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Modeling Gentrification as a dynamic spatio-temporal process

Gentrification, Urban Dynamics, Inequalities, Network Dynamics, Temporal Networks

Extended Abstract

Gentrification, "the rapid increase in cost and standard of living in a disadvantaged neighbourhood" [1], causes the relocation of lower-income inhabitants in favor of wealthier citizens. Relocation is caused by socio-economic inequalities and may be influenced by the presence of amenities and infrastructures.

In this work, we focus on relocation *trajectories* and develop an agent-based gentrification model. We model society as a mixture of agents belonging to three (*Low-*, *Middle-*, *High-*) income profiles, with different needs and possibilities to improve their living conditions. We represent the urban system as a hierarchical, modular network whose nodes are housing units, communities are coarse-grained neighborhoods, and agents (individuals) relocate between two housing units. Agents of different types base their choice of whether to move on the current cost of living at different spatial network scales (micro, meso, macro). For example, high-income agents have access to *temporal* information regarding the fluctuations of cost-of-living across the nodes and communities in the underlying network, i.e., its rate of change. A visual representation of agents' behaviours can be found in Figure 1.

A *Low-Income* agent ℓ moves from its current node when its income at time t is lower than the average income on the node (micro-scale), $w_\ell(t) < \overline{w}_{n_1}(t) \equiv \langle w_i(t) \rangle_{i \in n_1}$. Agent ℓ relocates to a new node n_i if $w_\ell(t) > \overline{w}n_i(t) - \epsilon$, where $\overline{w}_{n_i}(t)$ is the average income in n_1 and $\epsilon \equiv \overline{w}_{n_1}(t) - \overline{w}_{n_i}(t)$ is the *cost-of-living gap* between two nodes. Agent a relocates when the cost of living increases and moves to a new, affordable node in the network.

A *Middle-Income* agent m moves from its current node if (1) the agent is poorer than the average wealth in its current community (neighborhood, meso-scale) C_1 by more than a fraction α of its own income; or (2) the agent is richer than the average wealth in its current community by more than α times its own income. Agent m relocates when either the cost of living in its current community is not affordable (1) or if aims for a better standard of living (2). In the former case, m moves to a random node in a new affordable community C_i, whose affordability depends on the cost-of-living gap w.r.t. the starting community. In the latter case, m relocates to (a random node in) a new community where the cost of living is not higher than the agent's income by more than the tolerance.

A *High-Income* agent h moves from its current node to maximize the profit of an investment in a new, up-and-coming neighborhood. At any time step, h evaluates the (discrete) rate of change of the average wealth of each community C_i in the network, $\delta\bar{w}_{C_i}(t)$ and moves to the community that maximizes this rate, if higher than its own by an investment-risk tolerance α. The overall model outcome is a collection of relocation trajectories of the three types of agents over time, which can naturally be translated into the framework of temporal networks.

Our model does not have a specific termination condition [2]. In fact, we model gentrification as a continuous process over time to understand what are the emerging and reoccurring spatio-temporal patterns. Ultimately, we introduce a temporal network-based gentrification indicator $\mathcal{G}i$ of a neighborhood (community) defined as the difference between the out-flow of *Low-Income* agents from the neighborhood, and the *coordinated* in-flow of *Middle-Income* agents. We conduct extensive experiments to characterize the gentrification phenomenon by integrating our $\mathcal{G}i$ with other socioeconomic segregation indices, showing that gentrification patterns arise in neighborhoods that have previously undergone periods of gradual segregation.

References

[1] N. Smith, "Of yuppies and housing: gentrification, social restructuring, and the urban dream," *Environment and Planning D: Society and Space*, vol. 5, no. 2, pp. 151–172, 1987.

[2] E. Moro, "The minority game: an introductory guide," *Advances in Condensed Matter and Statistical Physics*, pp. 263–286, 2004.

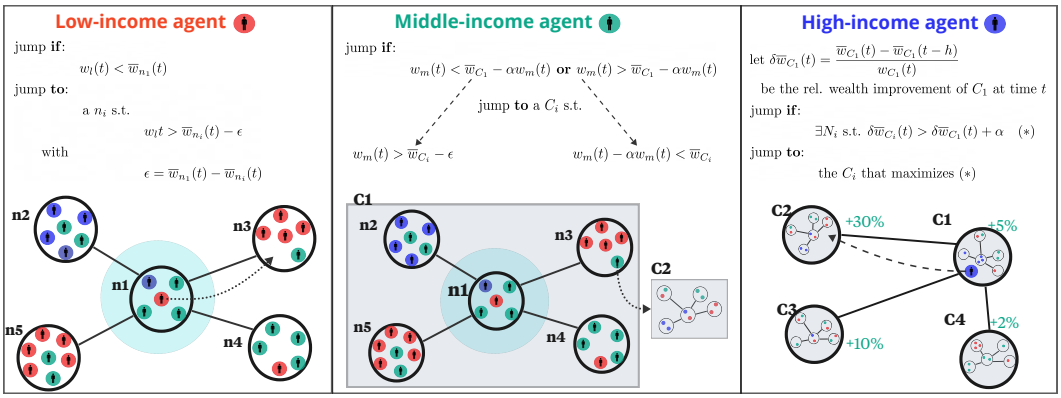

Figure 1: **Income-profile-specific agent behaviour**. (Left) A *Low-Income* agent relocates if poorer than the local (node-wise, micro-scale) mean income over its current node and moves to a new node where it is richer than the local mean by ϵ. (Center) A *Middle-Income* agent relocates if it is way poorer (or way richer) than the average of its community (meso-scale) and moves into a new community where it will be richer (poorer) than the community-wise mean by ϵ (by at most a fraction α of its income). (Right) A *High-Income* evaluates the rate of growth of all communities. It moves to the one with the best rate of growth, if way higher than that of the current community.