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| Autores(as) | Bernardo Alves Furtado |
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FINAL REMARKS

This book presents, elaborates on and shows the rationale behind the model called *PolicySpace2*. In addition, it validates this model and reviews some public policies and their results. The model relies on decision-making processes of workers and their families and firms in an empirical and spatial context based on data from 2010 for the 46 ACPs (Áreas de Concentração de População – Areas of Concentrated Population) in Brazilian metropolitan regions. The grounds for the mechanisms and the interaction of agents in the goods, labor and real estate markets follow suggestions from the literature, and we list motives and practices when they are innovative. The methodology used in the construction of *PolicySpace2* is called Agent-Based Modeling (ABM) and its description follows the precepts of the Overview, Design Concepts and Details (ODD) protocol, as well as Transparent and Comprehensive Model Evaluation (TRACE) methodology.

The purpose of this book is to build an empirical model of the real estate market for the Brazilian use case in order to describe and understand market mechanisms, in addition to driving analogies that may possibly suggest alternative policies.

In the simulation process, it is possible to understand the order of magnitude and relevance of changing parameters, rules, agent characteristics and implementation or absence of any public policy or exogenous change. The results are conditioned on the processes that are described and choices that are made.

Model validation is performed according to its purposes. In the case of *PolicySpace2*, it is possible to demonstrate that the model is robust with regard to the alteration of parameters and mechanisms, so that exogenous variations generally keep the model within adequate behaviors. Specifically, we classify this reasonable behavior based on a set of four parameters:

- GDP does not show exponential behavior or tends to zero, for example (it keeps endogenous variations and moderate growth);
- inflation has a stable monthly value (up to 2% of monthly variation) and does not generate hyperinflation, or zero inflation (except when workers' productivity has very low parameters);

- inequality among families evolves to a number close to those observed (around 0.470); and
- unemployment does not exceed 20% of workers, for several configurations of parameters.

Specifically in the case of the real estate market, *PolicySpace2* only partially reflects the price distribution, with close similarity in the first half of the distribution. The simulated spatial distribution is similar to the one we observed; however, the location is more dependent on and oriented to the location of the firms, and, in the present case, we see more valuable properties in the absence of job offers and the presence of other factors.

The preliminary results of the simulation made by *PolicySpace2* allow us to draw some conclusions. The relevance of the real estate market and its consequences throughout the economy is evident. The simple increase of families' participation in the market, the influx of families or the change in the size scale of the metropolitan area leads to effects in the real estate market that reverberate in better quality of life, savings, profits and, sometimes, less inequality.

In an endogenous way, given the configuration of *PolicySpace2*, productivity increases seem to be the most influential factor in the general behavior of the economy and its results. In the real estate market, in particular, the ability of municipalities to transform funds that are collected into life quality improvements is also relevant to make the economy more dynamic.

On a parallel basis, it is also possible to note that better salary distributions, with less retention of resources by the firms, in the format outlined in *PolicySpace2*, simultaneously suggest economic gains and lower inequality. However, it should be noted that the reinvestment of firms' capital is not incorporated as feedback in the presented interaction system.

Other elements already identified in the previous version of the model were reinforced by this analysis, which to a large extent, is more detailed than the previous one. One of them is the identification that the parameter that defines hiring only by proximity or only by qualification seems to be inadequate as an empirical explanation. In both the current and previous models, the restriction of only one criterion in the labor market leads to economic results far below those observed with intermediate parameters. This seems to suggest that, in fact, there is an "optimal" combination of criteria between spatial location and training and qualification that benefits firms and candidates.

Another result reinforced in the *PolicySpace2* is the endogenous redistribution of resources collected by the municipalities with criteria preferably for equality,

within the scope of the metropolitan region, to the detriment of the binomial local collection and local distribution.

Also, in accordance with the configuration adopted in the *PolicySpace2*, the most relevant taxes for changes in the economy were those referring to consumption and work. Lower taxes in this sense simultaneously contribute to an increase in savings in the hands of families, who participate more strongly in the real estate market and thus boost the economy.

Finally, another indication of the sensitivity analysis is that the speed with which construction firms incorporate real estate sales values seems to be relevant when this period for receiving values is small. The built-in mechanisms imply that the firm spends its own capital to maintain workers' wages when there is no receipt of sales figures. As a result, there is a greater redistribution of capital from construction firms, which generates large savings for families, encouraging their participation in the goods and real estate markets.

In the analysis of policy alternatives, the simulation of *PolicySpace2* suggests that the housing policy for the provision of 24-month rent vouchers for families brings greater social benefits to the economy as a whole, in terms of boosting the economy and reducing inequality, when compared to the policy of purchasing and distributing real estate to families. By way of illustration, the non-housing policy of offering monetary assistance to a much larger number of families (with a lower value per family, given that the resources used are the same for the alternative policies) seems to be even more beneficial than the rental policy.

In terms of future work, it is our intention to investigate whether there is a combination of policies that produces more satisfactory results than any one alone. An analysis will also be carried out using resources external to the metropolitan region – simulating the effects of federal investments or other financing entities.

Regarding the platform, several other additional analyses are possible. In particular, the plan is to link household investment in education, household ownership of firms, perhaps through quotas and shares, and credit market sophistication, also including access to firms.

Among the limitations of the model, by way of conclusion, it seems to us that two relevant elements of the real estate market cycle were not included. On the one hand, it would be interesting to include remuneration or reinvestment of resources, or even ownership of the capital of firms. On the other hand, a better characterization of the real estate market space also seems to be absent and relevant, with the possible inclusion of urban amenities, which generate value, and the possibilities and limitations given by the regulation of urban land.

In addition to the results of the analysis of the real estate market and the identification of relevant elements for the dynamism of the economy, *PolicySpace2* can also be characterized as an analysis platform that encompasses numerous possibilities. Given its open code characteristics, its transparency in the documentation and its standard explanation of the mechanisms according to best practices and modularity, it is not expensive to adapt the model to new research questions and investigations of specific regions.

We saw that *PolicySpace2* was especially promising for analysis of inequality and the real estate market, labor qualification, sector analysis and innovation at the firm level. Additionally, analyses of urban mobility and greenhouse gas emissions can benefit from the fact that each month, the model contains the location of workers and firms, in addition to their income and family composition and qualifications.

In the near future, we imagine that it will be relatively simple to incorporate elements from the 2010 real estate market, such as replacing size and quality as intrinsic characteristics of the property with real attributes, such as number of bedrooms, bathrooms and vacancies, still relating quality to the Municipal Index of Human Development (IDHM). With this, the initial configuration of the property stock will be more similar to the real one, making it possible to obtain simulated results that are not exclusively endogenous.

It also seems easy to introduce specific analyses of greenhouse gas emissions that consider the existing differentiation in the model between public and private transport.

Finally, once the platform is built, as it stands at the moment, it is possible to make comparisons between all the metropolitan regions present and to evaluate, in a comparative and relative way, different results for each of them, given the same parameters and mechanisms.