

How real estate agents behavior affects urban growth: an agent-based model approach

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Abstract—During the early 2000s Spanish territory has suffered major transformations due to fast urbanization. The main actors involved on this process are: urban planners, real estate agents and population. This paper presents an Agent-Based Model (ABM) which simulates the behavior of those three agents in order to better understand how the interaction of those different actors contributes to the process and produces changes in the territory in the form of urban growth. This study is applied to the Corredor del Henares, an area of 18 municipalities at Madrid Region in Spain. The paper presents the overall model with particular focus on the behavior of Real Estate Agents. Preliminary results suggest the model is capable to produce realistic scenarios and, thus, help to improve the understanding of the dynamics of urban growth in Corredor del Henares.

I. INTRODUCTION

The present paper studies the process of urbanization and urban growth in Spain. Urbanization in Spain can be described as a three-stage process involving three types of actors: urban planners, real estate agents, and population. The process starts by the choice for new urbanizable areas by urban planners following national, regional and local policies. On a second phase, real estate agents will chose where to promote new residential developments. Finally, the population will select their places to live based on their individual preferences and according to their income possibilities.

In order to better understand this urbanization process, we introduce a model that simulates this process using Agent-Based Modeling (ABM) techniques. ABM is particularly suitable for this case because it allows each of the actors' behavior to be simulated individually as well as how they, together, produce changes to the territory in the form of urban growth. ABM has been often used for urban growth simulation, mostly applied to local level (for examples, see [1] [2] [3] [4] [5] [6] [7] [8] [9]), although some few examples of application at sub-regional level can be found (see [10] [11] [12] [13]).

The present study simulates the urban growth process in the Spanish region called *Corredor del Henares*. This subre-

gional area, composed by 18 municipalities, had a phase of very rapid urban development during the housing bubble in the late 1990s and early 2000s, in particular along the transport lines (motorway and railway) which links Madrid to Guadalajara. In addition to the strong influence of the city of Madrid, the complexity of the dynamics of urban growth in the area is increased by the large number of municipalities regulating the development as well as conflict between urban development and conservation of protected environmental areas in specific locations within the region.

The next section will present the model for urban growth in the *Corredor del Henares* with particular focus on the simulation of Real Estate Agents. Hence, the next section presents the integrated model, followed by a more detailed section on the submodel of Real Estate Agents.

II. AN ABM MODEL FOR URBAN GROWTH IN THE "CORREDOR DEL HENARES"

The model developed in this research consists of three independent but integrated submodels, each simulating the behavior of one of the three actors of the urbanization process in Spain: urban planners, real estate agents, and population.

The first submodel simulates the *Urban Planner's* decision-making process, which consists of selecting new areas to be urbanized according to physical restrictions (i.e. protected areas, high slopes, proximity to hydrographic bodies), distance to elements of interest (i.e. roads or consolidated urban areas), and the amount of growth required to attend existing demand. These criteria are set as parameters and can be modified at initialization to generate different scenarios.

The second submodel focuses on *Real Estate Agents* decision making process on building new residential developments. As part of their behavior they must decide where to build new developments, how many developments must be built, their size, and their target economic group. The decision making process takes into account the legal status of the territory (defined by Urban Planners in submodel 1) as well as the areas which optimize their profits. This submodel will be further detailed in the next section.

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The third submodel simulates the process of residential location choice and occupation by the **Population**. In this case, they look for the best place to move according to their economic restrictions and location preferences, such as distance to public transport network, education facilities, and so on.

The flowchart in Fig. 1 shows how the submodels are integrated, where the result of each submodel feeds into the next, in a chain-like process.

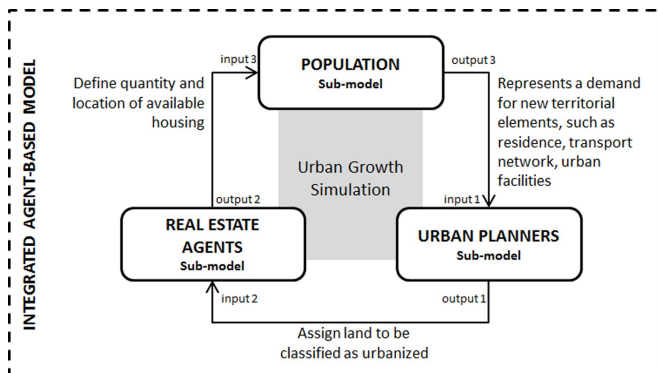


Fig. 1 Integrated decision model to simulate urban growth

III. HOUSING DEVELOPMENT SUBMODEL (REAL ESTATE AGENTS)

As mentioned, the submodel of Real Estate Agents behavior aims to simulate the development of new residential buildings. Their aim is to maximize profit and, as such, to create new residential developments that are attractive to potential buyers. This is achieved by selecting specific locations as well as building to the standards of the targeted economic group (high, medium and low). The current version of the submodel assumes all real estate agents have the same behavior but different behaviors will be incorporated in the next stage of the model development.

The set of criteria used by agents to select a location to build residences is presented in Table 1, below, and includes attributes such as zoning, housing standard, density, and distance to specific components. Residential developments can be targeted to high, medium or low income groups.

Fig. 2 shows the flowchart of the Real Estate Agent sub-model where both the available territory after eliminating re-

strictive areas (A) and the agent's preferences for specific geographical location (B) are considered.

The model, developed in *NetLogo* [14], allows the creation of scenarios through the weighting of different variables, such as the status of new buildings, distances to elements of interest or social similarity with neighbors, and also through the definition of the number of new residence to simulate.

IV. CONCLUSION

The Real Estate Agents submodel allows the user to see the distribution of new settlements as well as have an overview of the dynamics of urban growth in the region of *Corredor de Henares*. By changing setting of parameters, the model can also simulate different scenarios, such as simulating the effect of real estate agents that have interest in developing a particular area or target a particular income group.

The model is still under development, with the final sub-model (population) currently being finalized. As such, the model has not yet been validated. Once the development of all individual submodels is completed, sensitivity analysis tests will be carried out for each submodel as well as for the integrated model.

Different planning and economic scenarios (i.e. housing boom, recession) will be used to test the model's outcomes and validation will be performed with data from before and after the early 2000s 'housing boom'.

Preliminary results suggest the model is capable to produce realistic scenarios and, thus, help to improve the understanding of the dynamics of urban growth in the *Corredor del Henares* region. The model has potential to support future territorial decisions in the region and, thus, fulfill the main potential of ABM applied to urban studies at a sub-regional scale.

TABLE I.
 VARIABLES THAT LEAD THE DECISION PROCESS OF REAL ESTATE AGENTS

Computer	How variables are incorporated in the model
Zoning	Classification of urban and developable land, that must be recognized by Real Estate Agents in order to find legal areas to build new residence
Housing standard	Distribution of different type of residential buildings (high, medium and low standard) according to their square meter average price
Density	Definition of collapsed areas and the occupation capacity of the existent or new buildings
Urban Consolidated Areas	Considered an element of interest in some cases, since the demand for new residence is sometimes higher on areas closer to urban centers
Public Transport Network	The proximity to public transport network is also included in the preferences of a group of people in order to choose where to live
Road Infrastructure	New development should be close to road infrastructure in order to be more attractive to a group of population

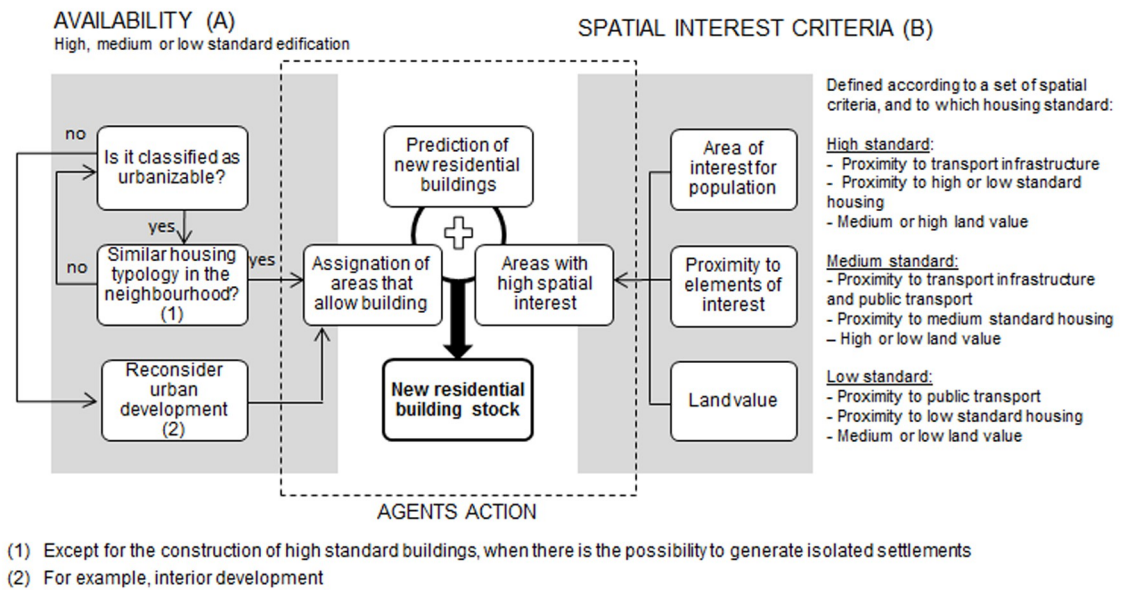


Fig. 2 Logic model of Real Estate Agents' decision process

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