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Agent-based simulation of real-estate transactions

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ABSTRACT

The prices of real-estate market influence the welfare of citizens and the business of real-estate investors. A well-known open challenge is to understand the repercussions of different combinations of individual buying/selling strategies on this market. The current approach is aimed at simulating these repercussions. For this purpose, a novel agent-based simulation tool includes common known strategies. This tool simulates the real-estate transactions from these strategies, showing the evolution of average prices and the results of each strategy (i.e. their success ratio, average price of their transactions and average waiting time). The underlying framework is extensible so that users can easily define and simulate new strategies. The experimentation of this work includes micro-validation of each kind of strategy. It also assesses this tool using a Spanish real-estate website (Idealista.com). The calibration of the tool was performed with the data of a small-medium city (Huesca), and the validation was performed for a different city (Teruel) to avoid overfitting. The results advocate that the current simulator might be an appropriate first step towards the simulation and analysis of the combination of certain buying and selling behaviors in the real-estate market.

1. Introduction

The real-estate market had been considered as an opaque market for a long time [1], and normally the real-estate transactions and specific information of the houses were not publicly available. However, nowadays the available data of real-estate market is increasing steeply in some massive websites. These are aimed at allowing ordinary citizens to contact each other for finding the best options for buying or selling houses.

In this context, Spain has a home-owner economy [2], and consequently real-estate websites have improved over the years. Examples of Spanish real-estate websites are "idealista.com" (referred as Idealista from this point forward) with over 1,400,000 announced properties, and normally over 9,000 new offers per day, and "fotocasa.es" with over 1,200,000 registered properties (considering the data observed in November 26, 2016).

Nevertheless, understanding the variety of individual behaviors of people in buying and selling houses and their emergent influences on the global market is still an open challenge [3]. Solving this problem could be useful for predicting changes in the real-estate market prices, or at least understanding the complex factors that affect this market. This could be useful for both citizens and investors, for respectively buying/selling houses and planning the construction of these. For example, in this line of research, a Decision Support System (DSS) was useful for finding the appropriate areas for building planning [4].

The current work presents an ABS called RealEstateSim that is aimed at simulating and analyzing different individual buying and selling strategies when combining together. This simulator includes a framework for defining and simulating new buying and selling strategies. This simulator has a twofold purpose. First, it can simulate future global changes in the market prices according to certain initial circumstances. Second, it allows simulating and comparing the particular performances of certain strategies when combined together, considering the success ratio of achieved transactions, the average prices of these, and the average waiting time.

2. Background

In the literature, several kinds of works relate to the current approach. These works departs from different research fields, and some of these are interdisciplinary. These works can be classified

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between (a) the ones that propose computer-based systems for the real-estate market, and (b) the theoretical research studies that analyze different facets of the real-estate market without proposing any computer-based solution. The computer-based systems of the first group are normally either DSSs [4–8] or simulators [9–14]. The existing DSSs assist (1) citizens in selecting houses considering certain properties [5,8], (2) victims of natural disasters in finding appropriate housing units after these disasters [6,7], and (3) construction companies in planning the building of houses [4]. The existing simulators are aimed at (i) explaining real-estate bubbles of different countries [9], (ii) estimating the business risks [10,11] and financial risks [11] of the real-estate market, (iii) simulating the negotiations between buyers and sellers [12] and (iv) detecting the driving forces behind the macroeconomic variables [14]. The purposes of the theoretical research studies vary, and some of these are (a) to analyze the behavioral differences in different cultures [15], (b) to detect the relevant factors in the decision-making processes of buyers [16,15], (c) to propose or analyze the repercussions of certain buying and selling strategies [17–19], and (d) to study real-state bubbles [18–21].

The existing works reveal the variety of house features that influence on the decision-making processes of buyers. Some of these features are about health and safety including the air pollution, the microclimate and climate changes [5]. Other features are related to the house unit such as whether it is a flat, whether it is a duplex, whether it is an attic, the number of bedrooms, the area, the floor, whether the house has a lift, whether it has a garage, the kind of heating, whether it is new/remodeled or not, whether it has a box room, the consumption systems that are complementary to the home, and the orientation [22]. Most of these features are available in the search tool of Idealista website. The locations of houses are another relevant aspect, and buyers usually consider the neighborhood, the social environment for children, the nearby services and the distances to workplaces [23,15]. Other works take other factors into consideration such as aspects of buyers' experience, their reasons for moving and husband-wife reasons for buying [15]. Experience factors include buying experience, mobility, community experience and the experience of parent purchases. Examples or reasons can be stop paying rent, family expansion and/or the desire for a larger home, and job change or transfer. Another work takes the educational, healthcare and socio-economics needs of families into account [7]. The family decisions are also influenced by their role structure, buying power, social status and life style [15]. Many works consider the prices of houses [5,24,25], and others even consider the buyers' perceptions of costs [26,15]. The potential access to loans also influences the buyers' decisions [14,13], as well as the reservation values and the search costs [27]. The buyers' decisions are also conditioned by the time pressure [28]. Furthermore, buyers consider other quality factors that determine consumer preferences such as the comfort and its elasticities [13]. This consideration was especially relevant in the simulation of sustainable housing.

There are many factors that can influence on the strategies of buyers such as the perceived difficulty [26,15], the ratio between buyers and sellers [17], the trends of prices [18], the frequency of real-estate transactions [19], the volatility [19], and the detection of bubbles [20,18,21]. The construction companies can consider different factors like models of migration, economic growth, prices, demographics, local markets, the common construction costs [4], the sale expectations and the near-zero energy building additional costs [13].

The works about real-estate take information from different sources. For instance, some works analyze the reasons and perceptions of buyers, and commonly surveyed buyers for performing their analyses [15]. Another work analyzes the behavior of construction companies, and consequently interviewed people from these companies [13]. Other works use public websites about real-estate. For example, some works use the Idealista website [29–32]. These works using Idealista pursue different objectives such as the analysis of spatial correlation in housing unit market prices [29], the study of the Spanish breakdown of bubbles [30,31], and the detection of discrimination in rental housing by contacting sellers with native and foreign sounding names [32]. Other works used real-estate information from Chinese databases [12,14]. Their goals were to simulate the negotiations of buyers and sellers considering the residential choices [12] and to study the different influences between private state-owned firms due to discriminatory financial constraints. Some works use real-estate information from USA and UK [20,18,21] and these were mainly related to the analysis of bubbles. Furthermore, there are works that use multiple sources of different countries. In particular, the work of Ge [9] uses the sources "Standard and Poors", "Nationwide", "Banco de España", "AusStats", "FNAIM" and "Permanent TSB", for respectively USA, UK, Spain, Australia, France and Ireland.

There are several ABS models about housing markets and landscape use [9,24–26,33]. Most of these works consider explicitly spatial information either by a grid division in a certain number of regions [9] or by considering geographic information [25]. In the reviewed works of this context, the only work that does not explicitly use spatial information plans to do it as revealed in its future research lines [26]. In general, these works use different agent types such as the real-estate agent, the developer, the bank, buyers and homeowners [9]. In this context, decision-making processes are based on different criteria such as the perceptions of the housing market possibilities [26], information search and price negotiations [25]. In this context, the ABS models were aimed at simulating different aspects such as the market of the housing units [9], the conversion of farmland to housing development over the time [24] and the land exchanges through rental transactions [33].

On the whole, a real-estate simulation can consider many market components such as economic objectives, spatial information, negotiations, specific house features, different real-estate agent roles, house construction development, conversion of farmlands, perception of agents, datasets from different countries, known buying/selling strategies, real-estate bubbles, different cultures of buyers/sellers, business risks and potential access to loans. Since including all these market components in only one ABS model would be quite complex, the current approach only focuses on a few of these. However, it plans to incorporate more of these components in the future.

3. RealEstateSim

The model of the proposed ABS has been defined using the updated version of ODD (Overview, Design concepts, and Details) protocol [34]. The presentation of this model includes the sections recommended by that protocol. In addition, Section 3.9 presents the user interface of the simulator tool.

3.1. Purpose

The RealEstateSim tool has a threefold goal. Firstly, it is aimed at providing a basis for defining and simulating different real-estate strategies, estimating the outcomes of each strategy in different combinations. In particular, it provides the success ratio of each strategy, the average price of its transactions, and its average waiting time, considering all the agent instances of the particular strategy. Secondly, the tool allows practitioners to provide possible explanations (i.e. combinations of certain selling/buying individual behaviors) that have similar outcomes to certain known real-estate history. Thirdly, the tool is also aimed at estimating the probable