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B E H A V E

# Agent-based modelling

**Research design - Prof. Filip Agneessens**

**A.A. 2022/23**

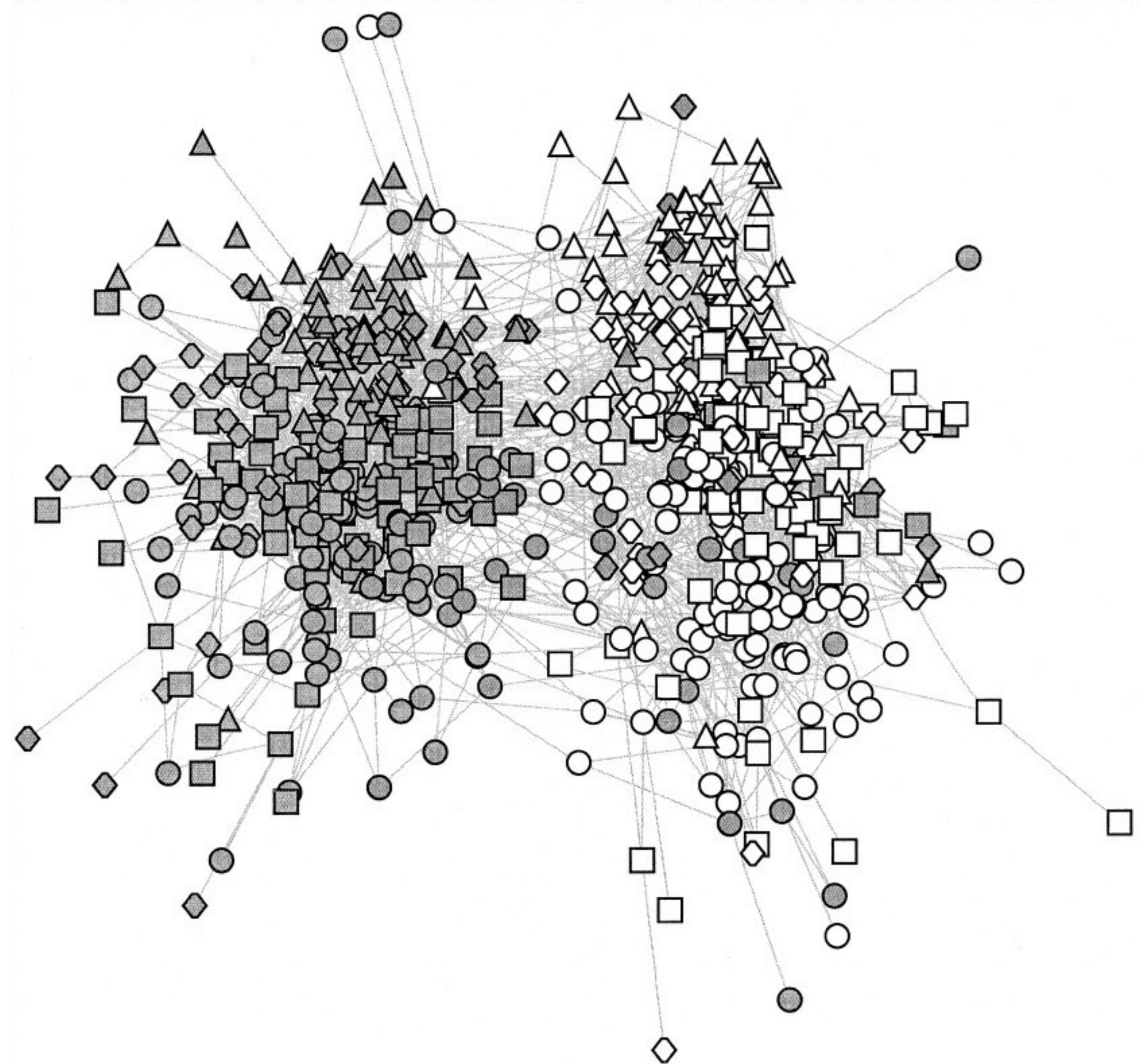
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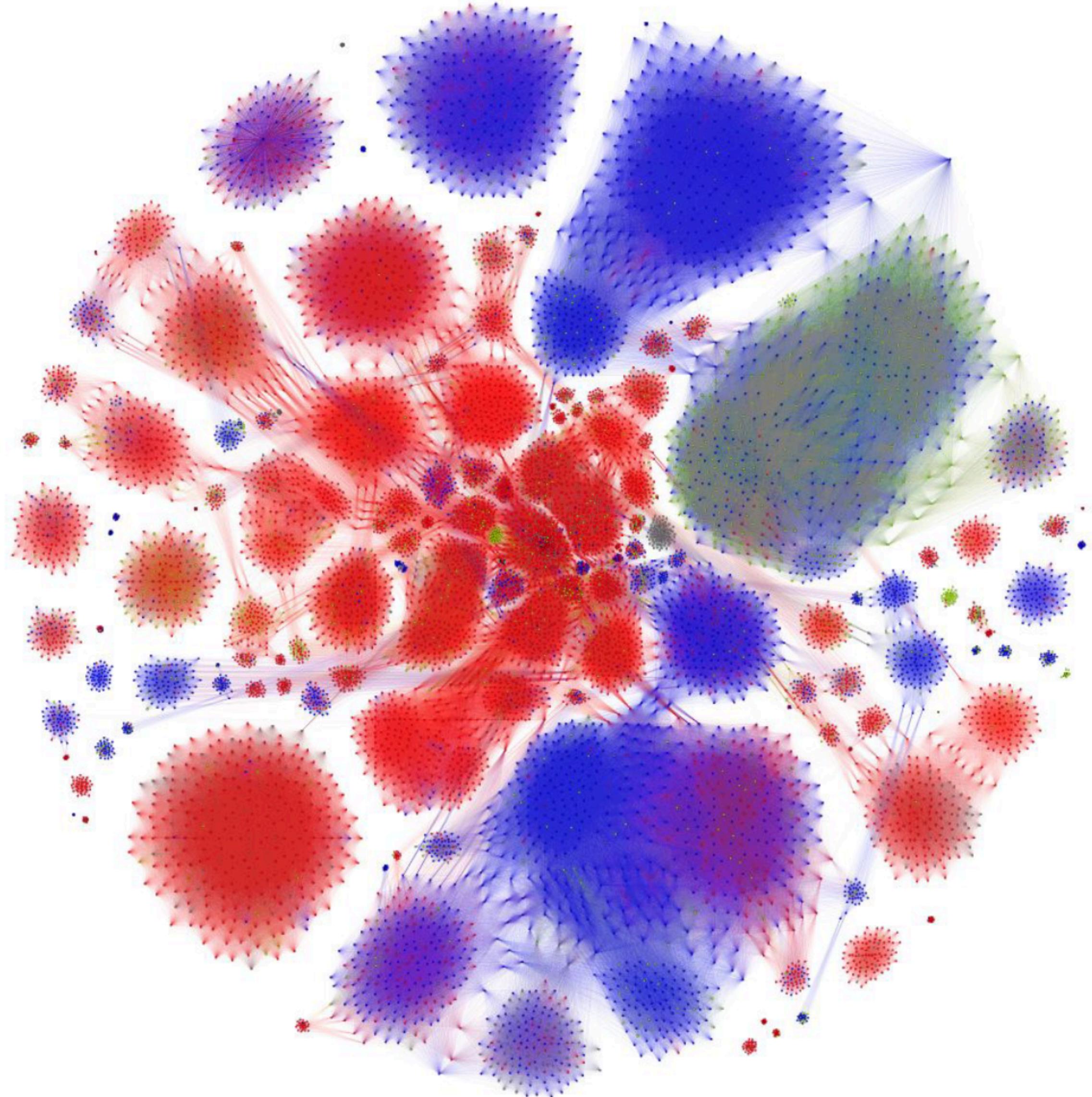
# **What explains segregation?**



Friendship ties in a US secondary school

(shaded figures: non-white students)

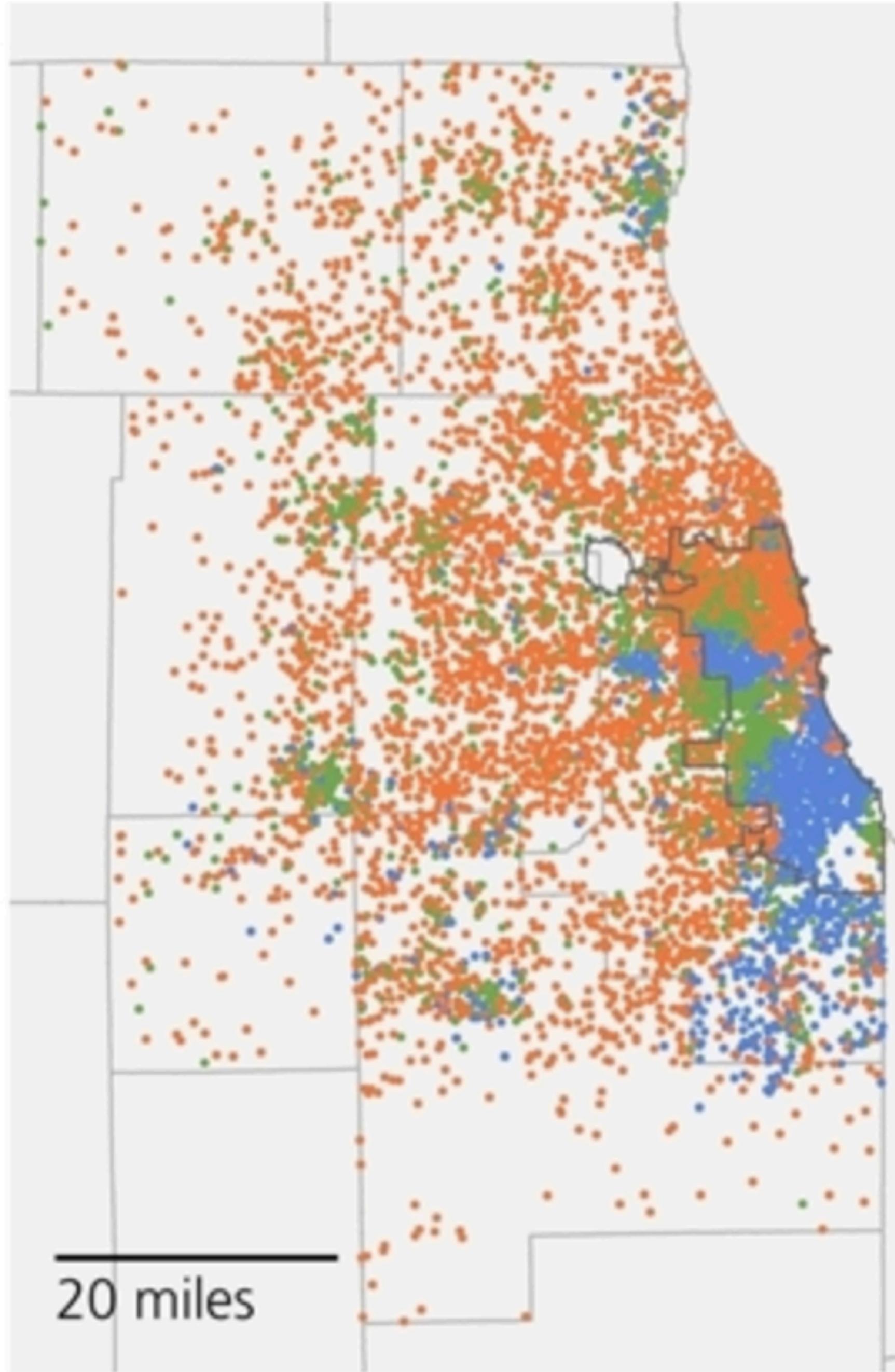
(Quillian & Campbell, 2003)



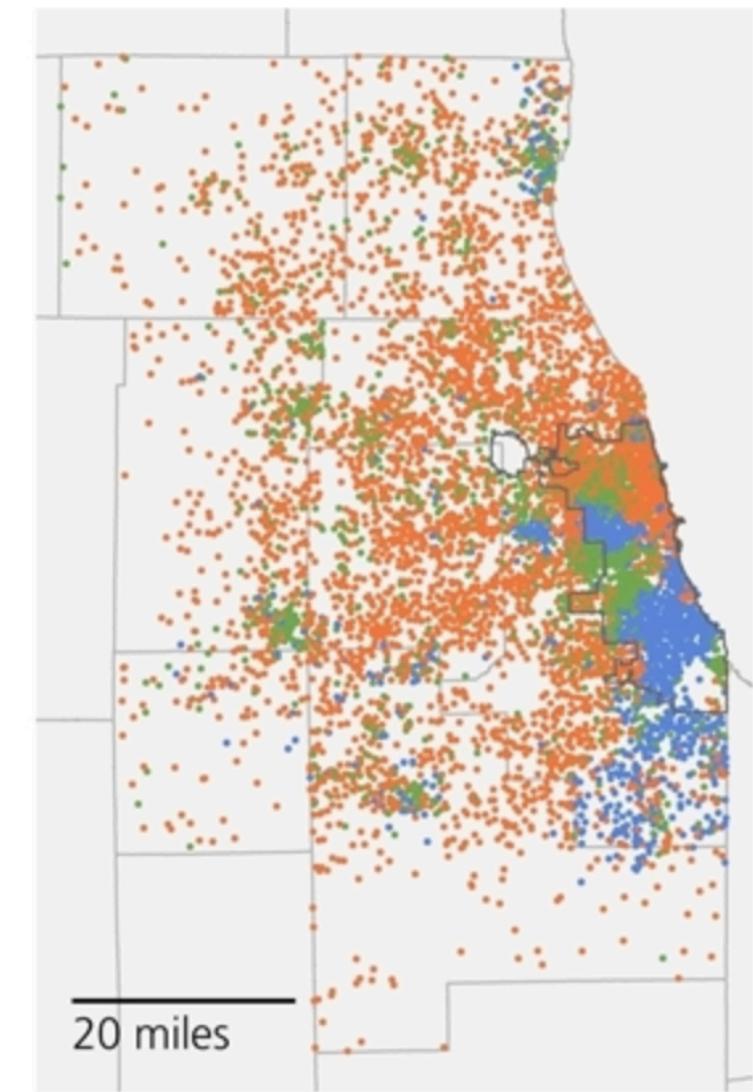
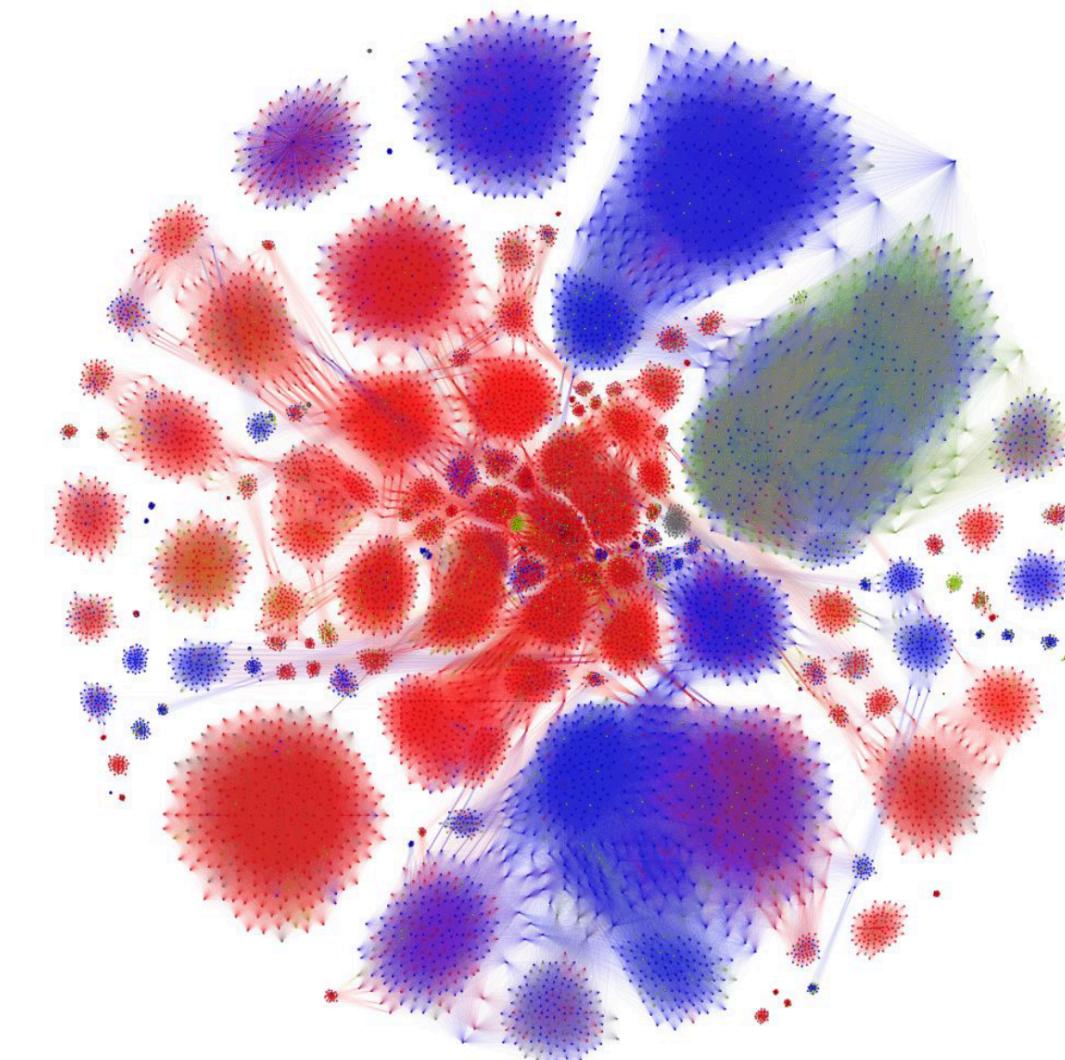
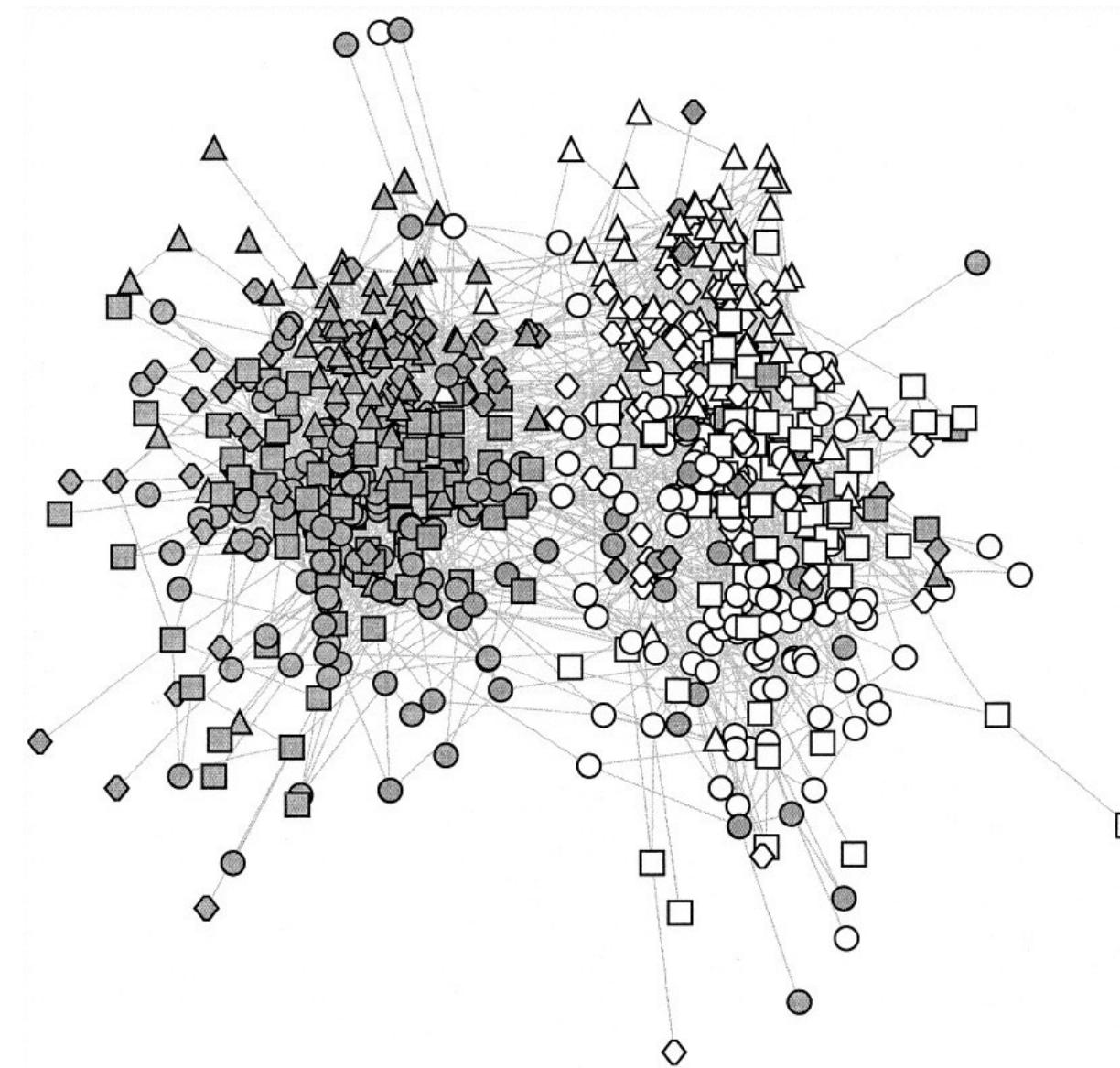
Cohabitation among  
shantytown dwellers in.  
Paris, 2013-2015

(red: Moldavia; blue:  
Transilvania; green:  
Bulgaria)

(Vitale, Bianchi & Cousin,  
2021)



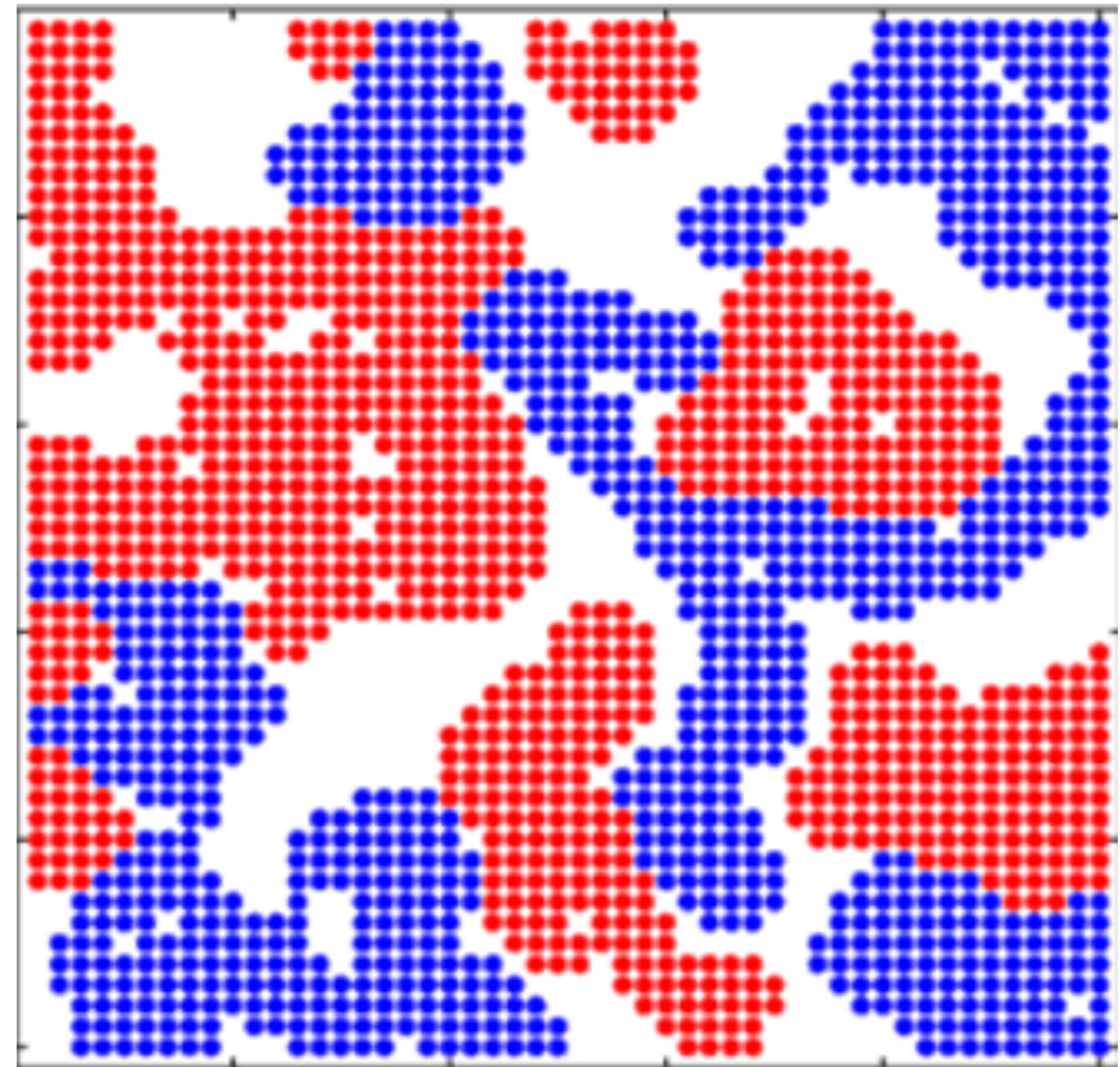
Chicago by ethnicity  
(orange: white; blue: African American; green: Latinx)  
(Metropolitan Planning Council)



Segregation: (*macro*) property of social system in which actors are separated from each other along certain (*micro*) individual properties

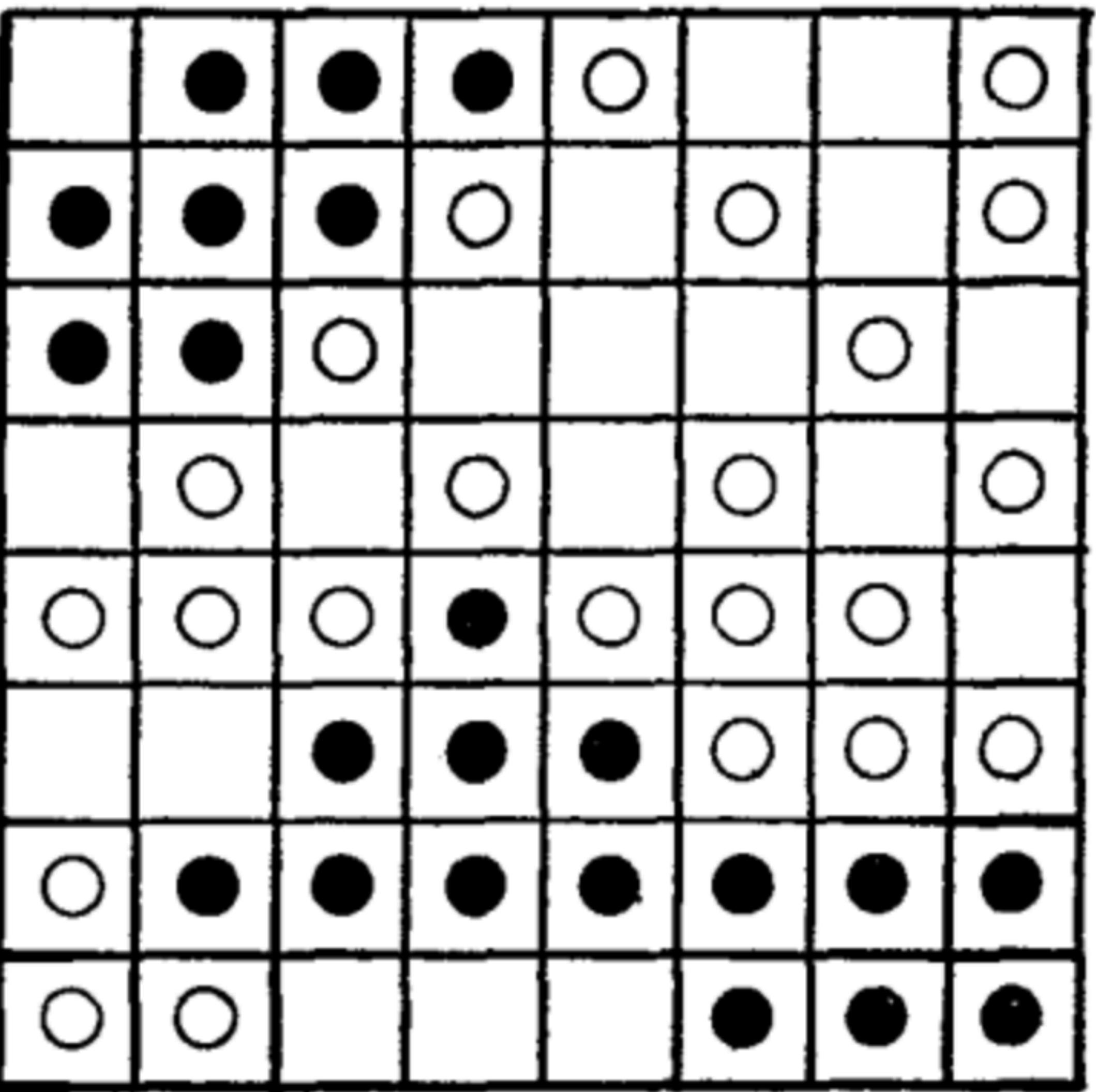
# Does segregation necessarily imply xenophobia?

- What causes segregation?
- What if segregation didn't need segregative preferences to emerge?



# Schelling-Sakoda segregation model

- Thomas C. Schelling (1971) - James M. Sakoda (1971)
- Formal model of:
  - Individuals (*agents*)
    - located on a grid (*environment*)
    - belonging to 2 groups (50-50) (*social structure*)
    - holding threshold-based tolerance towards the % of other-group individuals in their neighborhood (8 cells) (*preferences*)
  - Randomly relocating elsewhere if % of other-group individuals in their neighborhood > their tolerance (*behaviour*)



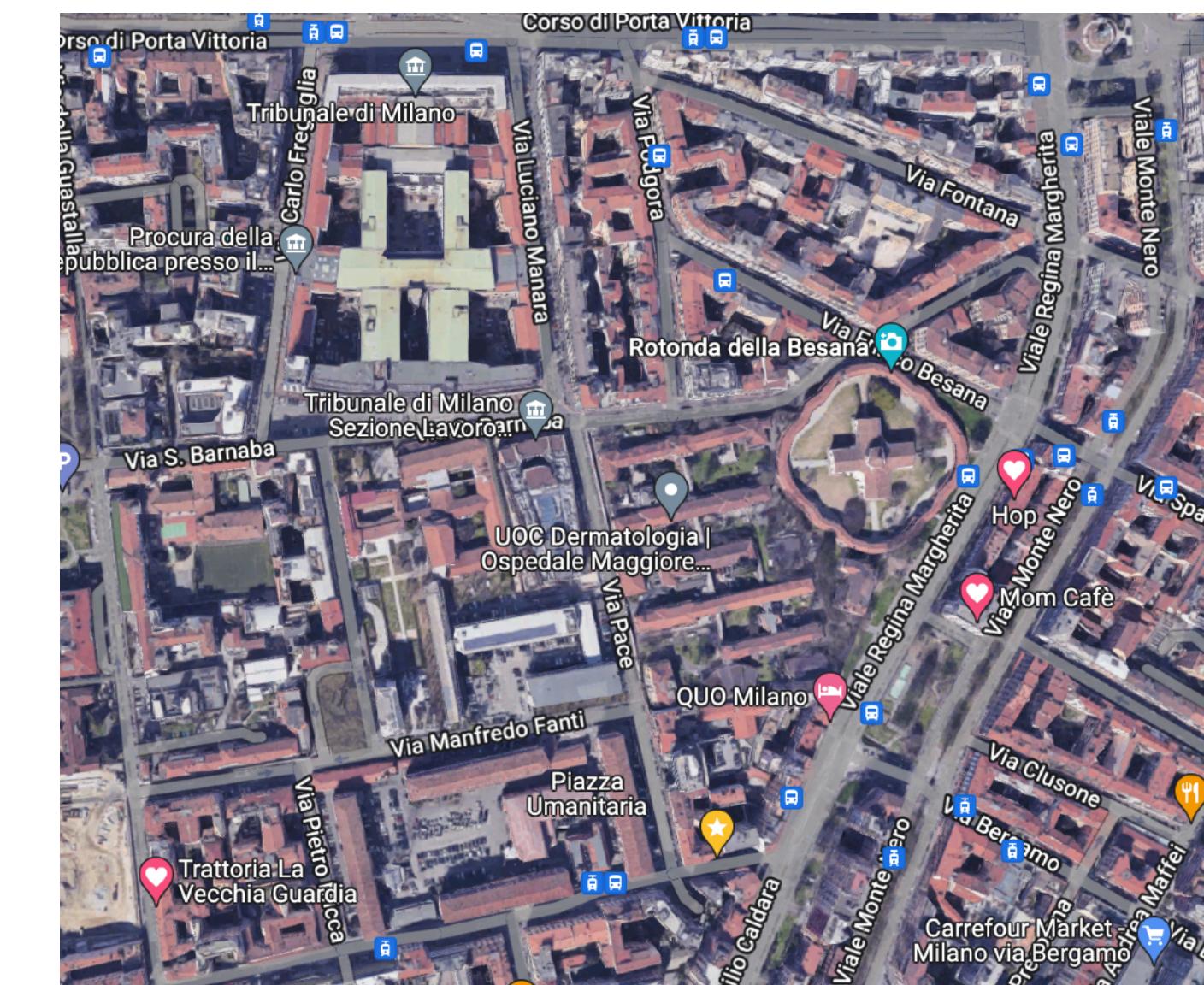
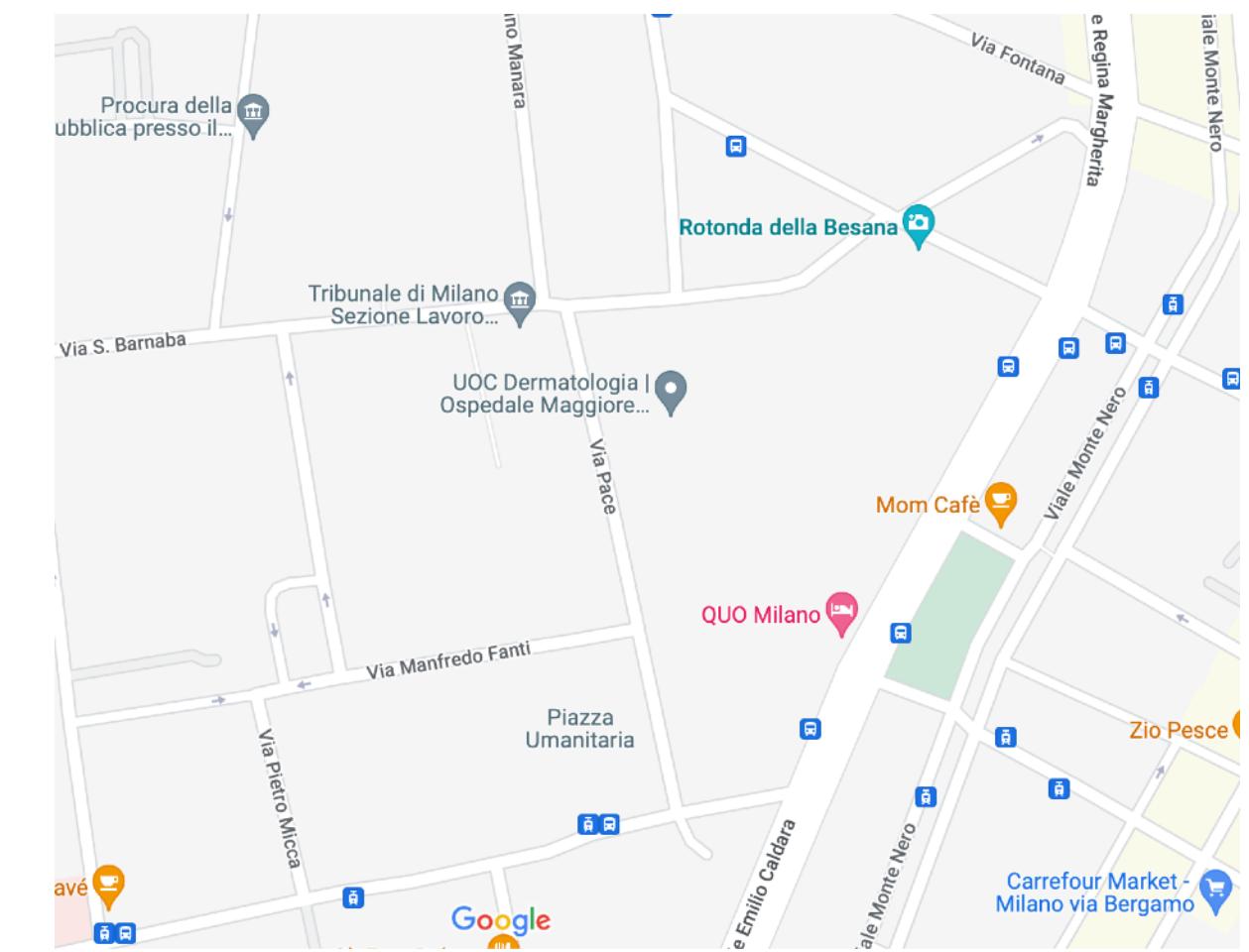
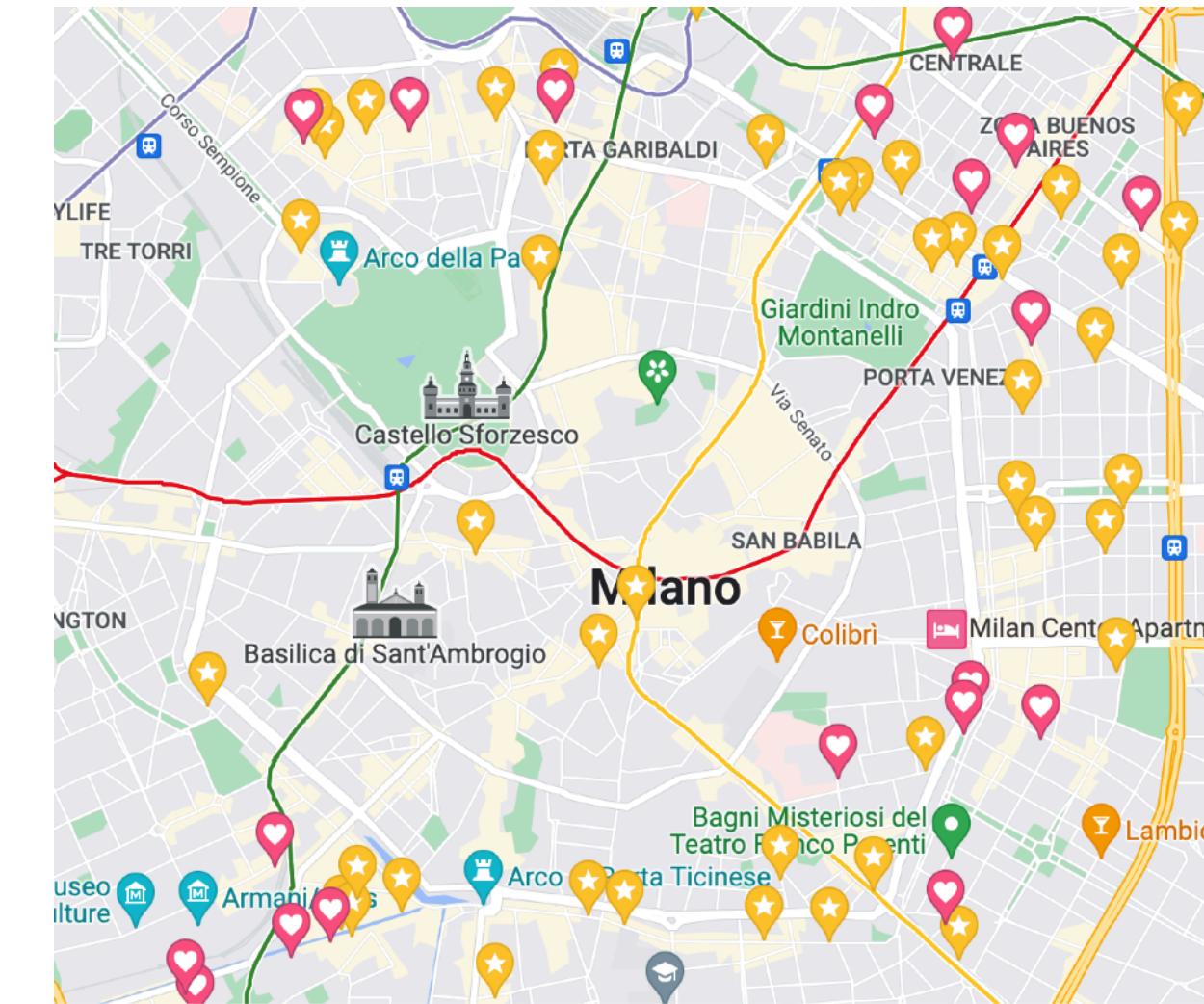
# Results

- Result: even integrative preferences (*micro*) can generate segregation at the system level (*macro*)
- Mechanism: each relocation changes the composition of the former neighborhood, which in turn might causes other relocations.
- Purely structural / compositional effects —> unintended consequences of individual actions
- Non-linear relationship between (*micro*) preferences and (*macro*) segregation

# **What is a model?**

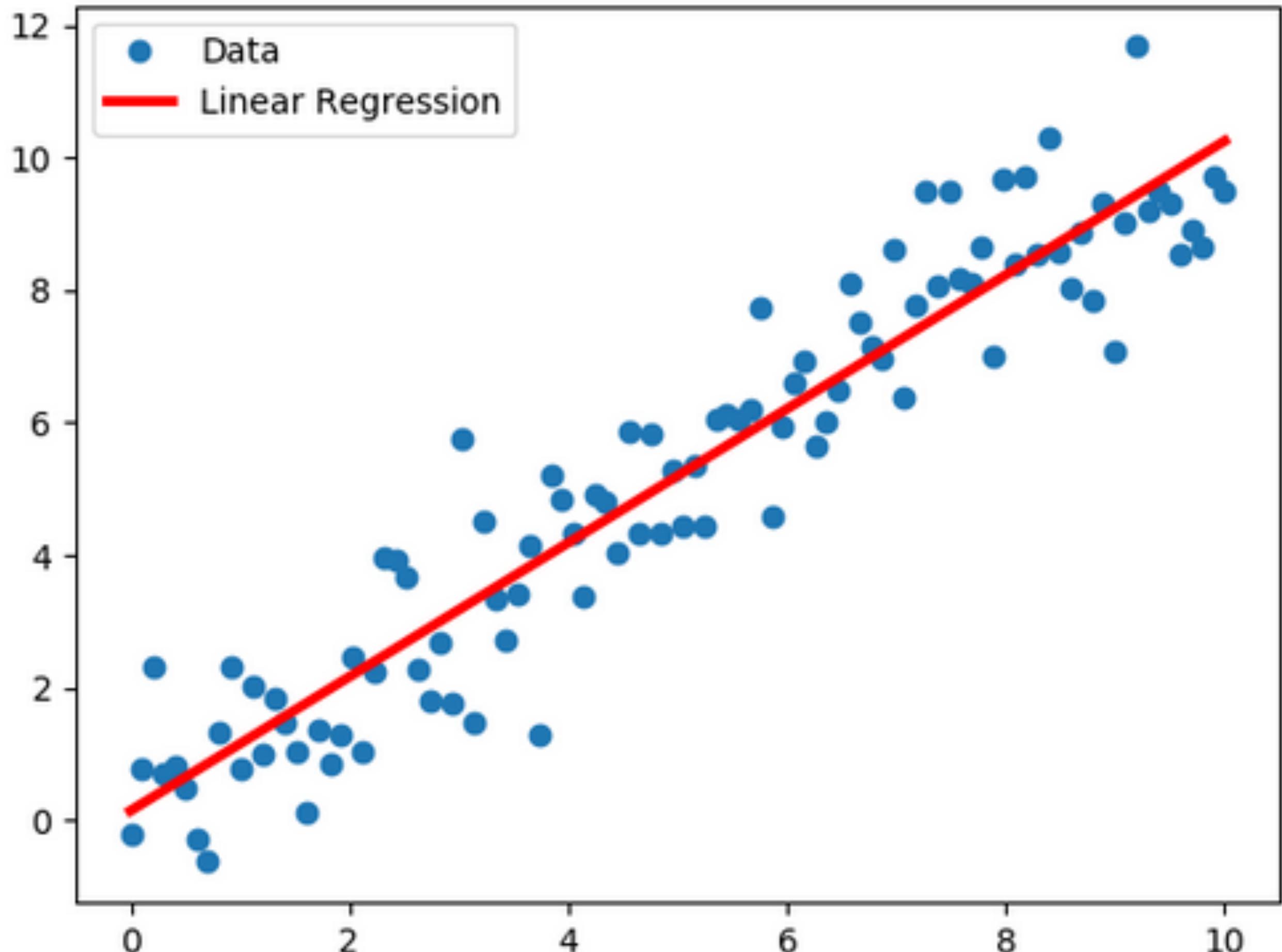
# Formal models

- A simplified representation of reality
- Models make reality analytically tractable and ‘observable’ by substitution and analogy (Hartman & Frigg, 2006)
- Models mediate between theory and empirical observations



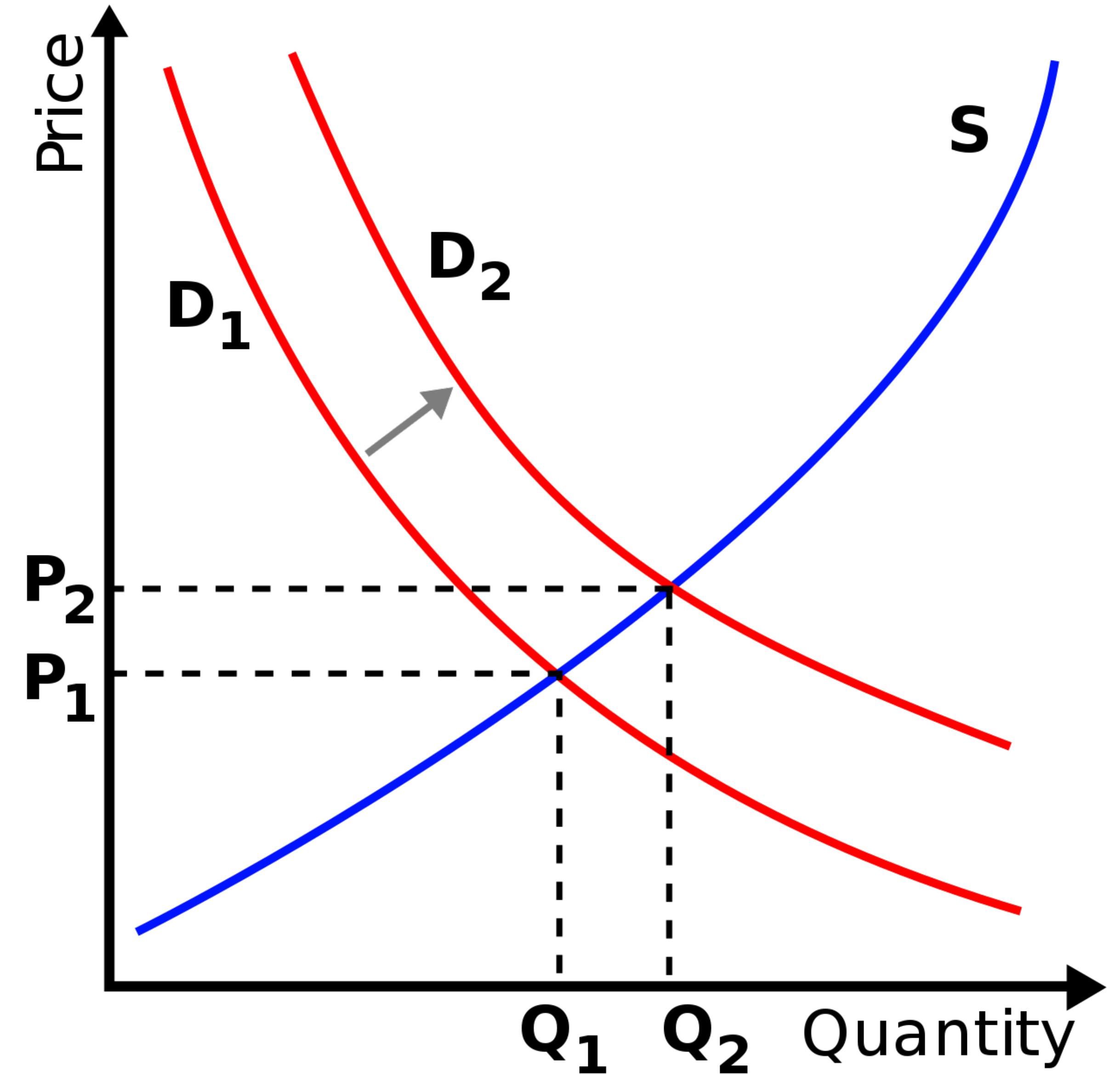
# Dirty (statistical) models

- Model the relationship (a curve) between vectors of individual characteristics (age, income, education, opinions, etc.)
- Don't model processes directly, can provide (indirect) evidence of processes (Sørensen, 1998)
- Model overall (average) covariance of individuals' properties



# Clean (mathematical) models

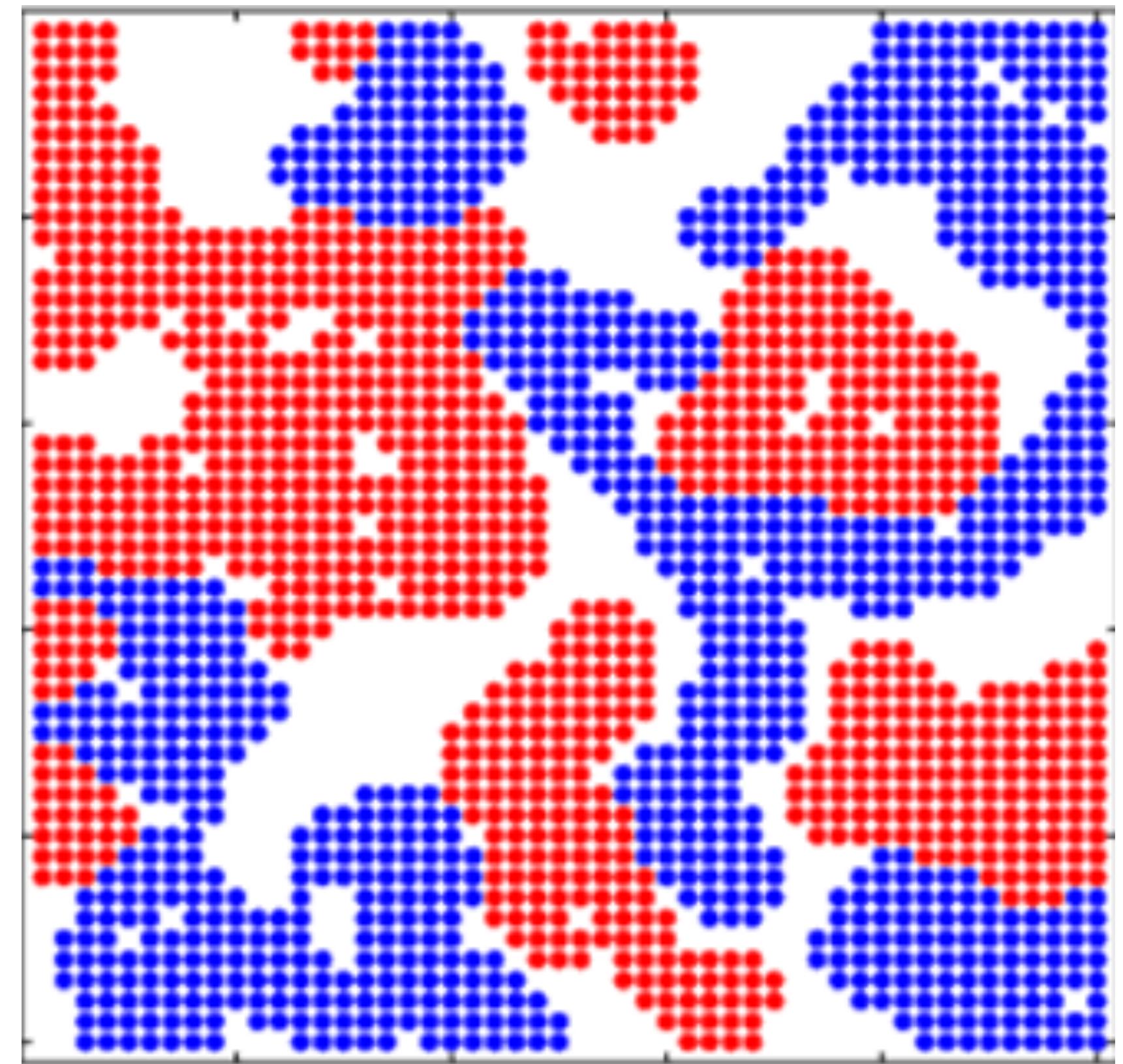
- Equation-based (usually a system of equations to be solved)
- Representative agent (all agents have the same properties, no heterogeneity)
- Very simple decision-making processes (RCT, utility maximization, etc.)
- Deduction of empirically observable consequences (to be tested)



# **Agent-based models**

# Agent-based models (ABM)

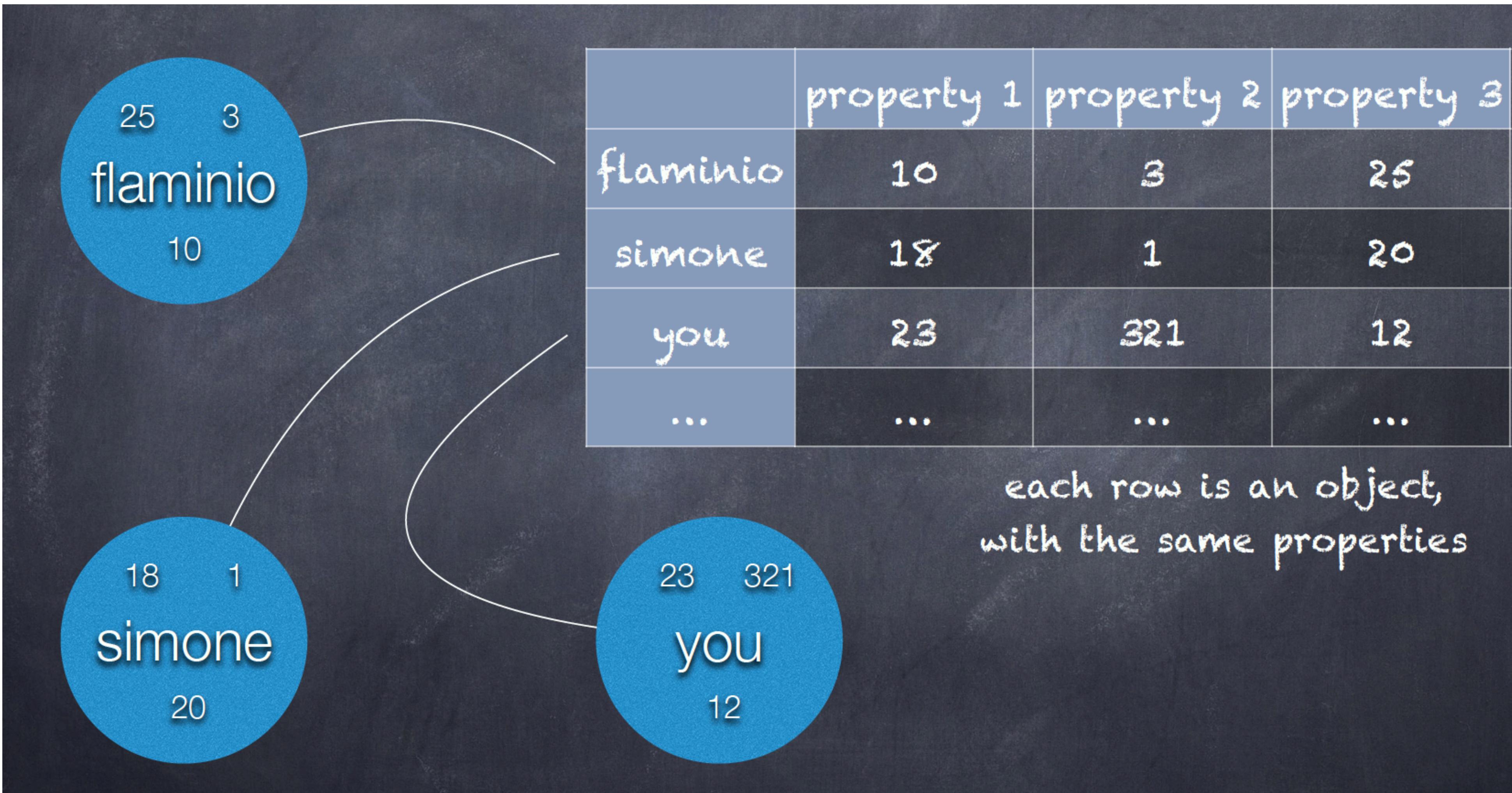
- A class of (more complex) formal models
- “A computational method that enables a researcher to create, analyse, and experiment with models composed of agents that interact within an environment” (Gilbert, 2008, p. 2)
- Model social systems through its micro-level components:
  - Agents (individuals or organizations)
  - Agents’ properties
  - Agents’ decision-making rules
  - Interaction between agents
  - Environmental constraints (institutions, networks, payoffs, etc.)



# ABM properties

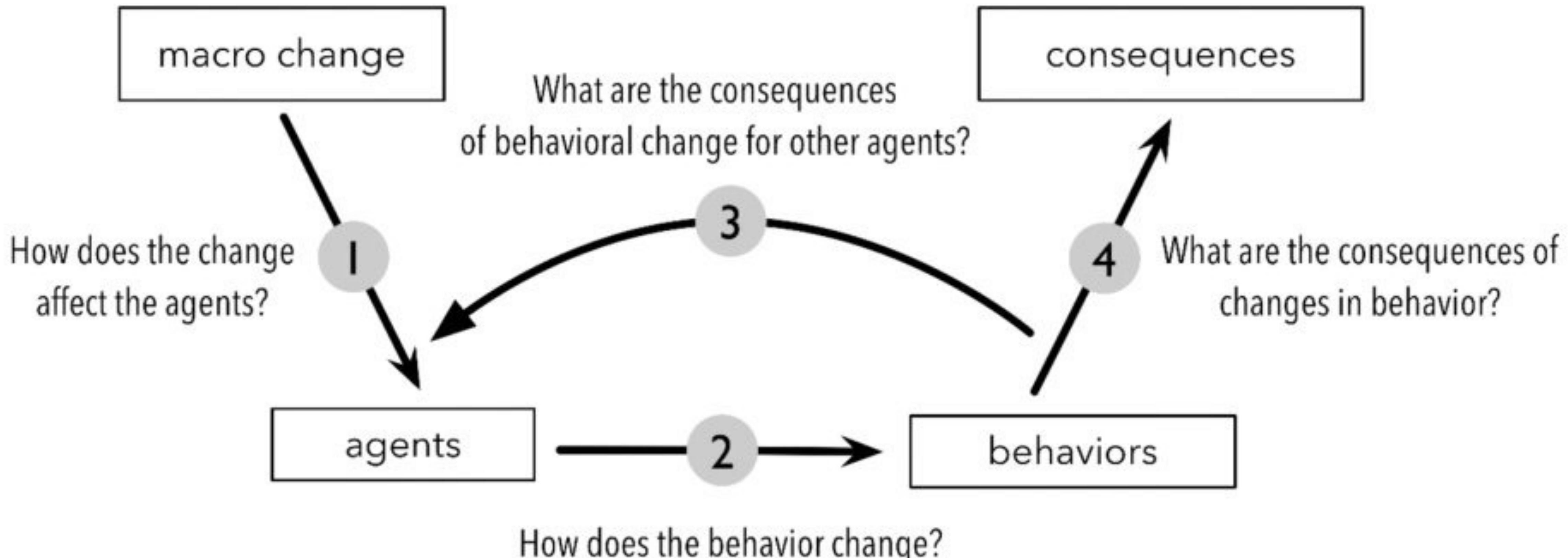
- Micro-macro emergence: micro-level components of a system (agents) are modelled, not the system itself. Macro-level outcomes emerge from the simulation of micro-level components.
- Simulation model: a dynamic model, incorporated into a computational software that runs the assumptions and generates an outcome
- Interaction and interdependence: agents affect each other's properties and behaviour by interacting with each other
- Heterogeneity: agents can be diverse in terms of behaviour and properties

# From factors to actors



# Mechanisms and generative explanations

# Social mechanisms



**Fig. 1.** The improved Coleman diagram.

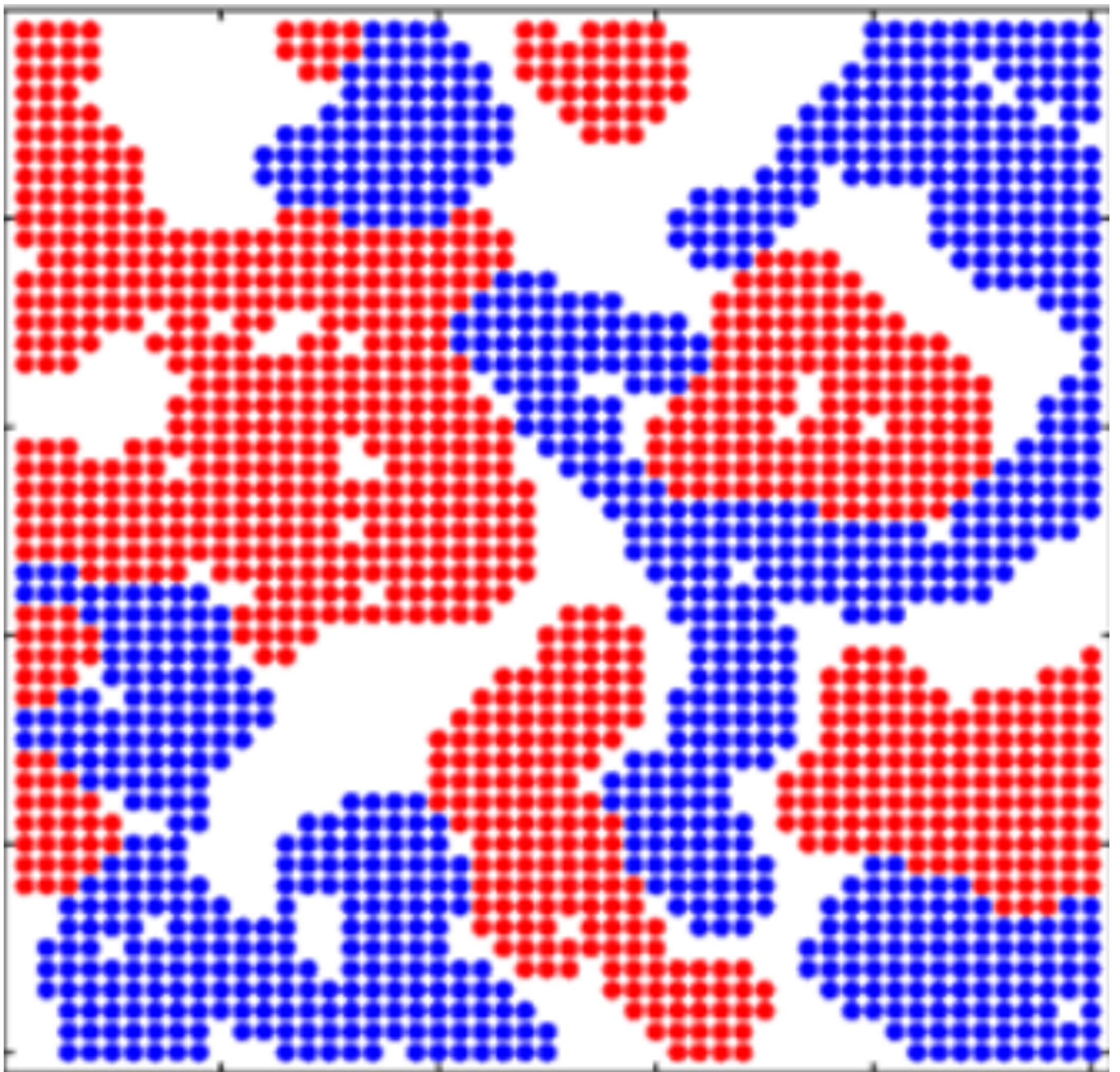
# Generative method

- Epstein, Joshua M. (2006). *Generative Social Science. Studies in Agent-Based Computational Modeling*. Princeton, NJ: Princeton University Press
- ABM motto: “If you didn’t grow it, you didn’t explain it”
- F is an explanandum (e.g. racial residential segregation in the U.S.)
- A hypothetical mechanism is formalized into a model M
- Run simulations by testing certain parameters (e.g. threshold preferences)
- If simulated outcome is  $\sim$  to F, then M provides ‘sufficient generative conditions’ of F.

# **Empirical ABMs**

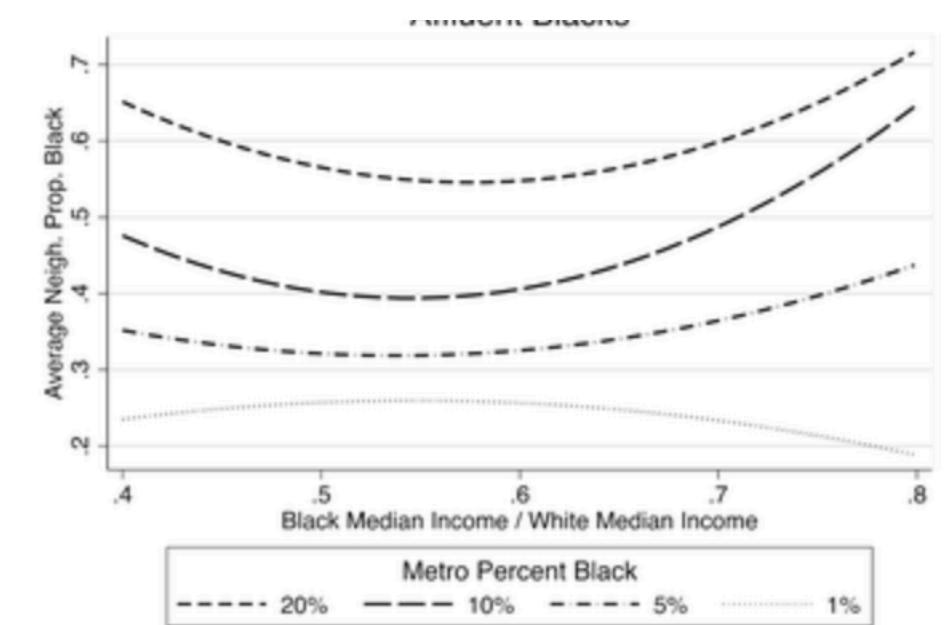
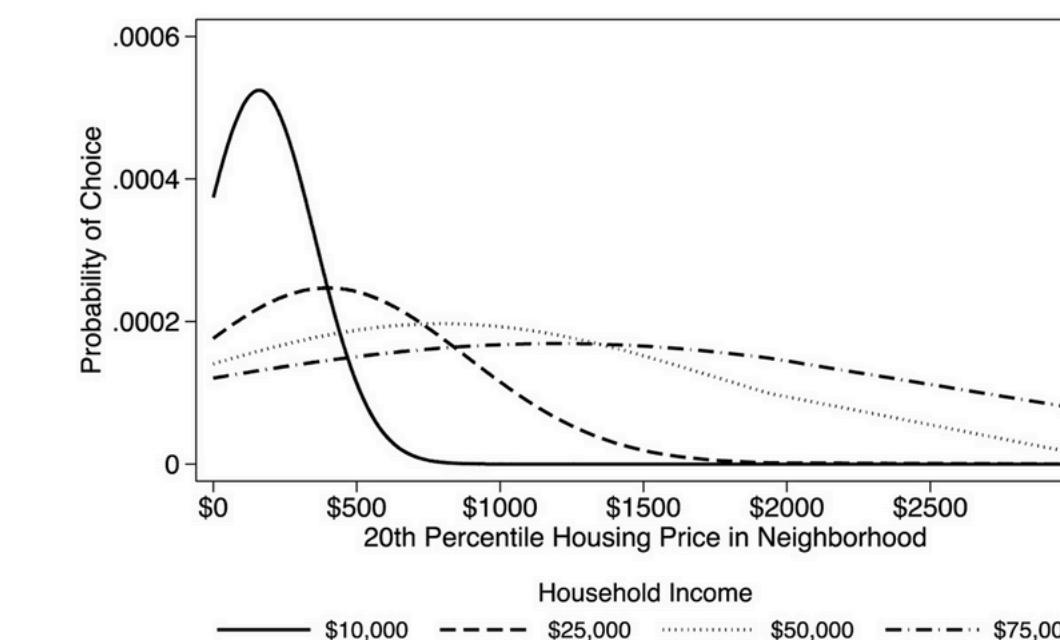
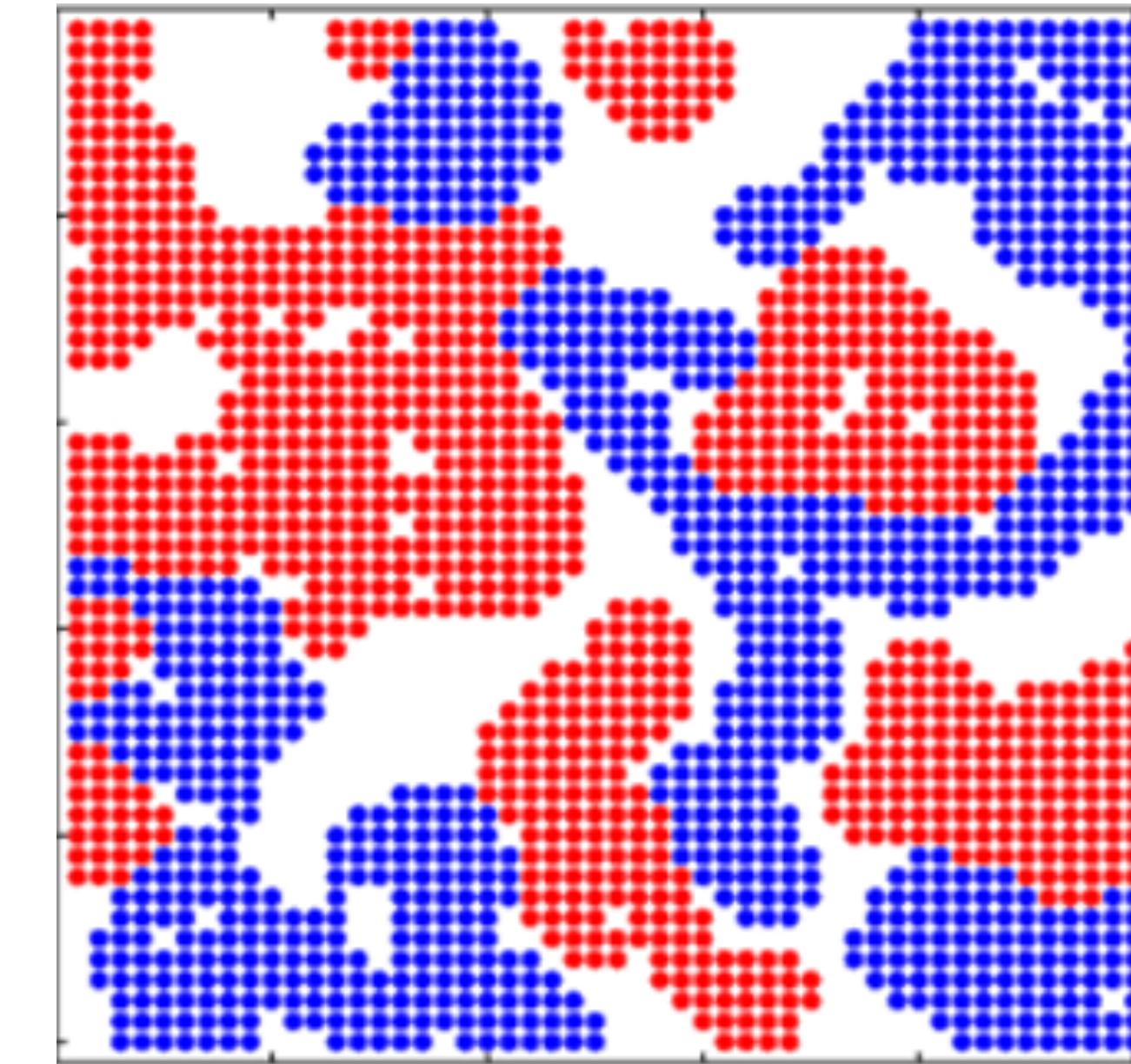
# Example 1: theoretical model

- Schelling-Sakoda model
- Assumptions on agents' behaviour and environment come out of speculation (they needn't do)
- Useful to
  - prove a theoretical point (theory-building)
  - Checking logical consistency of theories
  - (Deduce testable hypotheses to control theories)



## Example 2: model calibrated/validated on observational data

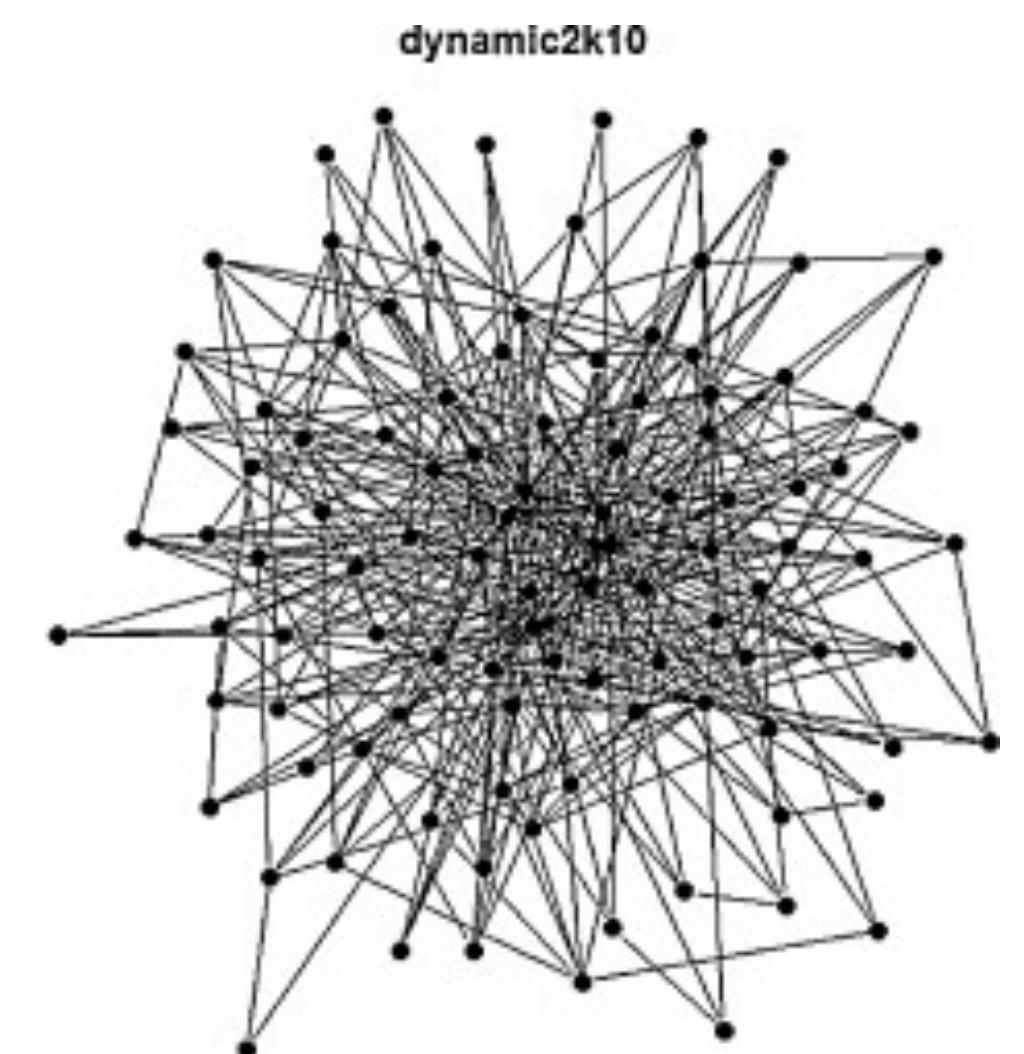
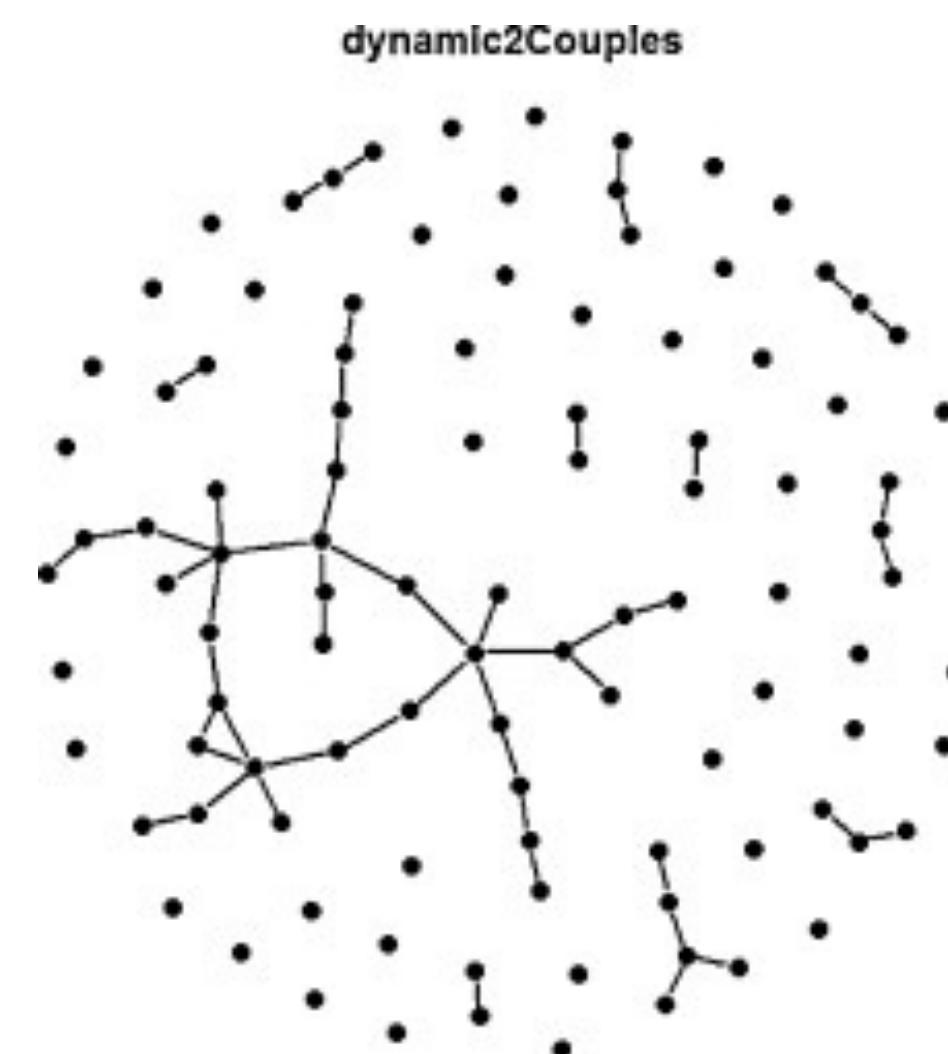
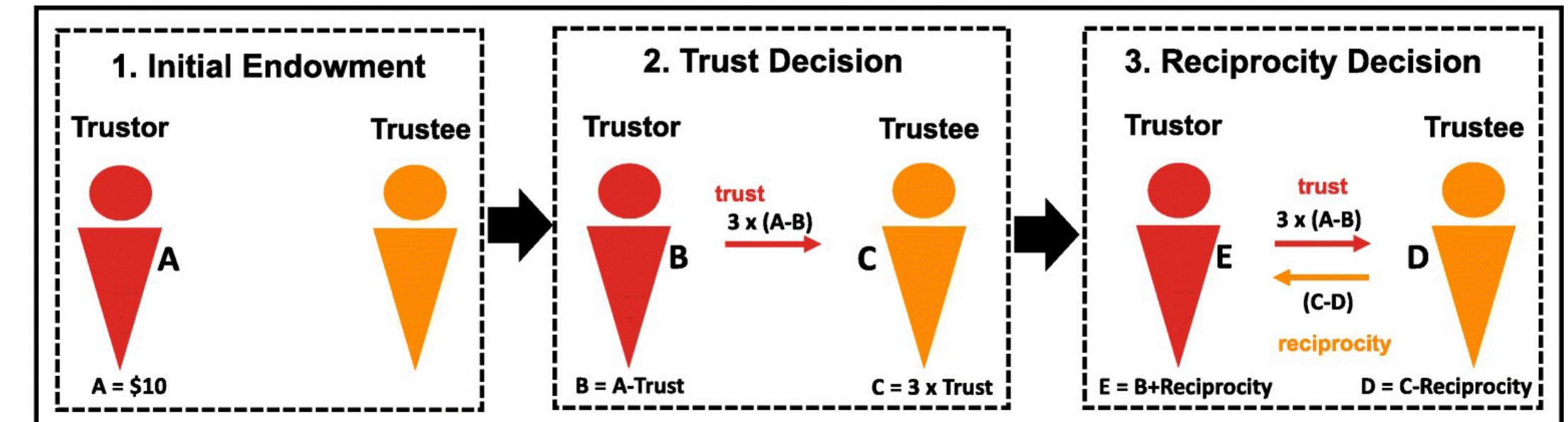
- Bruch (AJS, 2014): empirical Schelling-Sakoda model
- Calibration: *micro-level* assumptions on agents' behaviour (households' preferences) estimated on survey data
- Validation: *macro-level* simulated segregation patterns fitted 1980-2000 U.S. census data



# Example 3: model calibrated on experimental data

- Bravo, Squazzoni, & Boero (*Social Networks*, 2012)
- How does network structure affect trust among business partners?
- Repeated trust game in the lab with human subjects
- Agents' behaviour calibrated on estimates of lab subjects' behaviour
- Manipulation of network structures in the model
- Results: no change

One-Round Trust Game



# Beyond data

# Modelling unobserved / unobservable

- Micro-macro link:
  - Micro: cognitive heuristics
  - Macro: institutional incentives or constraints / network structure / geographical space...
- Some processes might be difficult/impossible to observe
  - Cognitive processes: e.g. learning, strategic behaviour, emotions
  - Social interaction: e.g. influence over time

# Testing policy scenarios

- Testing a policy: manipulating reality with a treatment which changes actors' opportunities/constraints/incentives (payoffs)
- RCT (Randomized Controlled Trial) is ‘the’ way because:
  - Ensures the isolation of the causal factor (treatment)
  - Helps study non-linear relationship between stimuli and consequences
- ABM is convenient for testing **possible** scenarios (*in silico* experiments)
- An ABM can reproduce reality and then environmental/institutional changes can be *simulated*

# Coding ABMs



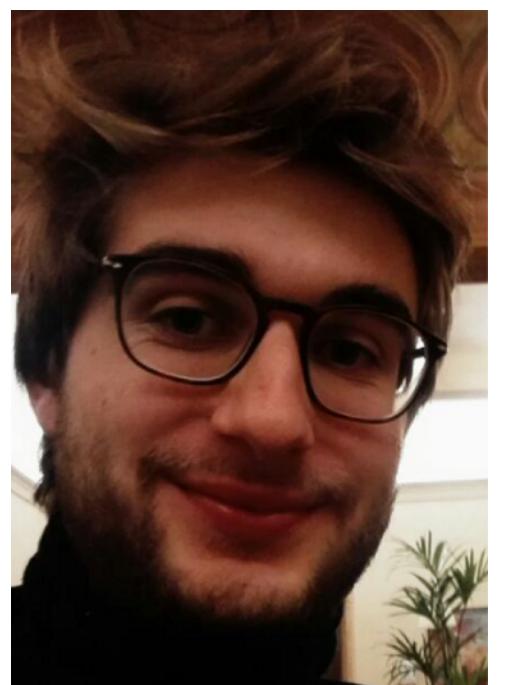
# Behave Summer School on ABM



[abmschool.behavelab.org/](http://abmschool.behavelab.org/)

Brescia, 11-22 September

Deadline: 30 April



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**Thank you!**

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