Human choice behavior makes city dynamics robust and, thus, predictable

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The city is an inherently human-driven self-organizing structure. Most of the modern models of urban development ignore this basic characteristic, and substitute humans with the derivatives of their activity: namely, by infrastructure elements. In infrastructure-based, e.g. Cellular Automata models, humans are considered, usually implicitly, as the fast component of the system, which adapts to slower infrastructure changes.

Despite of noteworthy achievements, the infrastructure-based view of urban systems is conceptually limited. A 'proper' urban model is *necessarily* a multi-agent one, where decisions to develop, destroy, renovate or change the land use on the one hand, or occupy, resettle or leave the place on the other, are made by interacting agents of different (but not many) types: developers, householders, firms, local councils, municipalities. When agents are employed explicitly, the achievements of cognitive, behavioral and social science can be directly incorporated into the urban model. Furthermore, multi-agent models can be used to establish the limits of the applicability of the infrastructure-based models.

Human agents are *autonomous* in a sense that their state and location are, at least partially, the result of their own decisions, the latter based on individual history and expectations. This autonomy is especially important when an agent faces several alternatives and must choose one of them, as in a case of residential decision of a householder, location decision of a service provider or construction decision of the developer. The city dynamics are determined by human choice behavior and the algorithms of agent choice provide, thus, a bridge between social science and urban modeling.

To elaborate the human-based approach, we consider several multi-agent models of the urban dynamics that employ agents of one or two types. Agents of the first type represent *users* of the infrastructure – householders or firms, all evolving and relocating in the city depending on their own properties, local conditions, and the state of the city as a whole. Agents of the second type are developers. Their own location in the city is unimportant, but they make decisions regarding the location and the characteristics of new infrastructure elements.

We study the dynamics of a simulated urban system, under different assumptions of agents' choice behavior. These assumptions base on the contemporary results of the behavioral science, the latter strongly in favor of some mixture of optimizing and satisfycing behavior of the human individuals.

The intuitive expectation from the behavioral autonomy of model agents is an increase in intricacy of the model outcomes. Our research demonstrates that realistic and experimentally justified assumptions regarding human choice entail the opposite - the model outcomes are *robust* to variations in the agents' behavior. We demonstrate that qualitative changes in the simulated urban infrastructure and/or population distribution follow only *global* changes in the model parameters, say, changes of priorities of *many* agents, significant changes in spatial constraints imposed on developers, etc.

This principal result explains the 'over'-success of recent high-resolution simulations of urban dynamics. Indeed, if the city dynamics is robust to minor changes in the system characteristics, then to simulate them

- We have to know the *main factors and relationships only* and can ignore marginal information

If so, researchers can simply 'guess right' the main factors and, consequently, construct the adequate model representation of the system. Only future research can demonstrate at what extent the main factors and dependencies are 'shareable' between different cities and aspects of cities' dynamics.

As an empirical confirmation of the proposed paradigm, we present a very good fit between the spatially explicit model and the actual dynamics of the residential distribution in a part of the Tel-Aviv residential area over the last fifty years. The model works at the resolution of separate buildings and employs residential agents, who follow human-like choice heuristics when making location decisions.