When Neighbours move: Segregation Dynamics with Adaptive Tolerance

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1 Theoretical Background

Residential segregation remains one of the most persistent and widely studied phenomena in urban sociology. From classical urban theory to contemporary debates on inequality and social cohesion, segregation is understood as both a structural outcome and a driver of social stratification. A central insight of research in this area is that even relatively weak individual preferences can give rise to strong aggregate patterns of separation.

Agent-based models, most prominently those based on the assumptions of Schelling (1978, 2006), have played a crucial role in demonstrating how local interactions generate macro-level segregation. These models show that even mild preferences for similar neighbours can lead to highly segregated spatial configurations. At the same time, however, they rely on a key simplifying assumption: preferences are typically treated as static.

This assumption stands in contrast to empirical observations. Social preferences, including tolerance toward other groups, are not fixed but may evolve through interaction. In particular, intergroup contact has been shown to influence attitudes and reduce prejudice under certain conditions (Allport, 1991). From this perspective, segregation is not only an outcome of preferences but also a context in which these preferences are formed and transformed.

Against this background, the present contribution situates agent-based simulation within a broader understanding of sociology as an experimental and exploratory science of possible futures. Rather than merely reproducing known dynamics, simulations can be used to systematically investigate how alternative assumptions about social behaviour, such as adaptive tolerance, shape the evolution of social systems.

2 Research Question

The study addresses the following research questions: How does adaptive tolerance, driven by intergroup contact, affect segregation dynamics?

More generally, the study explores how micro-level learning processes interact with spatial and structural constraints to produce different macro-level outcomes.

3 Model Description

To investigate these questions, I developed an agent-based model on a two-dimensional grid representing an abstract urban space. Agents are distributed across this space and interact locally within their neighbourhoods.

3.1 Agents and Attributes

Each agent is characterized by three key attributes:

- Ethnicity (group membership)
- Income class, which constrains access to certain locations
- Tolerance level, representing the desired proportion of similar neighbours

Tolerance is operationalized as a threshold: agents evaluate their local neighbourhood based on the fraction of similar agents and compare it to their individual tolerance level.

3.2 Spatial Structure

The environment is structured through spatial heterogeneity in housing conditions. In particular, the model introduces concentric “rent zones” that impose constraints on where agents can relocate depending on their income. This creates a structured space with a centre and a periphery, allowing for the analysis of spatial differentiation.

3.3 Decision Rule and Movement

At each time step, agents evaluate their current eight neighbours. If the proportion of similar neighbours falls below their tolerance threshold, they are considered “unhappy” and attempt to relocate. Movement is constrained by:

- availability of empty locations
- compatibility between rent level and income class

Relocation is implemented as a stochastic search process.

3.4 Adaptive Tolerance

The key innovation of this model lies in the introduction of adaptive tolerance. Rather than remaining fixed, tolerance evolves based on local interaction:

- When agents are exposed to a higher proportion of dissimilar neighbours, their tolerance can increases.

- In more homogeneous environments, tolerance may decrease.

This dynamic introduces a feedback loop between spatial structure and preference formation. The base for the individual tolerance will be empirical data from the General Social Survey in Germany.

3.5 Cascade Dynamics

In addition to individual decision-making, the model incorporates cascade effects. If a sufficiently large proportion of neighbours relocates, this may trigger further dissatisfaction and movement among remaining agents. These cascades capture the idea that local instability can propagate through the system.

4 Experiments

To explore the behavior of the model, we conduct a series of simulation experiments in which key parameters are systematically varied.

4.1 Parameters

The main varied parameters include:

- Population density (fraction of occupied cells)
- Cascade threshold (sensitivity to neighbor movement)
- Initial tolerance distribution

4.2 Experimental Design

For each parameter configuration, multiple simulation runs are conducted to account for stochastic variation. Simulation outputs are recorded and exported, allowing for systematic comparison across runs.
The focus is not on prediction, but on exploring the range of possible system behaviors under different assumptions.

5 First results

A consistent finding is the emergence of spatial heterogeneity. Central areas, characterized by higher interaction density, tend to stabilize over time. In these regions, agents experience more frequent intergroup contact, leading to increased tolerance levels and reduced mobility.

In contrast, peripheral areas exhibit greater instability. Lower interaction density limits opportunities for tolerance adaptation, and agents are more likely to remain dissatisfied. This results in higher mobility and a greater susceptibility to cascade effects.

6 Outlook

In the next step I will extend the model along several key dimensions. A central step is the integration of random friendship networks, adding non-spatial social ties to local neighborhood interactions. This allows me to examine how exposure beyond immediate spatial contexts shapes adaptive tolerance. I expect such networks to foster integration by increasing diverse contacts, while potentially amplifying cascade dynamics through network-based diffusion.
Comparisons with alternative modeling approaches will help isolate the specific effects of adaptive tolerance and network structures.
Overall, these developments are expected to provide deeper insights into the conditions under which integration, segregation, or persistent instability emerge, and to strengthen the model's role as an exploratory tool for analyzing possible social futures.

References

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