IDENTIFYING RESIDENTIAL SUB-MARKETS USING INTRA-URBAN MIGRATIONS: THE CASE OF STUDY OF BARCELONA'S NEIGHBORHOODS.

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ABSTRACT.

The dynamic evolution of the real estate market, as well as the sophistications of the interactions of the actors involved in it have caused that, contrary to classical economic theory, the real estate market is increasingly being thought of as a set of submarkets. This is because, among other things, the modeling of a segmented housing market allows, on the one hand, to design housing policies that are better adapted to the needs of the population, but on the other hand, it allows the generation of both marketing and supply strategies Oriented to specific population sectors. Such strategies in theory should behave as options with relatively low uncertainty, thus representing an attractive offer to all market players. However, in praxis, the segmentation of the real estate market is usually modeled on the offer. It is therefore that this paper proposes a modeling from observed preferences[3] seen through intraurban migrations. In particular, it is proposed to model the market through the interaction value of Coombes, scaling the results in order to visualize the resulting submarket structure from the construction of a PAM (Partitioning Algorithm Medoids).

KEY WORLDS.

Submarket, dimensional scaling, interaction value, PAM, Barcelona.

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[3] This can be understood as the materialization between supply and demand, since they constitute consummate facts.

1. INTRODUCTION.

In the new economy, the housing market has had a historical treatment with a tendency to approach theoretically from the perspective of supply, and this that is generally conceived as a single entity distributed throughout the territory. However, an urban reality that has been modeled through a number of factors ranging from space, social, as well as environmental, accessibility, planning and management among so many other factors, tends to generate a segmented market where the concept of a break in the continuity of the price structure of a real estate market has been coined specifically as a submarket. The original idea is introduced successfully in the urban economy in the 70's, (Straszheim, R. 1975) and continuing to the present day as a line of research that has been approached from different perspectives and with different results. In an attempt to avoid bias in their studies, some researchers developed new approaches in terms of both empirical and alternative modeling techniques to define submarkets. A few researchers have defined submarkets based on mobility / intra-urban migration systems of households (Jones, Leishman, Watkins 2004) being this one of the few approaches that has been done to study the market from a demand perspective in recent times.

In the other hand, some other researchers let the data determine the submarkets through the use of principal components and cluster analysis (Maclennan, Munro, Wood 1987; Martin, Peng, Bourassa, Hoesli, Peng 2003; Bourassa, Cantoni, Hoesli, Bourassa, Cantoni, Hoesli 2005). In parallel, postal codes have been used frequently for the identification of submarkets, (Goodman 1981), (G., Goodman, Thibodeau 2003). Also others tried to define submarkets through the use of cellular automata and discrete choice models (Meen, Meen 2003).

However, to date, as already mentioned, the vast majority of research in this field is generated from the perspective of supply, with the demand being relegated to a second term. In this sense, when approaching to the question of the demand through interurban migrations (i.e. registers and changes in the municipality census), we obtain a perspective that is somehow new to the paradigm of the delimitation of submarkets in the literature, strongly supported in the analysis of the supply and not on the demand, or in any case, of the price, understood this as the interaction between both parts of the market. Furthermore, a population stratum would tend to be located over time in a sector of the real estate market with specific characteristics that serve more efficiently to their needs than the rest of the market. In the meantime, household that not change their economic or demographic situation, but their home, would be expected to value their architectural and urban attributes equally. In this way, it is naturally to theorize that two houses who can be substitutable between them, would have to belong to the same submarket, everything else equal. Obviously, households are not equal (i.e. economically, culturally and demographically) which would lead to produce differentiated submarkets. With all of the above, the article structure is constructed as follows: i) a brief discussion about urban migrations and theoretical approaches to model them, ii) a brief discussion of the interaction value (IV) as a modelling technique to render the dynamics of residential mobility, iii) a brief discussion of multidimensional scaling (MDS) as a modeling technique for visualizing groups of multivariate data, iv) the presentation of the case study, v) a reflexive discussion of the limitations of the spatial segmentation model, as well as the explanation of the same in the urban context, and vi) the conclusions about the results obtained with this approach.

1.1. Intra-Urban Mobility Motivations.

Intra-urban mobility is a phenomenon that the majority of individuals and households experiment during their lives through the urban space. Residential relocation can be voluntary or involuntary (i.e. some of the motivations can be an adjustment of space, cost or tenure change on the housing or induced by employment change, or a change on the marital status for naming some examples). Nevertheless, the stimulus for a voluntary move may be externally induced, but in general it is agreed that the most important reasons for relocation refer to the characteristics of the dwelling unit (Pacione 2009). This was starting to be documented by early 50's when it became obvious that the excess or lack of housing space was the principal reason for search for a new house, followed by the quality and design of the unit or the desire to change the tenure status (Rossi 1955; Clark, Onaka 1983). Neighborhood characteristics at this moment were slighter significant than the accessibility attributes that an urban space would present, making the households make a trade off a long commuting for more square feet and better amenities at their houses at less cost (Alonso 1963). Later a concept of a life cycle was linked to the residential adjustment or relocation considering mayor factors like marriage, birth of a child, retirement or a death of a spouse were considered some key factors to induce this spatial behavior (Rowland 1982). Essentially, city inhabitants trend to move motivated for the expectation of reaching an enhanced living environment. This idea underlines the Golledge and Stimson value expectancy model in which migration behavior is seen as a result of: i) individual and household characteristics; ii) societal and cultural norms; iii) personal traits; iv) opportunity structure; v) information (Golledge, Stimson 1997). In parallel it has been pointed that environmental characteristic of a residential space such as crime rate or pollution levels can trigger the decision to seek for other place for living (Brown, Moore 1970). At this moment it has been suggested that the motivations for migrating can be induced by several factors that can be seen like a complex process with many significant layers, but in the end, intra-urban migration means a movement between areas that can be properly modelled by tracing the spatial origins and destination of the householders.

2. METODOLOGY

2.1. Intra-Urban Migration.

Whatever the motivation of households to migrate between residential areas a consequence is the delimitation and segmentation of the territory. This question has historically occurred from demographic (i.e., census tracts) to administrative approaches (i.e., municipal boundaries). However, there are also segmentations based on the predominant stock of housing stock that ultimately affect market value. Furthermore the motivations of the householders to migrate in the literature, the question of the delimitation of urban areas has been Different perspectives, starting with an early approximation with the development of the theory of the central place (Christaller 1966), until a recent one of in where it is distinguished three types of territorial networks of urban character (i.e. hierarchical, multipolar and equipotential) (Dematteis 1990). Beyond all the above, other approaches have been taken to segment the urban space, based more on the mass exchanges that the areas have between them, showing these to be more functional as they take into account the tradeoff that the commuters make along their working days. However, in the 1970's at the request of the British Department of Employment, it was developed the methodology of the labor markets which has as one of its the definition of the so-called travel to work areas (TTWA) aimed at the development of local employment policies (Smart 1974; Roca, Moix 2005). Then this methodology was partially modified (Coombes, Green, Openshaw 1986), being wide used in English urban mobility policies and subsequently exported to other countries, (e.g. Italy (Sfonzi 1991)). Also, it was being pointed, that without neglecting the substance of the concept of Self-containment, there is no doubt that from the perspective of determining urban spaces characterized by strong ties of interaction with the intention of delimiting systems Interaction value (*IV*) represents a robust indicator of (and not only of the attraction between two masses of different size) existing between two areas or functional spaces (Roca, Moix 2005). This, considering not only the transitory relation (f_{ij}, f_{ji}) but in addition the weight of the flow between the masses of origin and destination, being consequently A quasi-gravitational approximation.

Conceptually, the interaction value defined in (1)[4] is based on two premises:

1. Self-sufficiency and self-containment of the different population loops.

2. Self-restraint is understood as the proportion of migrants Move throughout their life in their reference self-containment loop (Migrants Moving Locally MML) with respect to the resident population in that loop (residing inside or outside that loop) (Immigrants). Self-sufficiency is calculated as the ratio of MML to total Population that changes its belonging loop (Emigrants).

$$IV = \frac{f_{ij}^2}{(I_i \times E_j)} + \frac{f_{ji}^2}{(I_j \times E_i)} \qquad (1)$$

Also, among the different methodologies of functional interaction[5], without doubts the ones based on the interaction value offer a more rigorous approach to the objective of delimiting supra regional systems at different scales of resolution (Roca, Moix 2005). Moreover, the discussion generated by the Coombe's interaction value about the supra regional systems, it is clear that the conception the same allows the approaching of a coherent visualization of the migratory dynamics. It is expected that those dynamics are generated by the flow of individuals who change their dwelling throughout their residential career in a space that far from presenting homogeneity in its composition, shows an endless of gradations that overlap in a diffuse and soft way.

2.2. Multidimensional scaling.

Multidimensional scaling (MDS) is a method that represents measures of similarity (or dissimilarity) between pairs of objects, this in the form of distance between points represented in a multidimensionality low space (i.e. two or three dimensions). By using this type of techniques it is possible to study cases that by their nature are presented as data sets

[4] Where: f_{ij} = flow of masses that move between zones *i* and *j*; I_{ij} = Immigrants arriving from zone *i* to zone *j*; E_{ij} = Emigrants leaving the area *i* to the *j*.

[5] Specifically, Roca & Moix studied the following methodologies (1) labor markets, (2) metropolitan areas and micropolitan urban systems (according to North American SMA methodology), (3) hierarchical aggregation according to the aggregation values (in the Smart, Coombes and Sforzi modalities), (4) the INTRAMAX method, (5) hierarchical classification by paying attention to the totality and not only to the binary relation between pairs of municipalities between intermunicipal relations and (6) markov chains, (Roca, Moix 2005).

that would tend to present a spatial proximity to the extent that they show a higher correlation, (e.g. intelligence correlation test). Thus, the graphical representation of the correlations that the MDS models provide allows literally to "see" the data and consequently to visually explore its structure. This often leads to a modeling where it is possible to observe regularities that would be difficult to appreciate by an approximation based on hard numbers. On the other hand, some parts of the mathematical approach of MDS are often used as models that allow judging dissimilarities in pairs of objects[6]. In the field of study, MDS as a formal method is generally used for four purposes (Borg, Groenen 2003).

• As a method that represents similarities or dissimilarities in data in the form of distance in a space with few dimensions, this with the intention of making the data accessible to a visual inspection and exploration.

• As a technique to check whether and how certain criteria by which the significant difference between different objects of interest can be distinguished are reflected in corresponding empirical differences of these objects.

• As an analytical approximation of data that allows to reveal the spatial dimensions that underlie the formulations of similarities or dissimilarities.

• As a psychological model that explains dissimilarity judgments in terms of rules reflecting a particular type of functional distance.

The MDS tends to represent proximities in the form of distances between points of a configuration with dimensions within an MDS space. The distances can be measured longitudinally with some precision in an MDS model with a space of up to three dimensions. But distances can be computed with arbitrary precision, and this can be done in a space with an arbitrarily high dimensionality. The computation is made possible by coordinating the space of an MDS. The most common method of coordination is by defining an array of axes oriented perpendicular to each other and intersecting at one point. With origin 0. These axes which in the applied context are commonly referred to as dimensions are divided into equal length intervals which represent, in effect, a perpendicular set of lengths. In particular, the model used is the proxscal that belongs to the MDS family defined in its loss function in (2)[7].

$$\sigma^2 = \frac{1}{m}\sum_{k=1}^{m}\sum_{i<j}^{n} W_{ijk}\left[[\hat{}d_{ijk} - d_{ij}(X_k)\right]^2 \qquad (2)$$

2.3. The case of study.

The municipality of Barcelona (100 km^2 and 1.64 million people) heads the second spanish metropolitan area (3,200 km^2 and 4.9 million people). Its compact and diverse urban model according has recently been awarded worldwide (Marmolejo, González 2009). On this basis,

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[6] For example, given two objects of interest, where one could explain the dissimilarity perceived as a result of the use of mental arithmetic in trying to compute the distance between the two objects, in this model Will tend to generate the impression of similarities by adding the perceived differences of the two objects with respect to their properties (Borg, Groenen 2003).

[7] Where: σ^2 = Weighted mean square error; m= Number of sources; n = Number of objects; $\hat{}d_{ijk}$ = transformed proximities of ij from source k; $d_{ij}(X_k)$ = Euclidean distance between objects with coordinates in rows X_k, W_k = Matrix nxn with weights of source k; And it is calculated as: $V_{ijk} = \begin{cases} \sum_{i\neq 1}^{n} -W_{ijk}, for\ i \neq j \\ W_{ijk}, for\ i = j \end{cases}$ Where V_{ijk} = Matrix nxn with $\{W_{ijk}\}$.

we study the movements of people along the municipal level, this measured by means of the ups and downs in the municipal register at the territorial scale of neighborhoods, this during the years 2007 and 2008, representing exactly 95,769 movements in 73 neighborhoods. Also, on the territorial scale, it has been chosen the neighborhood scale because the way the Municipality government defined them including several criteria like historical memory, spatial and demographic size among others variables[8]. At the moment the research about residential submarkets in Barcelona is almost inexistent, with the exception of a noise study using a geographically weighted regression (GWR) where is concluded the existence of a differentiated market appreciation for the noise nuisance, being some areas more sensitive to noise pollution than others (Marmolejo, González 2010). In this sense, this research presents a paradigmatic alternative to the submarket research field for approaching to the case of study by modelling the reality materialized of the consummated fact between the offer and the demand being this a highly potent concept by its very nature.

3. RESULTS.

Starting from the interaction value model (IV), it is necessary to reduce its dimensions to generate a spatial representation, through PROXSCAL, a 2 dimensional model is proposed according to the literature (Spence, Ogilvie 1973). The ***¡Error! No se encuentra el origen de la referencia.*** presents the summary of the PROXSCAL model of two dimensions. Meanwhile, the ***¡Error! No se encuentra el origen de la referencia.*** shows that the Dispersion Accounted For (D.A.F.) is in the order of 0.84513, which is the square of the Tucker Coefficient of Congruence. The DAF is a measure that explains the variance, so we can say that this model explains 84.51% of the variability product of the MDS. On the other hand the Tucker Coefficient of Congruence[9] is calculated to measure the similarity between factors that have been derived from a factor analysis. It is generally assumed that a coefficient greater than 0.90 assumes a high degree of similarity, while above 0.95 indicates that the factors are virtually identical. Therefore, a suitable range to judge the similarity of neighborhoods is assumed between 0.85 to 0.94.

[8] According to the statistical department of the Barcelona City Council, the criteria or conditions for the delimitation of the 73 neighborhoods have been: i) Internal delimitation of the districts, without altering their limits; Ii) Historical and / or consolidated identity in the citizen's perception; Iii) An important degree of internal homogeneity and differentiation of others from the urban and social points of view; Iv) Non-fragmentation of very cohesive and homogeneous neighborhoods, except when their dimensions make it necessary; V) Population between 5,000 and 50,000 inhabitants (with some exceptions), in order to avoid very large differences between them, and at the same time ensure viability as spaces for coexistence and provision of services, urban endowments and equipment; (Vi) Similar territorial extension; Vii) Forecast of new growth already planned (Federació D'associacions de veïns i veïnes de Barcelona 2008).

[9] The coefficient of congruence of Tucker is calculated as follows: $r_c = \frac{\sum XY}{\sqrt{\sum X^2 \sum Y^2}}$ where *X* and *Y* are vector columns.

Tab 1. History of iterations of the proxscal model of two dimensions of Barcelona's neighborhood scale.

Iteration	Raw Stress	Normalization Improvement
0	0.75884*a*	-
1	0.18936	0.56948
2	0.17028	0.01908
3	0.16224	0.00803
4	0.15857	0.00367
5	0.15684	0.00173
6	0.15598	0.00086
7	0.15552	0.00046
8	0.15525	0.00027
9	0.15508	0.00017
10	0.15496	0.00012
11	0.15487	0.00009*b*

Source: (Own production based on intraurban migration data from the municipal pattern of 2008 and 2009)[10].

Tab 2. Adjustment and stress measures of the model of two dimensions of Barcelona's neighborhood scale.

Standardized raw stress	0.15487
Stress−I	0.39354*a*
Stress−II	0.96123*a*
S−Stress	0.34177*b*
Dispersion explained (D.A.F.)	0.84513
Tucker coefficient of congruence	0.91931

Source: (Own production based on intraurban migration data from the municipal pattern of 2008 and 2009).

4. DISCUSSION

The ***¡Error! No se encuentra el origen de la referencia.*** shows the clustering result of the partition around medoids (PAM)[11] model selected. The model represent the euclidean space

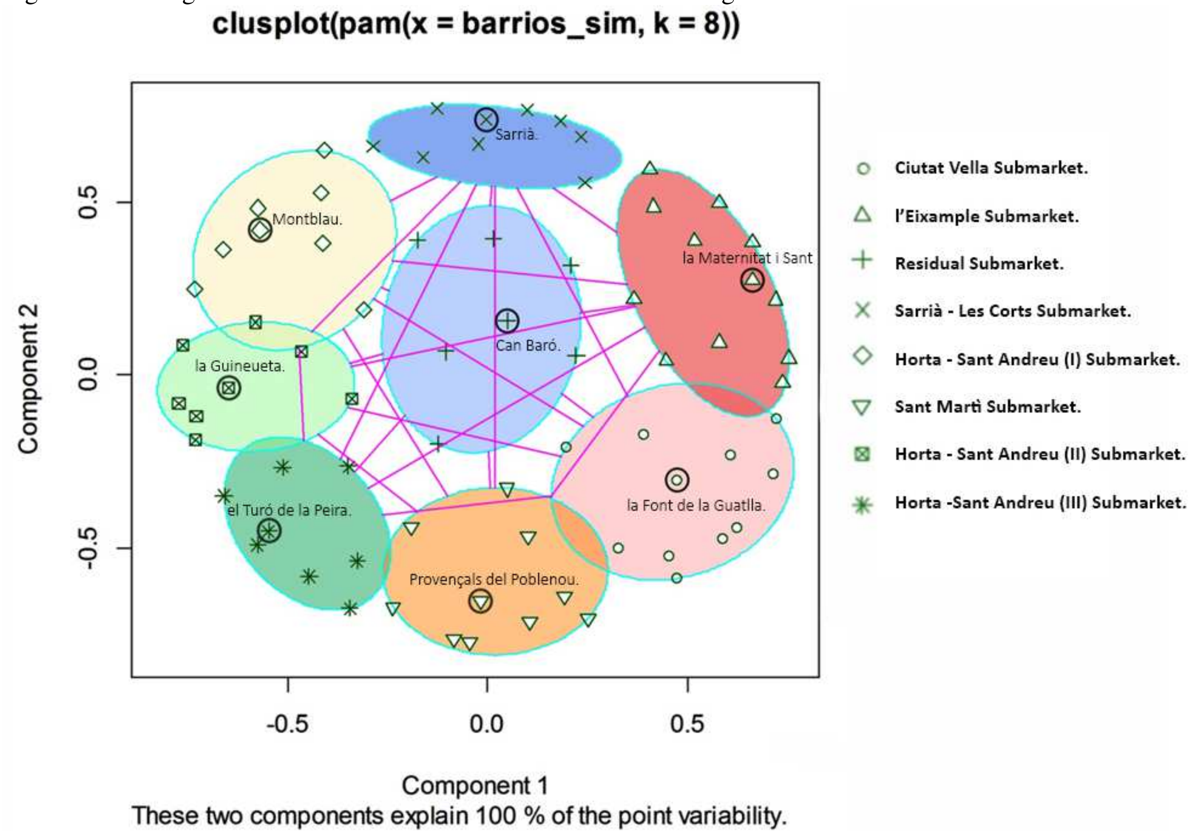
[10] Factors for optimal scaling ***a*** = 1.183, ***b*** = 0.877.

[11] Fifteen PAM models have been constructed, ranging from a segmentation of 5 up to 20 cluster models. Also the PAM allows to compute silhouettes which is a technique that allows to detect the similarities in relation to a scale (e.g. euclidean distances) when looking for a cluster of clusters compact and clearly defined (Kaufman, Rousseeuw 1990). The silhouettes are calculated as follows (Rousseeuw 1987):
To construct the silhouettes, only 2 things are needed, i) the partition model obtained (e.g. PAM), ii) the collection of all dissimilarities between objects. The model for calculating the silhouettes is as follows.
$s(i) = \frac{b(i)-a(i)}{\max\{a(i),b(i)\}}$ where:
$s(i)$, is the dissimilarity computed.

and the clustering arrangement while the ***¡Error! No se encuentra el origen de la referencia.*** shows the silhouettes statistics. It is interesting to point the roll that the cluster 3 (residual submarket) plays in the entire spatial arrangement, because in reality this submarket lack of significance compared to the rest of the submarkets, this is consistent with its silhouette compared with the rest of the submarkets which have a better silhouette performance. Prima facie the model showed in the ***¡Error! No se encuentra el origen de la referencia.*** displays an enormous linkage with the reality residential market in Barcelona, while the Ciutat Vella submarket is constructed by the majority of the neighborhoods associated to the beginning of the residential race, the l'Eixample submarket trends to identify those neighborhoods more valorized by the households that are on their way to the economic stabilization. The Sarrià-Les Corts submarket is related to the high stands neighborhoods, while the Sant Martì submarket trends to group the neighborhoods where the former Barcelona's industrial zone was located. In parallel the residential submarkets of Horta-Sant Andreu (I), (II), (III) is an interesting case, because in real life they not present a significant difference between them but it may seem that unmeasured differences that can be linked to a slightly cultural variability of each submarket. All of the above can be understood by looking the ***¡Error! No se encuentra el origen de la referencia.*** where is shown the percentage differences between the intra-urban movements and the population of each submarket, the graphic performance as is expected and therefore is highly significate in relation with the residential submarkets spatial model.

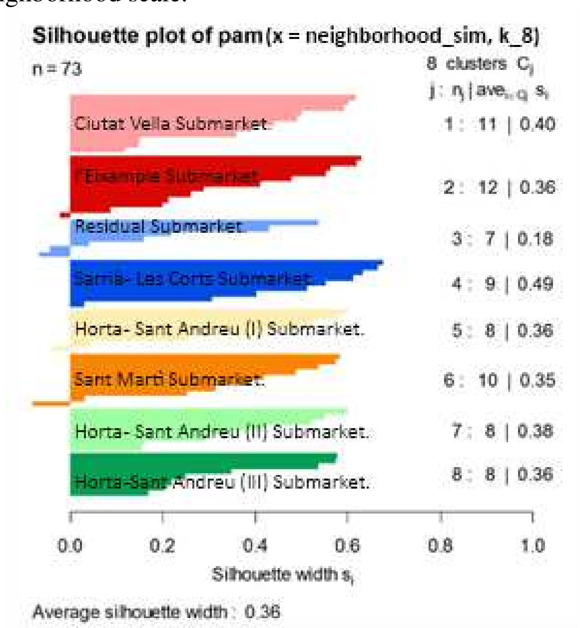
$a(i)$, is the average dissimilarity of an object i with respect to all objects of A.
$b(i)$, is the average dissimilarity of an object i with respect to all objects of B.

Figure 1. Pam segmentation model of 8 clusters of Barcelona at neighborhood scale.



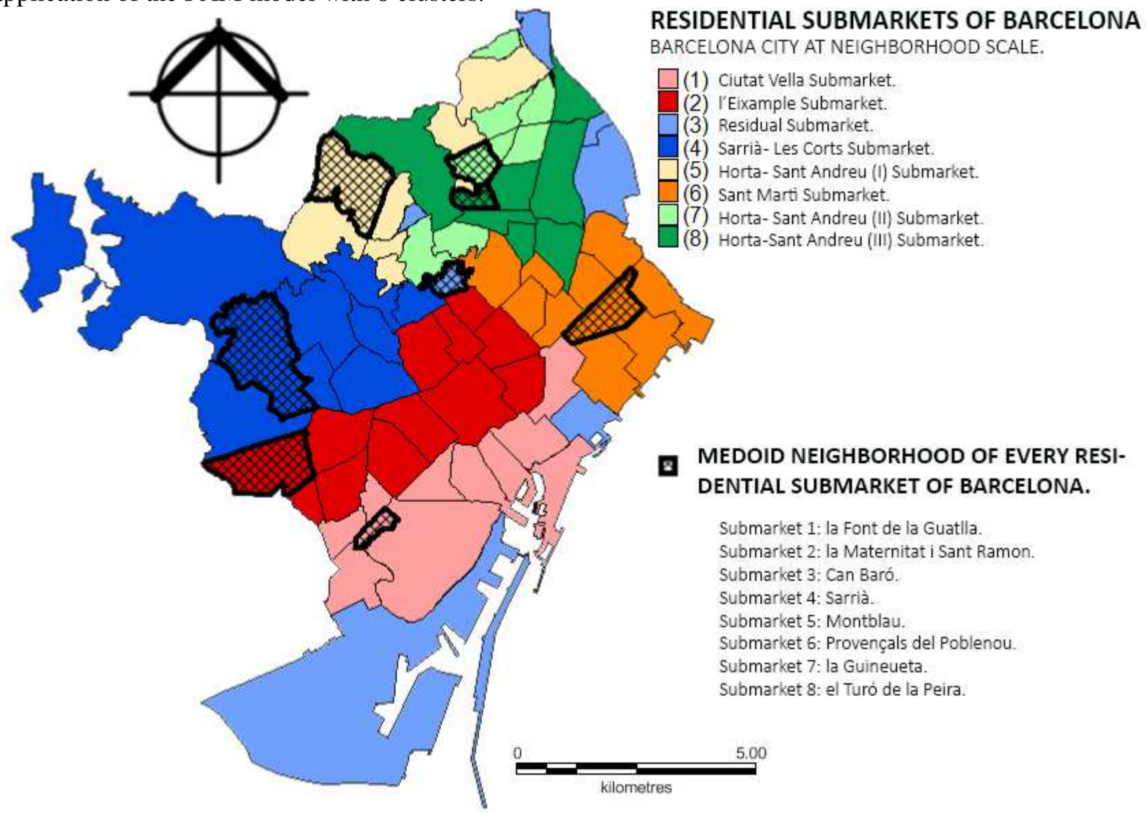
Source: (Own production based on intra-urban migration data from the municipal pattern of 2008 and 2009).

Figure 2. Representation of silhouettes resulting from each cluster conforming the spatial clustering model of 8 PAM of Barcelona at neighborhood scale.



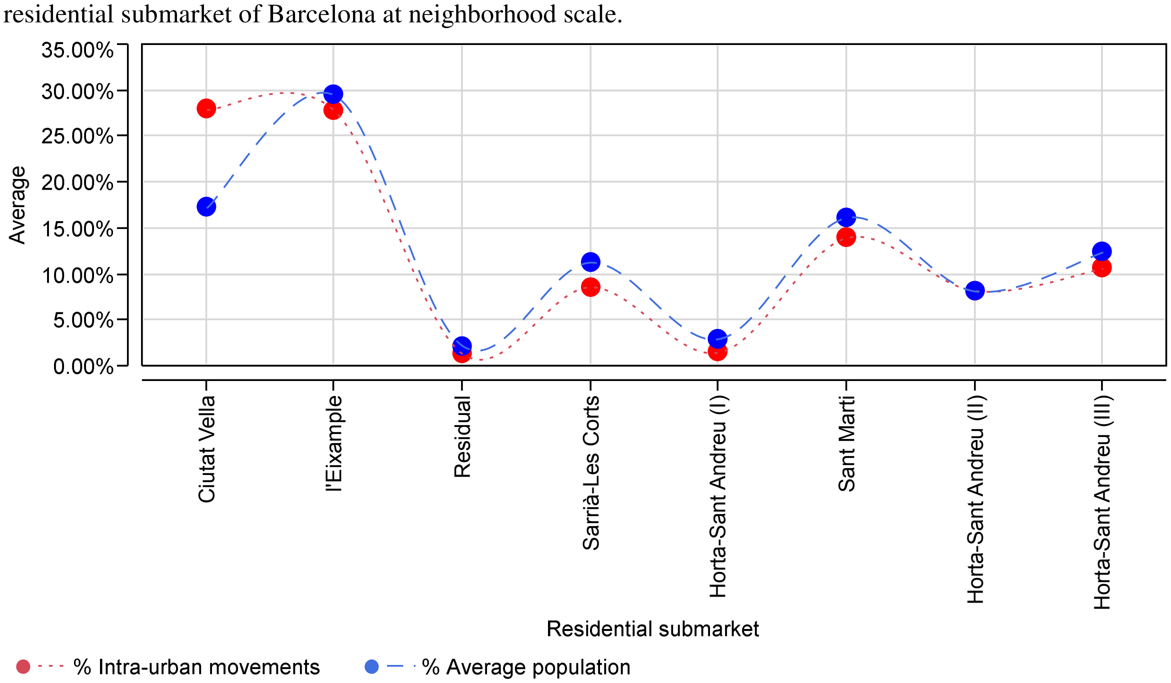
Source: (Own production based on intra-urban migration data from the municipal pattern of 2008 and 2009).

Figure 3. Resulting residential submarkets structure of Barcelona at neighborhood scale based on the application of the PAM model with 8 clusters.



Source: (Own production based on intra-urban migration data from the municipal pattern of 2008 and 2009).

Figure 4. Relationship of percentage of intra-urban migratory movements and average population of each residential submarket of Barcelona at neighborhood scale.



Source: (Own production based on intra-urban migration data from the municipal pattern of 2008 and 2009).

5. CONCLUSIONS.

Beyond the results shown in this paper, it can be said that the approach proposed clearly succeeded to identify 8 residential submarkets in Barcelona's city at neighborhood scale, this by the correct replication and visualization of the topological intra-urban migration structures subjacent along the studied urban space. The evidence presented suggest that the intra-urban migrations may induce a significant effect that may segment the housing market in Barcelona. Therefore, invoking the ceteris paribus concept, these migrations very well may obey to different needs of the households along their different stages during their life cycles and are materialized by the preferences revealed at the moment to choose a house that fits its integral needs. This is exactly the key concept behind the sub-market idea, a market attribute valued differently by a specific sector of the households that represent the demand in the residential real estate market general equilibrium model. Moreover, further research has to be done in order to understand the specifically conditions of each residential submarket, and the exact motivations of the households to remain there or to change, also is interesting to fully comprehend the effect of changing the spatial scale by scaling this research to the Barcelona at metropolitan region and specifically, what is the role of the distance on the formulation of the those residential sub-markets once the spatial conditions have change completely.

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