ipea Instituto de Pesquisa Econômica Aplicada

INTRODUCTION

The real estate market is intrinsically convoluted, just as in botany – it is tangled, with leaves rolling together in cylinders. This analogy seems to make sense. The real estate market involves different elements with asynchronous adjustments: economic cycles, changes in interest rates and levels of financial liquidity; intertemporal decisions made by families; investor choices; urban regulation and zoning; construction; and location of jobs, amenities, neighborhoods, perceptions, and preferences. In addition, real estate consists of durable goods, with high transaction costs, which are relatively expensive, usually indivisible, with a unique (monopolistic) and heterogeneous location.

There is vast literature that analyzes real estate markets. The seminal text and reference of urban economics consolidates the model of rational economic choice (Dipasquale and Wheaton, 1992). Abstractly and diagrammatically, the authors propose a spatial balance model that combines financial asset market and real estate market, mediated by the civil construction market's ability to adjust inventory.

Empirical work, however, suggests that current interest rates in the financial market are not fully reflected in real estate prices, which would suggest inefficient markets (Case and Shiller, 1989). Otherwise, it can be said that there is excessive variance of prices in relation to fundamentals (Glaeser et al., 2014). In this sense, there is some consensus that the available models do not capture the volatile and heterogeneous aspects that are intrinsic to this market (Davis and Nieuwerburgh, 2015; Glaeser and Nathanson, 2015).

This understanding was reinforced after the housing credit crisis of the 2000s. The unexpected volatility prompted a series of literature reviews in order to identify what is known and what is not known about the general behavior of real estate markets. Regarding the influence of the credit market and real estate financing, Chan, Haughwout and Tracy (2015) note that the user cost structure points to the direction of demand in times of growth. However, the size and location of the change are not reflected in current models. The analysis suggests that spatial equilibrium models based on rational choices would be limited in scope (Glaeser and Nathanson, 2017).

This difficulty of traditional urban economic models dealing with multiple, simultaneous impacting factors supported the expansion of the epistemological field and the search for contributions from other disciplines and analytical methods.

Among these search initiatives for integration and methodological alternatives to understand the real estate market, we must highlight three aspects: one based on traditional economics, which intends to expand the understanding of finance and encompass liquidity and credit with a more empirical bias (Davis and Nieuwerburgh, 2015; Leamer, 2015; Saiz, 2019); a second one focused on the spatial and urban issue, on the dynamic transformation of uses, by addressing land use, integration with transport, its potential to generate new uses and change the occupational pattern and urban planning (Waddell et al., 2018a; 2018b); and a third one that analyzes macroeconomics from a computational point of view with an essential change in methodology (Dawid et al., 2012; Dawid and Gatti, 2018).

In addition to these integration efforts, other authors have proposed initial computational models that replicate the fundamentals and empirical data observed in the real estate market (Baptista et al., 2016; Geanakoplos et al., 2012). These papers emphasized financial volatility, the relevance of asset markets, and the possibilities of macroeconomic prudential action for the financial manager in charge of public accounts.

Within the scope of spatial dynamic analysis, computational modeling, called Land Use Change and Transport Model (LUT), has a more consolidated tradition and history of applications (Engelen, White and Uljee, 1997; Filatova, Parker and Veen, 2009; Parker et al., 2003). Traditionally, it models the evolution of the conversion of agricultural to urban uses, industrialization and de-industrialization, as well as changes in the composition of green areas in general. More recently, these models have incorporated real estate dynamics associated with transport structure planning (Waddell, 2011; Waddell, Wang and Liu, 2008).

In this context, *PolicySpace2* is a primarily endogenous, empirical, dynamic, spatial computational model, which includes real estate financing, civil construction, tax collection and distribution; labor, goods and services, and real estate markets for Brazilian metropolitan regions. The platform makes it possible to understand real estate market mechanisms, so that changes in a certain behavior can generate effects on the model's indicators. Additionally, *PolicySpace2* allows tests of investment of endogenous resources in alternative public policies for housing: transfer of properties, payment of rent or money aid for families.

In short, from the empirical description of the status quo in 2010, individuals, families and properties are probabilistically generated and spatially allocated. Subsequently, each month, families and firms interact in the goods, labor and real estate markets, mediated by: loans, bank deposits, and investment remuneration; location; and mobility of workers between these firms and families and their places of residence. In this way, they generate transactions in the markets, whose taxes are collected and reinvested in the municipalities, characterizing the remarkably

endogenous and dynamic aspect of the process and providing a scenario for public policy experiments, with relative comparability of results.

PolicySpace2 brings together three types of modeling – economic, land use and transport – in a joint and integrated fashion. We do not know of any other computational platform for the real estate market:

- that is open (open source);

- that contains official data, organized at the intra-urban level of weighting areas of the Brazilian Institute of Geography and Statistics (IBGE) or equivalent;

- that adopts spatial rules associated with all markets (goods and services, labor and real estate markets);

- that includes a system of tax approximation at the municipal level;

- whose decision-making agents are primarily firms and families; and

- whose policy tests are based on the endogenous development of demand and supply of resources and families.

Thereby, *PolicySpace2* positions itself as a model that is capable of correlating real estate price formation mechanisms based on several of its own influences:

- composition and location of families;

- productivity and location of firms in the goods and services market;

- migration, formation of new families and demographics;

- credit system and financial liquidity;

- labor market and recruitment processes that consider distance and qualification; and

- the dynamics of the entry of families in the real estate market and construction firms.

Additionally, *PolicySpace2* is described according to the most recent and transparent practices in the Agent-Based Modeling (ABM) literature, following the protocol Overview, Design Concepts and Details (ODD) (Grimm et al., 2020) and the TRACE suggestion (Grimm et al., 2014).

The performance of the *PolicySpace2* model is evaluated successively and cumulatively as described in the following.

1) The processes and rules are inspired and justified according to the preexisting literature, which is explained throughout the model description.

2) Extensive and exhaustive sensitivity analysis is performed to test the inclusion or absence of rules and mechanisms (structural sensitivity) and how robust the results are after changing the parameters. Simulations are run numerous times and the results are expressed as the average of the results of each simulation.

3) Internally, graphs depicting 66 indicators are produced and guarantee the observation of the simultaneous behavior of various processes, states and mechanisms.

4) The code itself is not error-free. However, several tests, checks, simulations and verifications have been repeated throughout the process in order to guarantee the accuracy of the presented results.

5) Macroeconomic behavior indicators, such as gross domestic product (GDP), inflation, unemployment and the Gini coefficient, remain at levels similar to those observed empirically.

6) Specifically in relation to the real estate market, we carried out a comparison of data from real properties, collected in 2020, with simulated data. Considering that no real estate market information is included and that only official data from firms and families are entered at the beginning of the simulation in 2010, the model behaves reasonably well and manages to replicate the first half of the real estate price distribution for the tested case in the Brazilian Federal District.

7) The public policy implementation test carried out presents results whose logic can provide some understanding and explanation based on the comprehension of how the model works.

The mechanisms and configuration of *PolicySpace2* suggest that, in the real estate market, the negotiation process, supply and real estate financing are less relevant to price dynamics, when compared to the relevance of household demand and their availability of resources. In addition, the location of firms and families, in conjunction with the increase of family income in the neighborhood, does not seem to be a sufficient element to exactly replicate the spatial design and distribution of real estate prices. Other factors not present in the model – such as the stock of properties and their characteristics observed at the beginning of the simulation or the regulation of land use – would need to be included so that the results could be more spatially reliable in relation to those observed.

The *PolicySpace2* model simulation, in particular, seems to confirm the absence of a perfect spatial equilibrium in the real estate market. Indeed, the rental market, given the design of the model, works as a receptacle for families that do not have a permanent and sufficient income. The concept also establishes that the initial

negotiation price, with low possibility of discounts, is the reference price in which the rent is a proportion of the sale price. As the design of the model also requires that all families have a residential property, families enter into the contract, but spend more than 30% of their income on rent, in a higher proportion than expected. Eventually, it is still possible that the family cannot pay the rent to the landlord.

The analysis of changes and interventions subject to public policies to be tested based on the model suggests that, in fact, the real estate market has the ability to boost the economy as a whole and does so when there are greater savings available to families, when there is greater participation of families in the market, when there is an influx of families or the creation of new families, when the productivity of workers increases and taxes on wages or consumption are reduced, or when the efficiency of municipal management increases.

Another factor that emerges from the analysis is the marked influence of productivity as a model mechanism capable of changing the levels of the economy as a whole. As such, the research joins several others that identify productivity as the core of the process of improving economic well-being.

The policy tests carried out reflect the investment of part of the municipal collection alternatively in: i) buying and transferring properties to registered families, in order to favor those with less resources; ii) paying the rent of these families for a period of two years; or iii) simply make transfers in the form of money aid to all families registered in the municipal system.

Considering the GDP of metropolitan regions and the Gini coefficient, the best policy is undoubtedly the (more equitable) distribution of resources among all families, vis-à-vis the payment of rent or purchase and the transfer of real estate.

Lastly, *PolicySpace2* reinforces the results obtained in the previous version (Furtado, 2018a). The model confirms the benefit in terms of quality of life for citizens by equitably, and not locally, redistributing tax funds raised among metropolitan municipalities.

In addition to this brief general introduction, chapter 1 provides a review of recent literature on the real estate market and defines ABM. ABM is the methodology on which the *PolicySpace2* is built, a computational modeling platform. Chapter 2 provides an intuitive description of *PolicySpace2* that will allow the reader to understand the features and limitations of the platform. Chapter 3 is methodological, details the purpose of the model, according to the suggestions of the ODD protocol (Grimm et al., 2020), and contains steps 2 to 7, also provided for in the protocol. Together, these steps provide an overview, detailing the processes and explaining all the rules, operations and functioning of the model. However, since the ODD process is built from the general to the specific, the reader interested in the formulas

and details of the model will find the information in section 7. Chapter 4 presents both some stylized facts replicated by the model and the data used to validate the model, its comparison with the simulated data, and other general results. Chapter 5 expands the sensitivity analysis to broaden the understanding of the possibilities of *PolicySpace2* and its applications. Finally, chapter 6 tests housing and social assistance policies and analyzes the performance of the metropolitan region in a comparative way. The final remarks conclude the book.