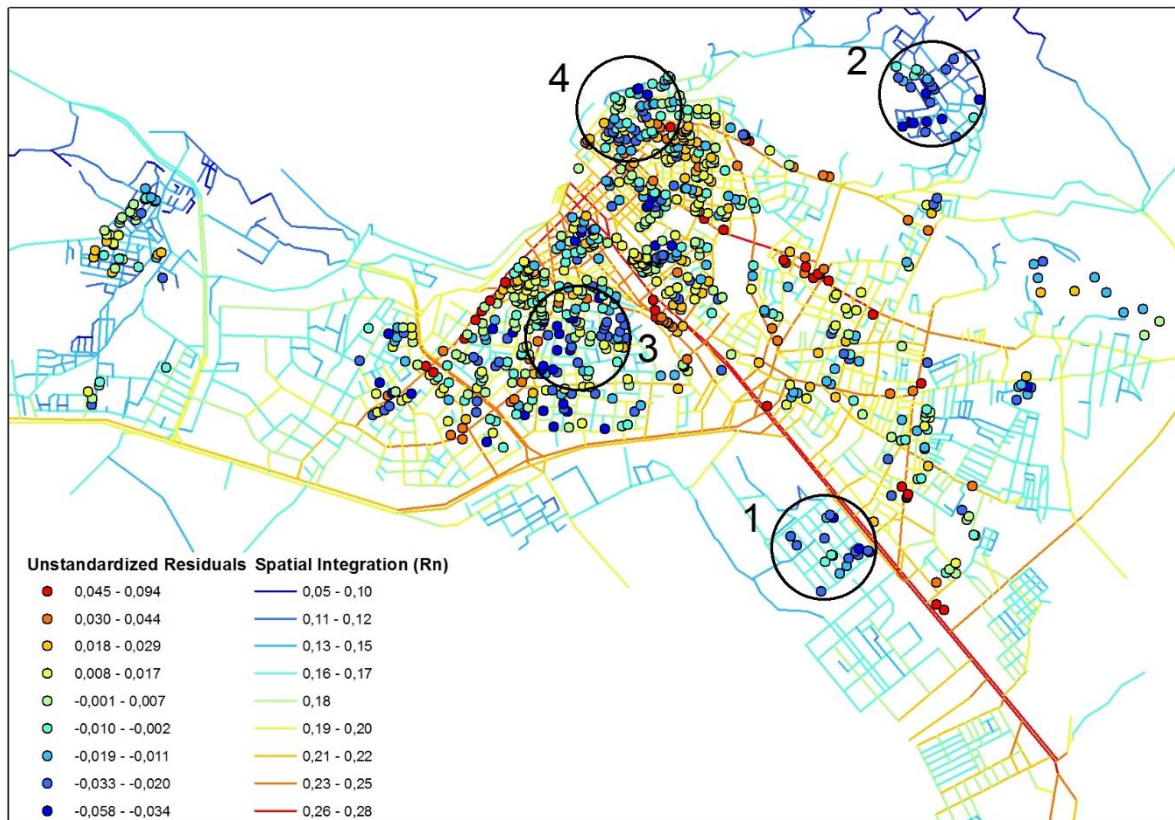


Figure 4. Lowest residual values and lower spatial integration values

The low integration values surrounded by or near the highly integrated roads are planned housing areas. These areas give opportunity of having a quiet environment and relatively good accessibility to the central activities via highly integrated roads. The one exception is the TOKI mass housing area which is located on the north east of the city (no. 2 in the Figure 4). On the other hand, generally unplanned areas of Bandırma have very low integration to the city. Although, the integration map is very useful to understand and explain the general morphological characteristics, the comparative analysis of integration and other spatial variables gives more realistic picture of the city.

Conclusion

This study highlights that space syntax method can be included to the models to contribute to explain morphological characteristics of physical environment. On the other hand the findings of statistical analysis shows that the locations close to the highly integrated areas are better explained in the regression model than isolated areas.

The independent parameters of regression analysis are housing price, environmental features and distance to the important functions. It has been seen that the linear model of the dependent value of integration is not explained powerful enough to be represent the whole area. However,

analyzing the spatial distribution over the area reveals some characteristic that are very difficult to be seen without the space syntax analysis such as the less integrated areas near the city center and the changing topological structure of planned and unplanned areas.

It is very remarkable to have clusters of the residuals over the spatially different residential areas. These clusters are reflects the spatial distribution of the global integration values which have low integration values but being very close to the highly integrated roads.

The clusters of residuals showing high integration and low environmental quality, the combination of both land and housing prices are needed to be evaluated as potential re-development areas. These areas have potential to be very attractive if the physical quality is improved. On the other hand, clusters of the low integration and low physical quality and housing prices are the housing areas which have limited, and facilities do not integrated to the city. These areas need to be connected via public transport and alternative transportation options to strengthen the connection with the city.

In summary, this analysis shows the relationship between topological structure and physical characteristics of housing environments. To be able to have the more reliable and enhanced results, it will be very useful to combine spatial statistics tools and spatial integration analysis.

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