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BEHAVE

Agent-based modelling

Research design - Prof. Filip Agneessens
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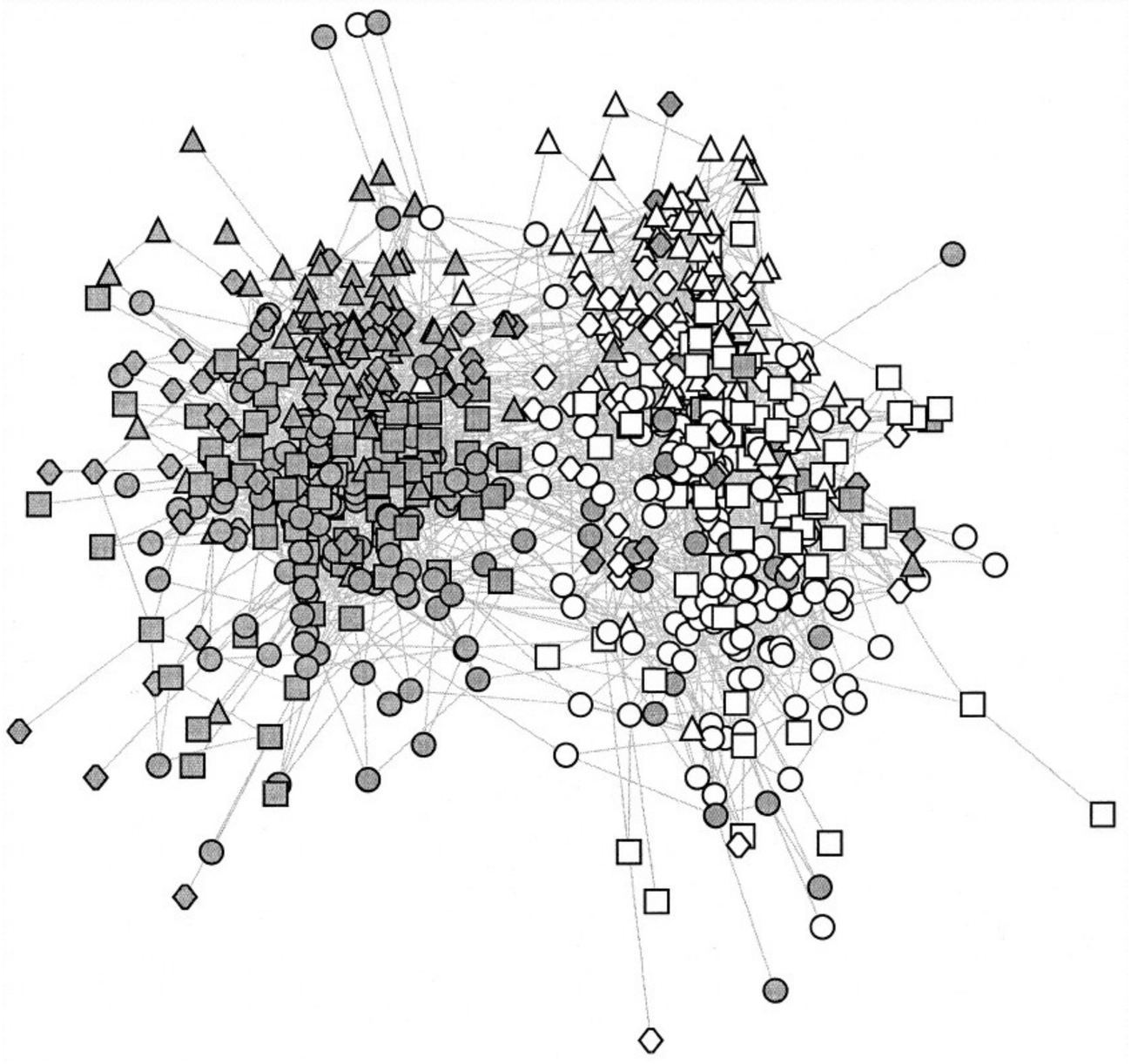
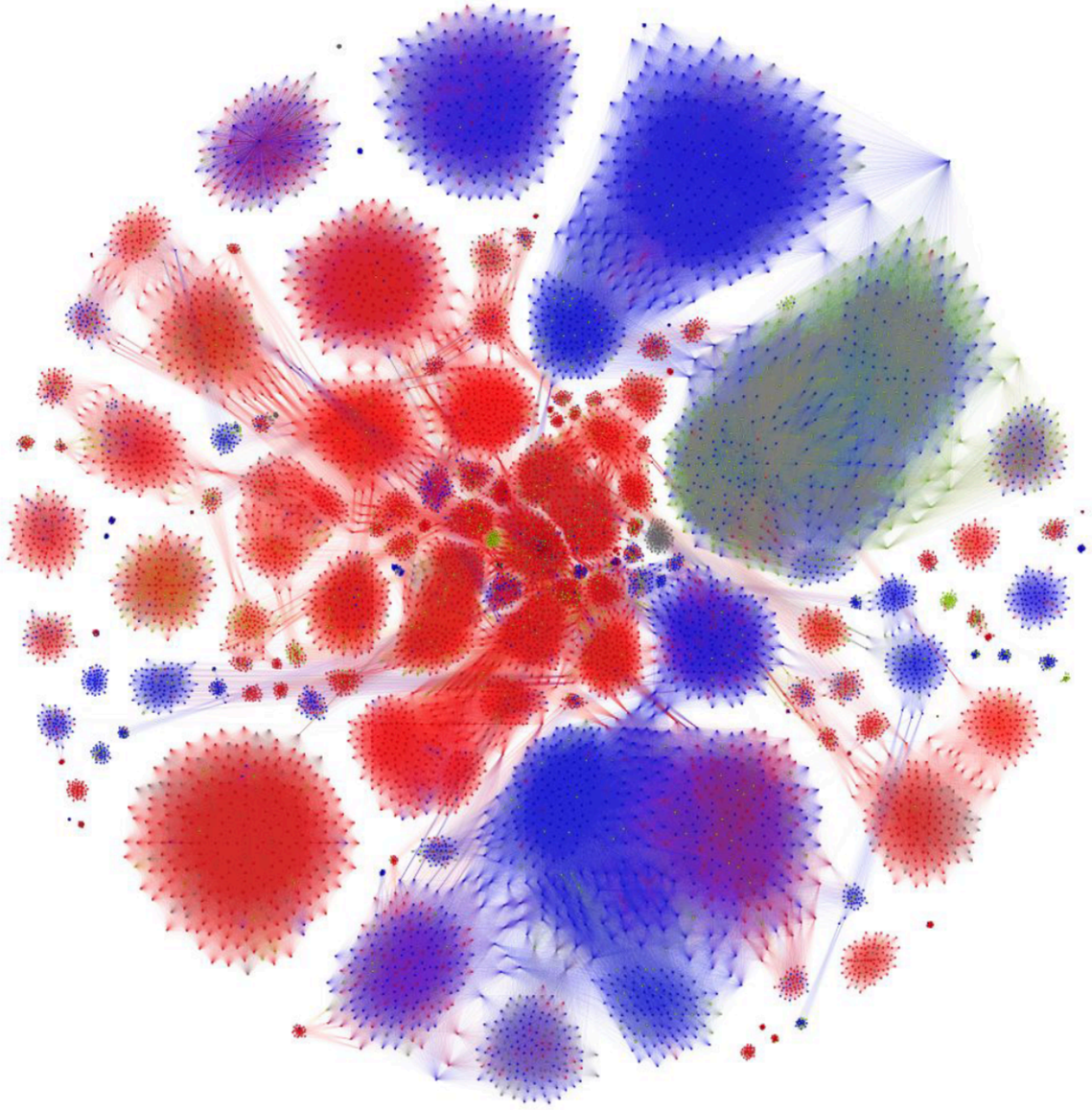
An exercise:
what explains segregation?



Friendship ties in a US secondary school

(shaded figures: non-white students)

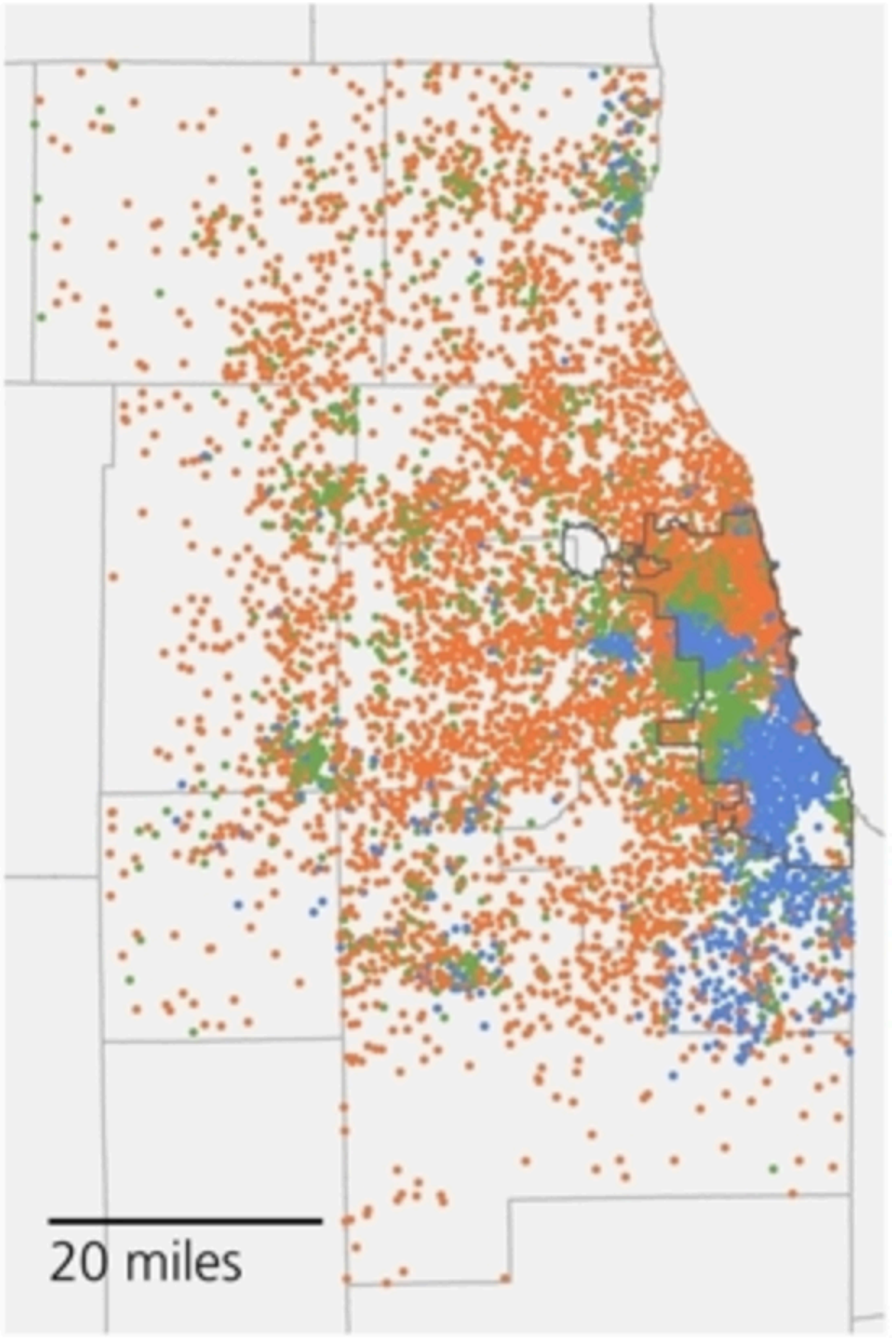
(Quillian & Campbell, 2003)



Cohabitation among shantytown dwellers in. Paris, 2013-2015

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

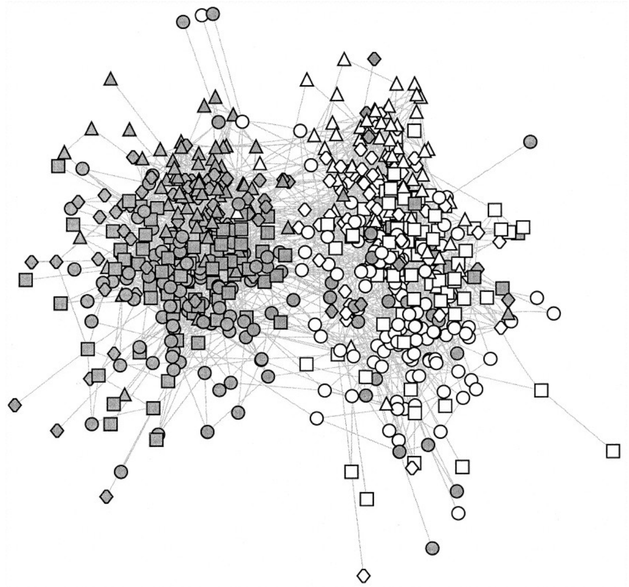
(Vitale, Bianchi & Cousin, 2021)

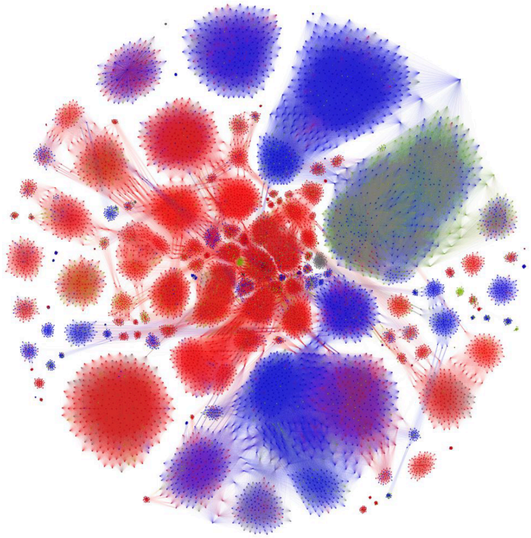


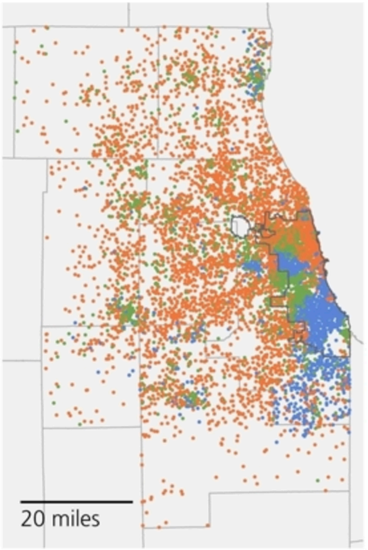
Chicago by ethnicity

(orange: white; blue: African American; green: Latinx)

(Metropolitan Planning Council)





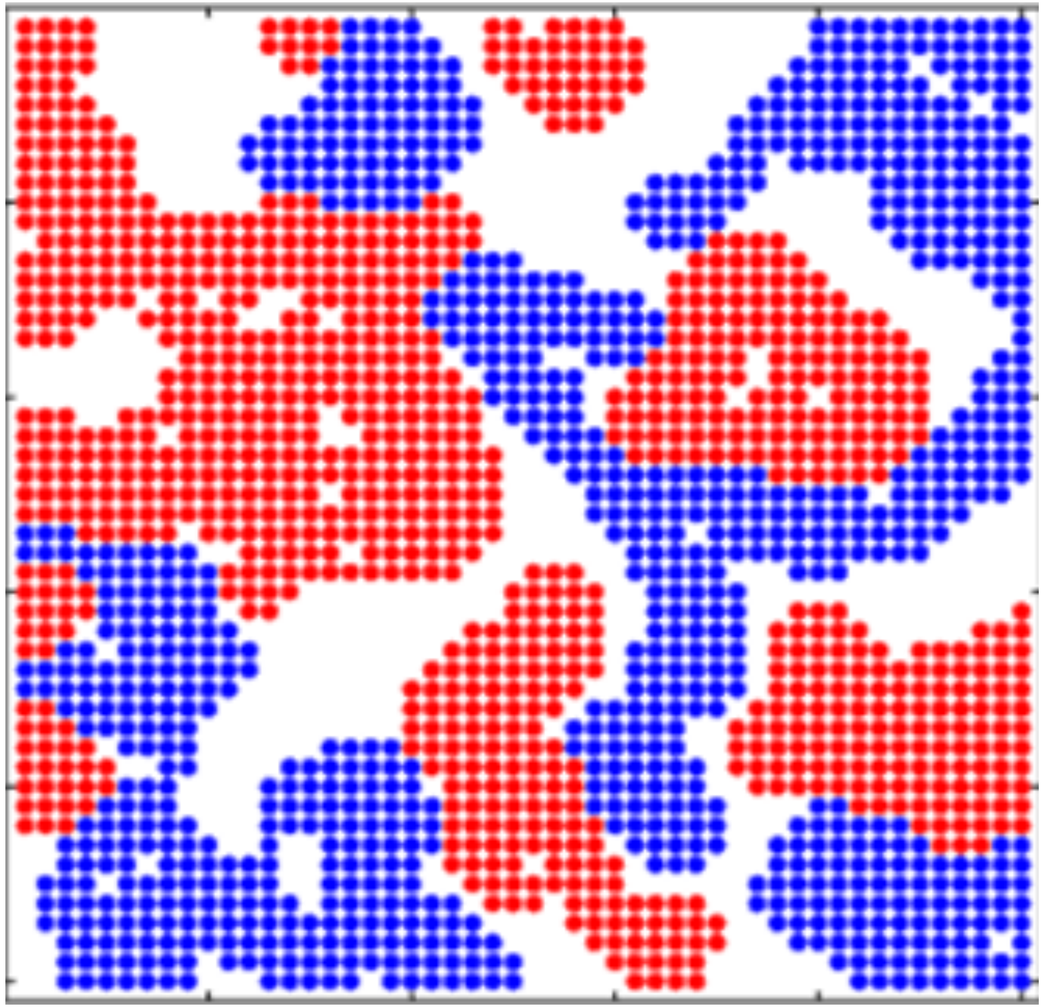


Segregation: (*macro*) property of social system in which actors are separated from each other along certain (*micro*) individual properties

Does segregation necessarily imply xenophobia?

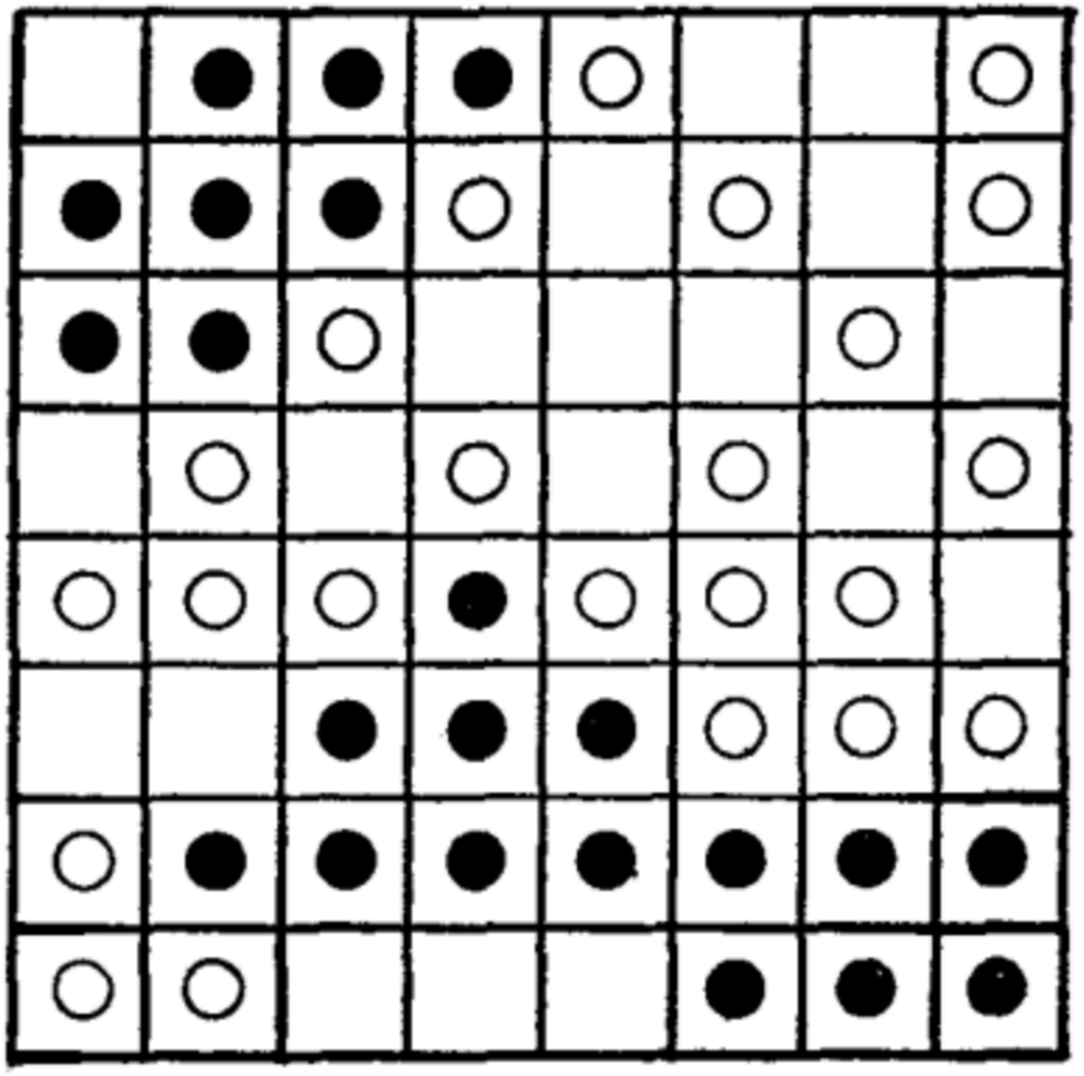
- What causes segregation?

- 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*)



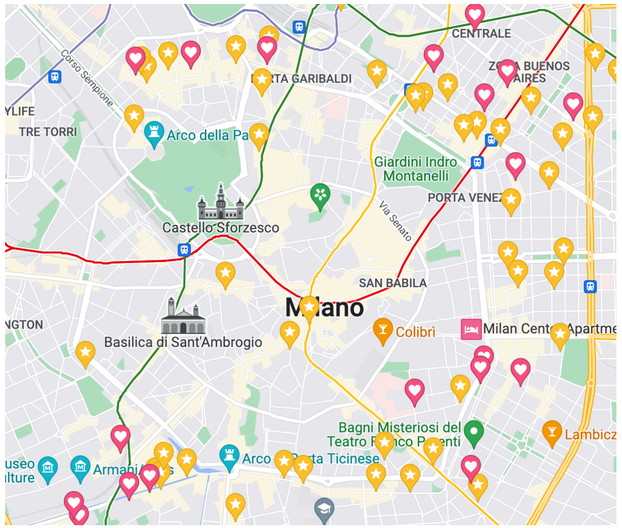
Results

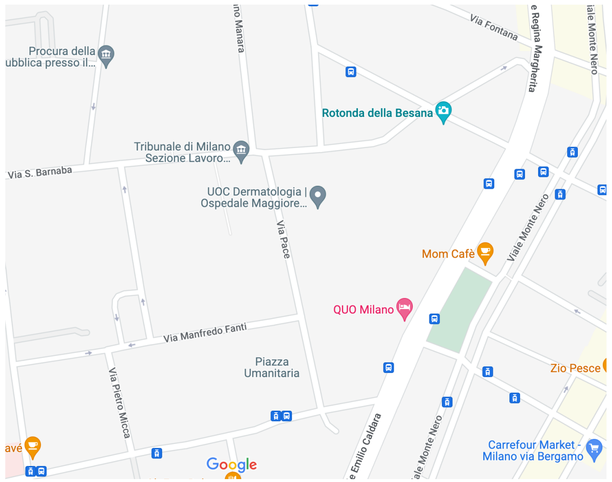
- Result: even integrative preferences (*micro*) can generate segregation at the system level (*macro*)
- Mechanism: each relocation changes the composition of the former neighborhood, which in turn might cause others to relocate
- Purely structural / compositional effects —> unintended consequences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

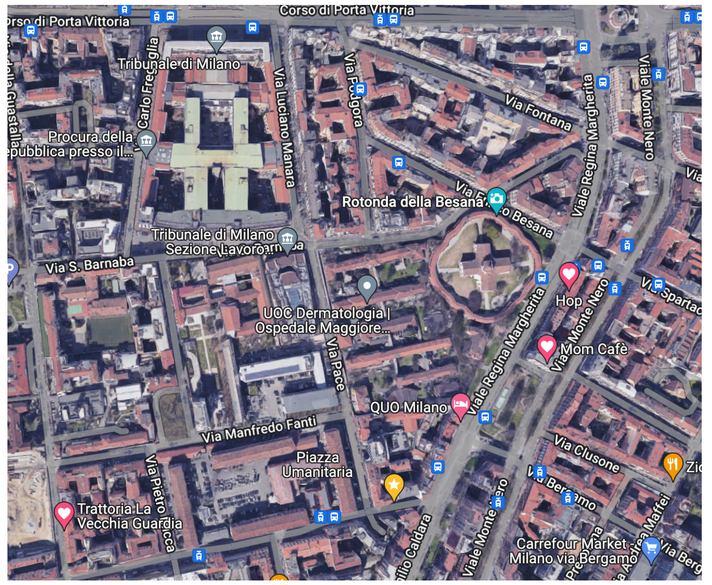
What is a model?

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

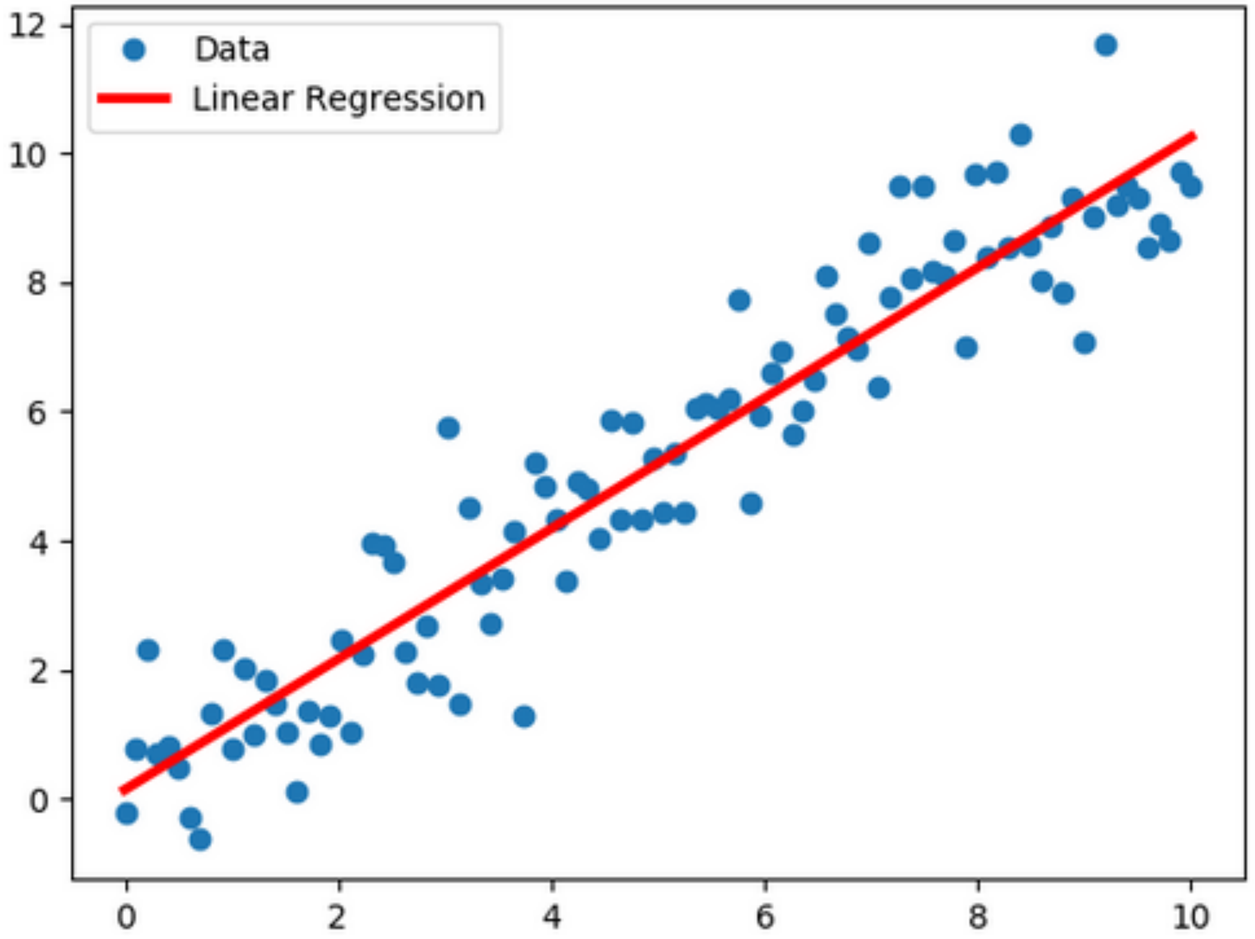






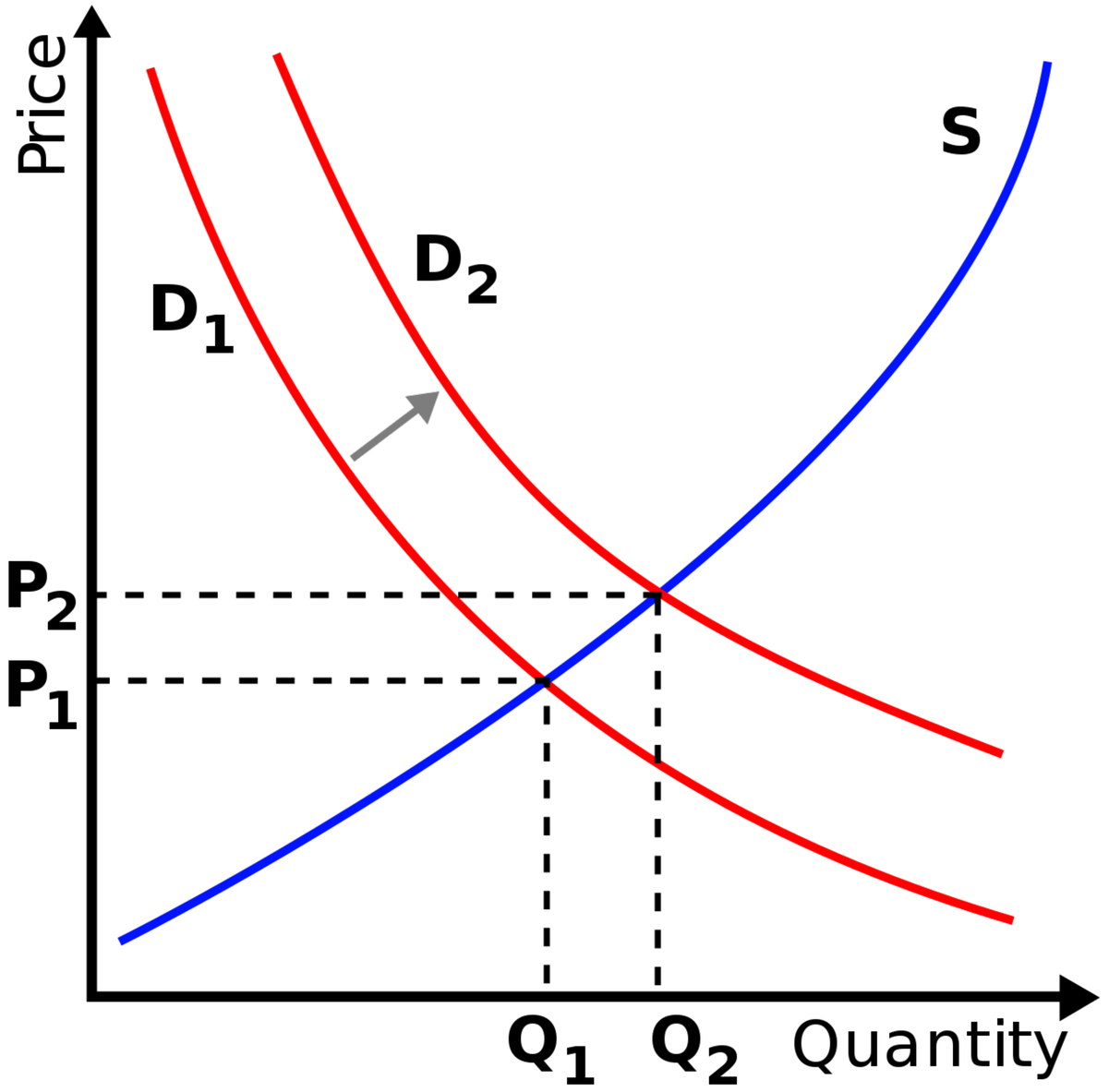
Dirty (statistical) models

- 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) co-variance of individuals’ properties
- Methodological models (Skvoretz, 1991)



Clean (mathematical) models

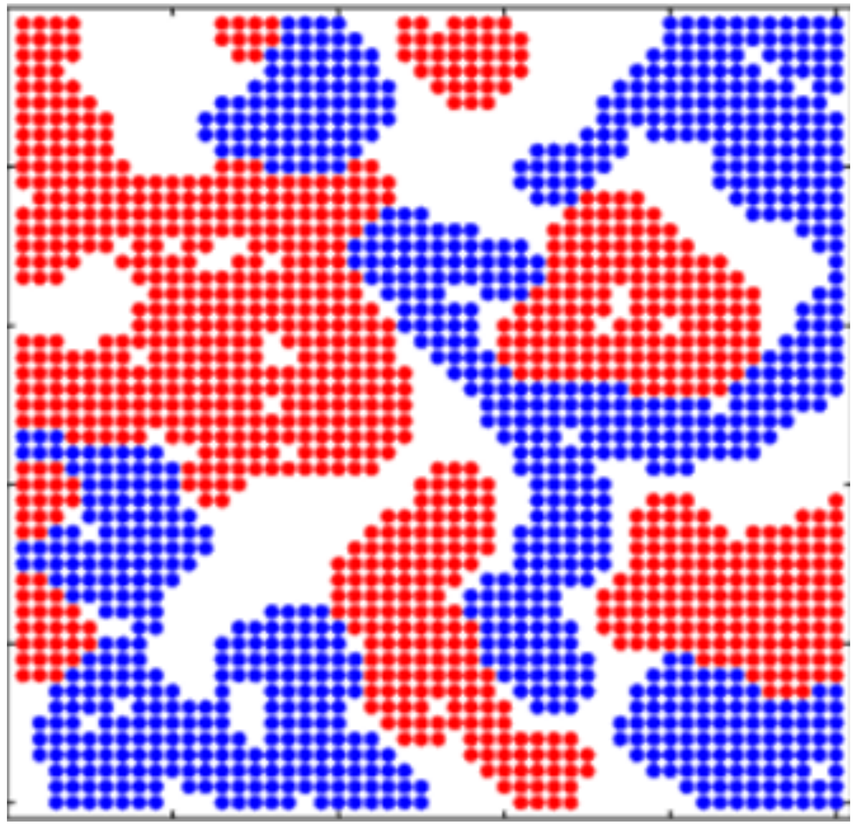
- Equation-based (usually a system of equations to be solved)
- Representative agent (all agents have the same properties, no heterogeneity)
- Very simple decision-making processes (RCT, utility maximization, etc.)
- Deduction of empirically observable consequences (to be tested)
- Theoretical models (Skvoretz, 1991)



Agent-based models

Agent-based models (ABM)

- A class of (more complex) formal models
- “a computational, dynamic model that formalises a population of interdependent agents — i.e., individual or collective social actors — with specific properties, interacting according to a set of behavioural rules within certain environmental constraints” (Bianchi & Renzini)
- 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.)



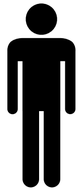
ABM properties

- 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 according to the assumptions and generates an outcome (mathematically untractable likelihood function)
- 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

ABMs are models of social interaction

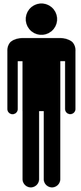
Time *t*

1



Age = 35
Gender = F
politics = left

2



Age = 47
Gender = F
politics = **right**

Time *t + 1*

1

Age = 35
Gender = F
politics = left

2

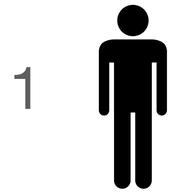
Age = 47
Gender = F
politics = **left**

	Age	**Gender**	**Politics**
1	35	F	left
2	47	F	right
...			
n			

"From factors to actors"
(Macy & Willer, 2002)

ABMs can model social networks

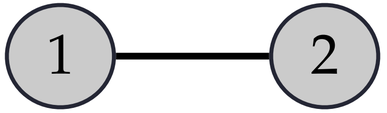
Time *t*



Age = 35
Gender = F
Neighbours = ( )

Age = 47
Gender = F
Neighbours = ( )

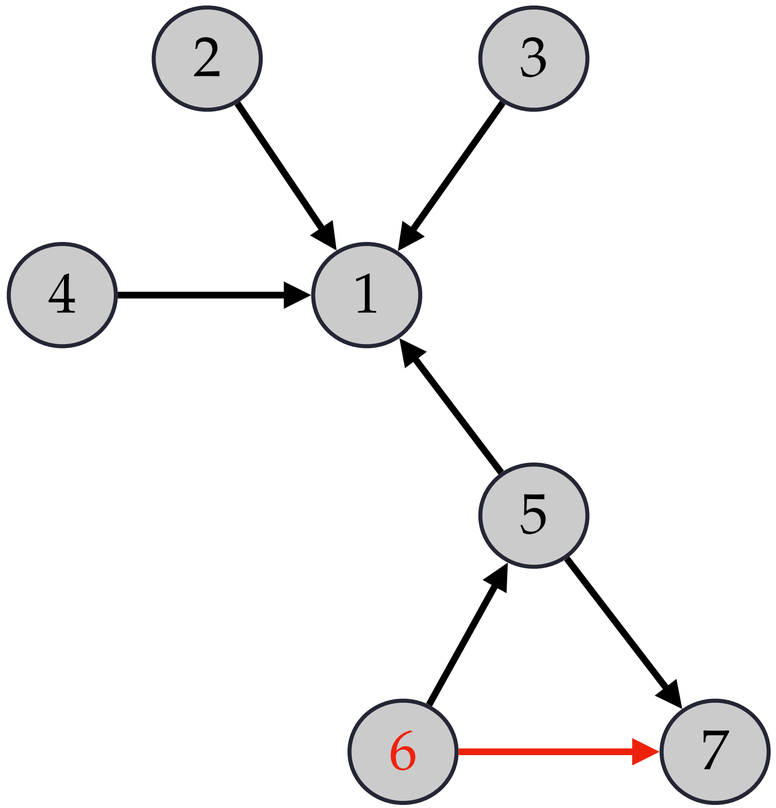
Time *t + 1*



Age = 35
Gender = F
Neighbours = (2)

Age = 47
Gender = M
Neighbours = (1)

Nodes are agents



Simple behaviour

If you're lying on a 2-path, then close the triad with some probability *p*

More complex behaviour

If you haven't asked anybody in the last *m* steps, then ask an agent who's not being asked by many agents

Mechanisms and generative explanations

Social mechanisms

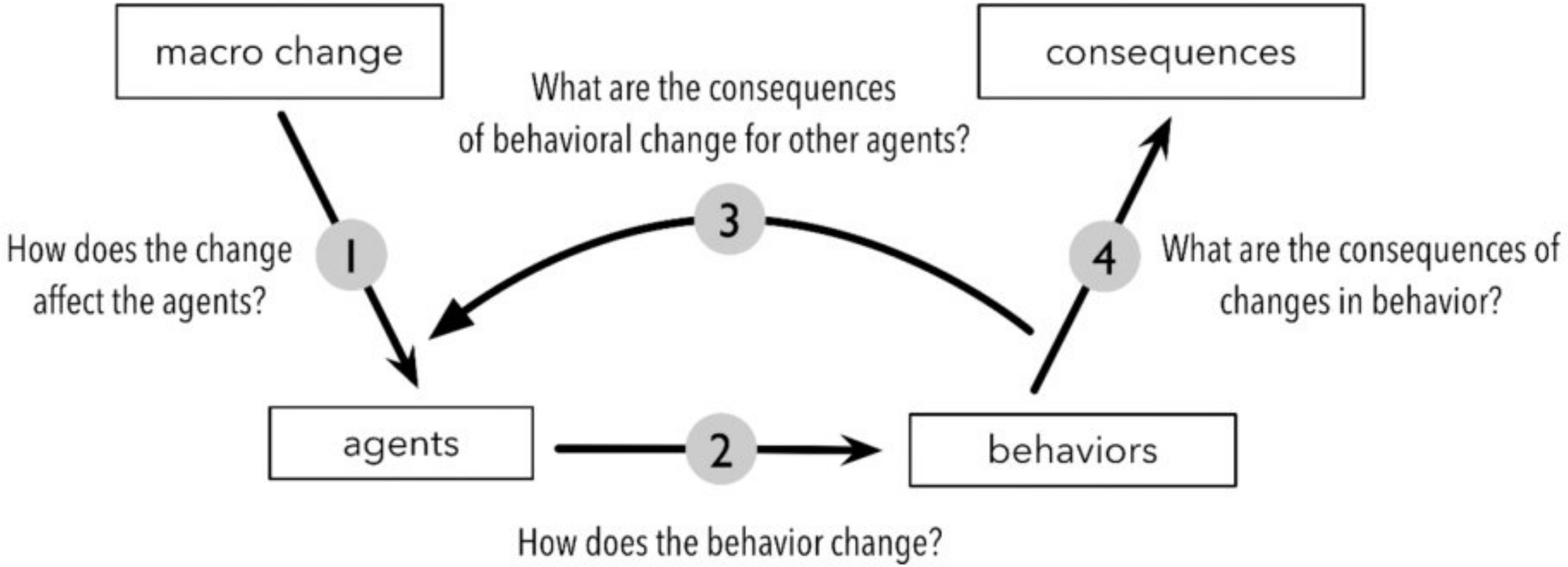


Fig. 1. The improved Coleman diagram.

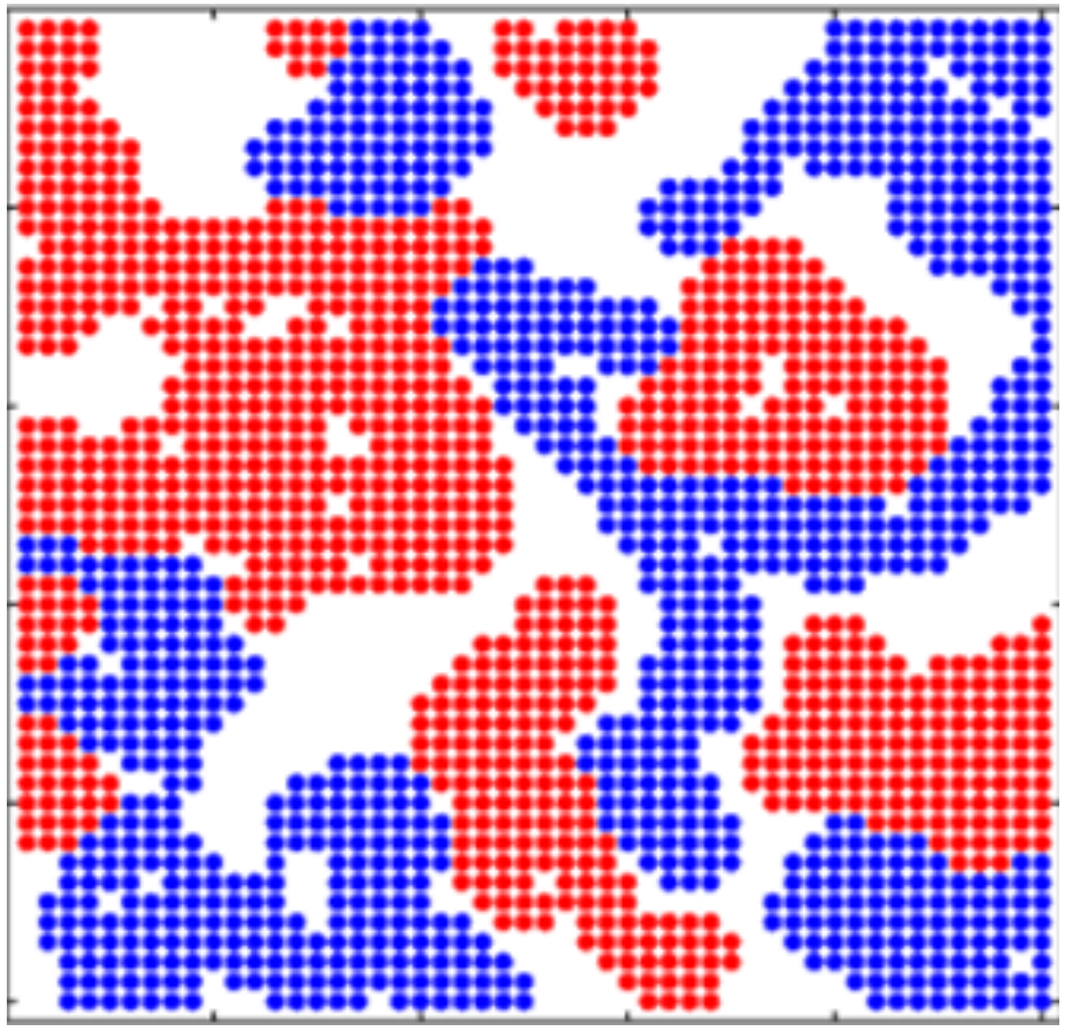
Generative method

- 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 ~ to *F*, then *M* provides ‘sufficient generative conditions’ of *F*.

Empirical ABMs

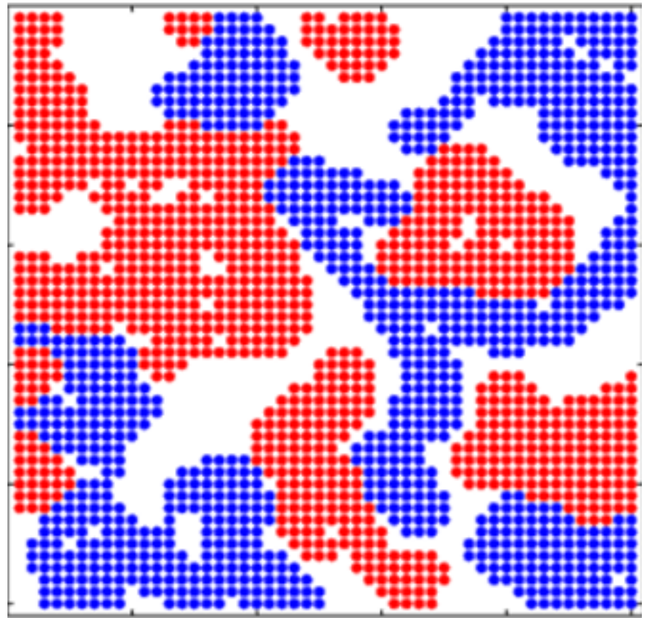
Example 1: theoretical model

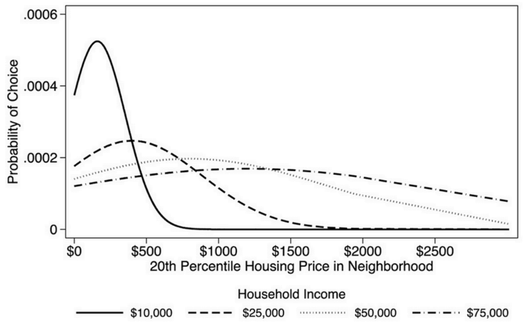
- Schelling-Sakoda model
- Assumptions on agents’ behaviour and environment come out of speculation (they needn't do)
- Useful to
  - prove a theoretical point (theory-building)
  - Checking logical consistency of theories
  - (Deduce testable hypotheses to control theories)

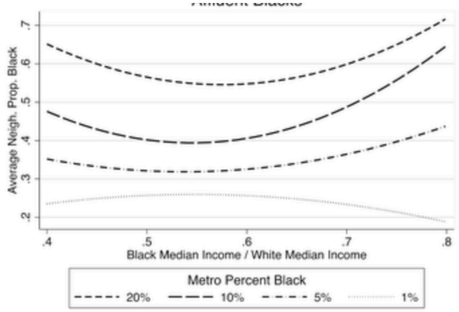


Example 2: model calibrated/validated on observational data

- 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



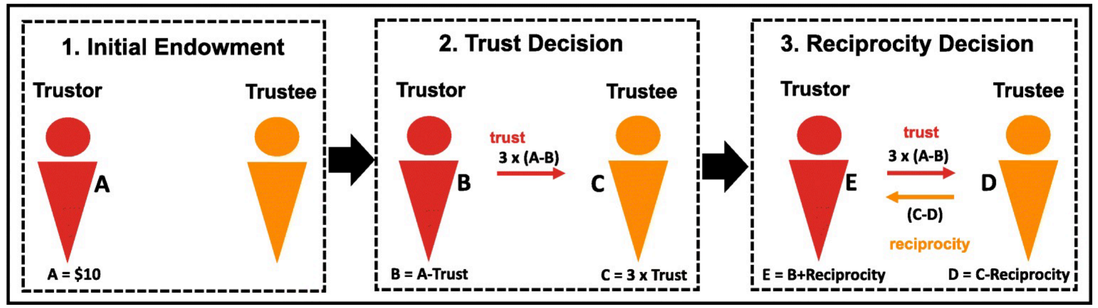


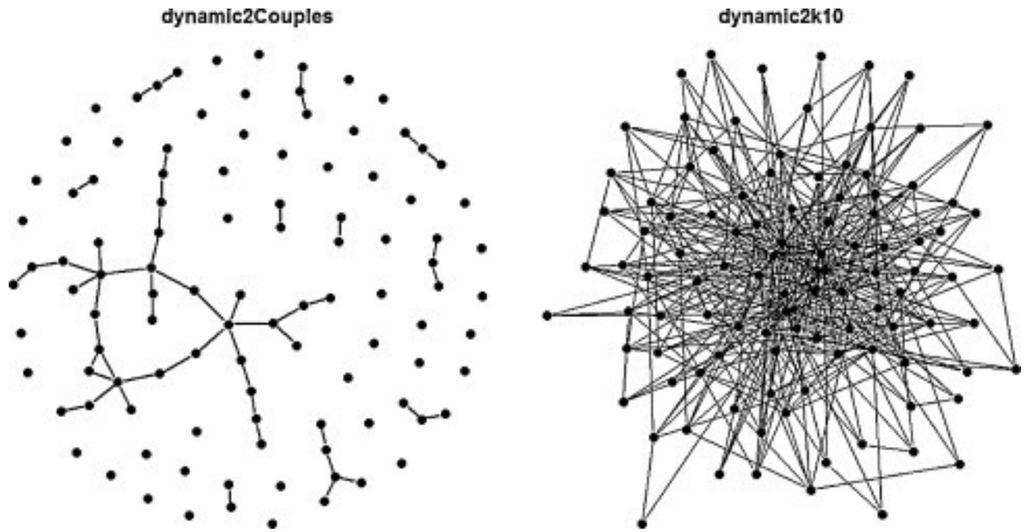


Example 3: model calibrated on experimental data

- 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

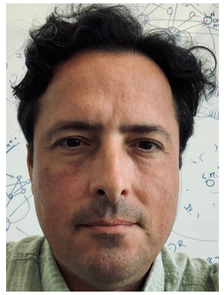
Testing policy scenarios

- 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*

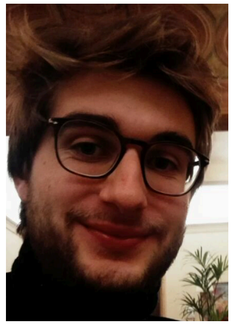
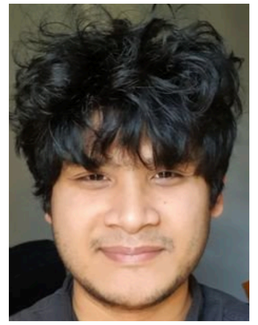
Coding ABMs

Behave Summer School on ABM

abmschool.behavelab.org/ Brescia, 2-13 September Deadline: 16 June









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