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Classifying Residential Real Estate Based on Their Exposure to Crime: a Research Agenda

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Abstract. Criminality and sense of security in residential areas are always present in the mind of citizens, and directly affect the work of police authorities, real estate agents and society at large. This study proposes the development of a multiple criteria model for the classification of residential areas based on their exposure to crime. By combining cognitive mapping with the Measuring Attractiveness by a Categorical Based Evaluation Technique (MACBETH), we also aim to increase transparency in the classification process of residential real estate, allowing improvement initiatives to be applied and crime rates to be reduced. The major difference between our proposal and the extant literature is the fact that the information collected from criminal, urbanism and real estate experts, who deal with crime adversities on a daily basis, will be analyzed and discussed during presential group meetings, allowing realism to be incorporated into the evaluation mechanism. The current proposal is a research agenda, and results will not yet be presented.

Keywords: Classification of Residential Areas; Crime Exposure; MCDA; Cognitive Mapping; MACBETH.

JEL Classification: C69, M20, R11.

Conference topic: Modern Business Management Problems and Perspectives.

Introduction

The choice of a residential area is based on the trust and belief that the chosen area ensures security for its residents. Crime can be a source of economic and social fragility, putting public welfare at risk. Considering that this phenomenon is present in each person's mind, it can be understood in different ways, depending on the perceptions and past experiences of each individual. As pointed out by Canas *et al.* (2015), this allows the classification of residential spaces to be considered a "complex decision problem", which needs to be analyzed in a structured way.

Classification models for residential real estate exist and are useful because they provide support to the decision processes of municipalities, police forces, real estate agents and citizens, allowing for a better understanding of social preferences and urban flows. It is worth noting, however, that the use of classification models is not without limitations, namely if one considers that subjectivity is omnipresent in the decision making framework (DeTombe 2002; Bana e Costa, Oliveira 2002; Ferreira 2016). In light of this reasoning, we propose a constructivist approach to the problem, based on the integrated use of cognitive mapping techniques with the Measuring Attractiveness by Categorical Based Evaluation Technique (MACBETH). Specifically, cognitive mapping allows evaluation criteria and their relationships to be revealed, while MACBETH facilitates the calculation of the respective trade-offs. Although both approaches have been previous applied and reported in the literature (see, for instance, Ferreira *et al.* 2011; Canas *et al.* 2015; Ferreira *et al.* 2015; Filipe *et al.* 2015; Oliveira *et al.* 2017), we have found no documented evidence reporting their combined use in the classification context of residential areas according to their exposure to crime.

The remainder of this paper is structured as follows. The next section presents the literature review. The ensuing section presents the methodological background, highlighting the advantages of the integrated use of cognitive mapping with MACBETH. The last section concludes the paper. It is worth underlying that the current proposal is a research agenda, and results will not yet be presented.

Related Work

It is well known that experiencing potentially dangerous situations is a source of emotional stress and increased feeling of insecurity. Several studies have shown that an increase in crime levels in residential areas is usually associated with an increased risk of experiencing psychological stress (*e.g.* Justus, Kassouf 2013; Janssen 2014). Crime is also related to health at a physical level (Kerr *et al.* 2015), with young people being the most vulnerable. It is also through the study of juvenile practices that it is possible to understand that it is the combination of individual, family and social factors (*e.g.* racial issues and unfavorable economic conditions) that dictate, in part, the levels of crime in a residential area (Hartinger-Saunders *et al.* 2012; Çaya 2014).

According to Okunola and Amole (2012), Hur and Nasar (2014), Ferreira (2016) and Foster *et al.* (2016), among others, a more technical form of crime control in residential areas results from the existence of urban planning, which should allow urban spaces to be effectively designed as safe environments. Although the selection of a particular residential area depends on the buyer's preferences, needs and way of living (Haybatollahi *et al.* 2015; Komeily, Srinivasan 2016), which introduces subjectivity in the decision-making framework, it is worth noting that classification models for residential real estate are useful because they can provide decision support to municipalities, police forces and economic agents alike, encouraging viable solutions to improve residential spaces, reduce crime levels and requalify residential areas (Steenberg *et al.* 2015; Ciampalini *et al.* 2016). Following this, Table 1 presents some of the

Table 1. Classification models of residential real estate: contributions and limitations (*Source*: composed by the authors)

Author	Method	Contribution	Limitations recognized by authors
Rizzo (1979)	Approach of the cost of crime to victims	Evaluates the relationship between crime and the value of the buildings, proving that these two variables are correlated. The higher the value of a property, the more money the owner will spend to protect it.	Lack of sufficient data.
Baker et al. (1997)	Acorn	Classification of residential spaces in 7 main areas: (1) modern areas, with potential for strong development; (2) old areas, where the population tends to be older; (3) rural areas with little technological and economic development; (4) deprived neighborhoods, associated with poor and unemployed people; (5) poor areas with large developmental delay, higher rate of unemployment and poverty; (6) areas of cohabitation; and (7) rich areas associated to high-class neighborhoods.	The results presented are general and present great variations and situations of exception.
Morenoff and Tienda (1997)	DNA Mapping of Urban Neighborhoods	Examines the changes in the typology of neighborhoods in Chicago between 1970 and 1990, classifying them in: (1) stable middle-class; (2) gentrifying yuppie; (3) transitional working class; and (4) ghetto.	Difficult to analyze the growing spatial polarisation of neighborhoods at both ends of the socio-economic spectrum.
Wei and Knox (2014)	Spatial Transformation of Metropolitan Cities	Construction of a longitudinal analysis of changes in the Census of all metropolitan areas of the United States of America between 1990 and 2010.	Loss of data specific to be a generalized analysis, covering a large area of time.
Delmelle (2015)	Census Track	Identifies consistencies and differences in socio-economic trajectories in different neighborhoods.	A study uses a small sample of cities; Do not evaluate macro level drivers, assuming a general understanding of the change of neighborhoods.
Haybatollahi et al. (2015)	Exploratory Study	This model features a group of clusters based on the preferences of residential spaces; being able to distinguish between various groups of people according to their perceptions of stability of the area where they live.	The information regarding the physical characteristics of the residential areas is limited.
Foote and Walter (2016)	Tracking Shifting Social Geographies	Creation of 5 types of residential spaces: (1) stable; (2) suburban; (3) mixed new starts; (4) immigrant starts; and (5) minority-concentrated.	Difficult to assign values to variables that change over time.
Nesticò and Bencardino (2016)	Neighborhood Maps through Geographic Information Systems (GIS)	Evaluates the values of real estate and the discrepancies between income within a given geographical area using vector analysis and GIS tool. The areas with greater socio-economic well-being are also the most expensive.	Conclusions change with the physical space being analyzed.

existing contributions in the context under analysis, where it can be seen that part of the studies presented combine quantitative and qualitative variables in a single approach, but none of them is without limitations. In fact, it is possible to identify some general limitations that can be grouped into two major categories, namely: (1) the way evaluation criteria are defined; and (2) how the weights of those same criteria are calculated.

Following this, a constructivist approach will be adopted, combining cognitive mapping techniques with the MACBETH approach. Cognitive mapping allows evaluation criteria and their relationships to be revealed (Eden, Ackermann 2004; Ferreira, Jalali 2015), while MACBETH is known for facilitating the calculation of trade-offs (Bana e Costa *et al.* 2012). The next section presents both approaches.

Methodological Background

As defended by Ferreira *et al.* (2011), "MCDA takes into account that decision-making processes are complex and composed of several actors with different perceptions and value systems, stressing that this approach highlights the limits of objectivity, and considers the possibility that some problems may not have an optimal solution" (also see Belton, Stewart 2002; Santos *et al.* 2002, 2008; Cinelli *et al.* 2014; Anchul *et al.* 2016; Corazza *et al.* 2016). In this sense, our study will be structured in three phases: (1) *structuring phase*, where cognitive mapping techniques will be applied to identify the evaluation criteria; (2) *evaluation phase*, in which the MACBETH technique will be used to calculate the trade-offs of the model and; (3) *recommendations phase*, where the main advantages and limitations of our proposal will be discussed. Figure 1 presents the sequence of steps to be followed.

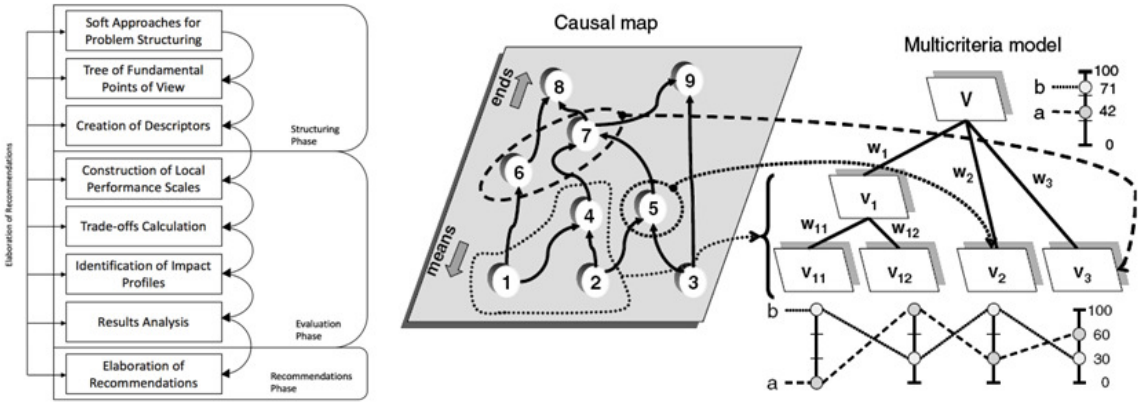

Fig. 1. Sequence of methodological procedures to be followed (*Source*: Ensslin *et al.* (2000, adap.) and Montibeller and Belton (2006, adap.))

In practice, the operational part of our study will start with the development of a collective cognitive map, which will provide us with the necessary information to construct a tree of Fundamental Points of View (FPVs) (Bana e Costa *et al.* 2012). This value tree will be operationalized, in a later stage of the structuring process, through the construction of descriptors (*i.e.* set of ordered performance levels) (see Filipe *et al.* 2015; Gonçalves *et al.* 2016). Next, the MACBETH approach will be applied, allowing the trade-offs between FPVs to be calculated, and local performance scales to be obtained for each descriptor.

Cognitive Mapping

In broad terms, cognitive maps are mental representations that can be used to: (1) promote discussion and provide group support; (2) reduce the number of omitted criteria in the decision making framework; and (3) guide strategic planning (*cf.* Eden, Ackermann, 2004; Canas *et al.* 2015; Ferreira *et al.* 2015; Komarov, Avdeeva 2015; Gonçalves *et al.* 2016). As pointed out by Gavrilova *et al.* (2013), "maps as visual tools facilitate the representation and communication, support the identification and the interpretation of information, facilitate consultation and codification, and stimulate mental associations". Figure 2 presents the functional logic of this type of maps.

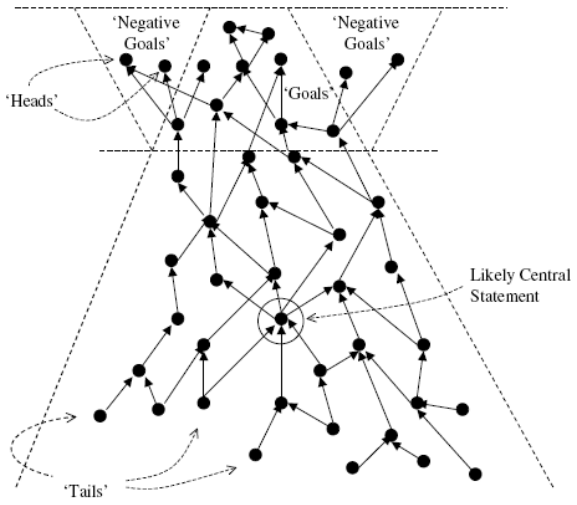

Fig. 2. Functional logic of cognitive mapping (*Source*: Eden 2004)

As can be seen in Figure 2, the dots stand for variables/concepts and the arrows represent the cause-and-effect relationships between them. This functional logic can be easily noticed in the example provided in Figure 3.

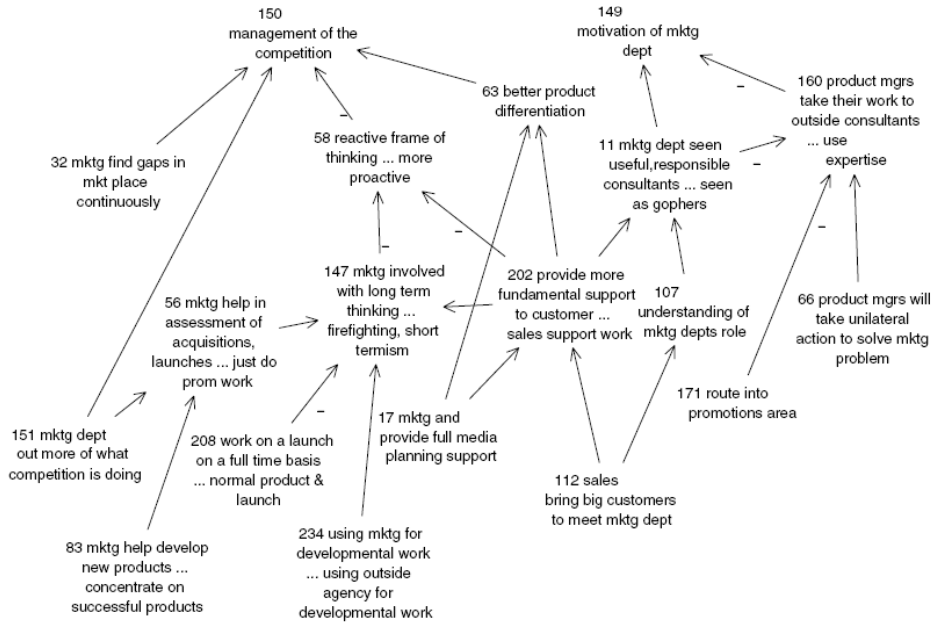

Fig. 3. Example of a cognitive map (*Source*: Eden 2004)

As discussed in the literature (*cf.* Eden, Ackermann 2004; Ferreira, Jalali 2015; Filipe *et al.* 2015), the construction of a cognitive map is not the final step of the structuring phase, but can provide important information for a transparent definition/selection of the evaluation criteria. Following this, cognitive mapping seems to hold great potential in the context of this study – *i.e.* classification of residential areas based on their exposure to crime –, namely because most of the evaluation dimensions are intangible.

The MACBETH Approach

The MACBETH approach was developed during the 1990s by Carlos Bana e Costa and Jean-Claude Vansnick (*cf.* Bana e Costa, Vansnick 1994). According to Canas *et al.* (2015), "this approach allows cardinal scales to be constructed and differences of attractiveness between choice alternatives to be measured based on the decision makers value judgments. It follows the MCDA constructivist conviction and holds great potential in the definition of trade-offs between evaluation criteria".

The mathematical foundations of MACBETH can be found in Bana e Costa *et al.* (2012). However, in practical terms, the technique aims to understand how much a choice alternative is preferred over another, and measure the difference of attractiveness between both. For that purpose, the method requires pairwise qualitative judgments on the part of the decision makers, using the semantic categories of difference of attractiveness presented in Table 2.

Table 2. Semantic categories of difference of attractiveness (*Source*: Bana e Costa *et al.* 1994, adap.)

Category	Difference of attractiveness
C_0	Difference of attractiveness **Null**
C_1	Difference of attractiveness **Very weak**
C_2	Difference of attractiveness **Weak**
C_3	Difference of attractiveness **Moderate**
C_4	Difference of attractiveness **Strong**
C_5	Difference of attractiveness **Very strong**
C_6	Difference of attractiveness **Extreme**

If the judgments provided by the decision makers respect the *ordinal* and *semantic* conditions required by the method (see Bana e Costa *et al.* 2012), then it is possible to apply linear programming and generate cardinal scales that are then presented to the decision makers for discussion and validation (see also, Filipe *et al.* 2015). This allows the trade-offs between criteria to be obtained.

As discussed in the literature (Bana e Costa *et al.* 2012; Filipe *et al.* 2015; Oliveira *et al.* 2017), the MACBETH technique presents several benefits. In particular, as pointed out by Ferreira *et al.* (2014), the method is simple, easy to understand, able to consider qualitative and quantitative evaluation criteria, and solidly supported on mathematics. Thus, considerable scope exists to explore its integrated applicability with cognitive mapping in the classification context of residential areas according to their exposure to crime. This is precisely what we aim to do...

Conclusions

The development and desirable implementation of residential real estate classification models are useful activities insofar as they allow local authorities, police, real estate agents and individuals to take more informed decisions and present viable solutions for real estate improvement, reducing crime levels and increasing property values.

In practice, the classification of residential real estate is a complex and time-consuming process, largely because it is influenced by the existence of different/intangible variables and by the fact that residential frontiers are sometimes difficult to define (Steenberg *et al.* 2015). The existing models are not exempt of methodological limitations, which can be grouped into two main categories, namely: (1) the way evaluation criteria are defined; and (2) how the weights of those same criteria are calculated. To address these issues, a constructivist approach will be adopted, through the combination of cognitive mapping techniques with the MACBETH approach.

The construction of a new classification system for residential spaces according to their exposure to crime will involve different decision makers (*e.g.* criminal, urbanism and real estate experts, who deal with crime adversities on a daily basis). We anticipate difficulties in getting them together for the group meetings. However, we believe that the combine use of cognitive mapping techniques with the MACBETH approach will be a step forward in the correct classification of residential real estate.

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