Agent-based Modeling as Research Tool in the Social Sciences: An Application in Voting Behavior

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Key points

- Model: Voters pick party from social cues, interaction estimated from empirical data
- Results: No identification with parties dominates, but: critical points for two years
- Interpretation: Model may indicate global alterations in party strength among voters

Motivation

Interpersonal communication is an important means by which individuals gather information, reduce ambiguity, and derive a common understanding of reality. Thus, their opinions should not be regarded as independent of each other. After neglecting earlier modeling attempts, Political Science has recently re-engaged interpersonal influence as a source of opinion change. Agent-based modeling can support this enterprise.

Theory

Many voters support the same party like a "standing decision" over recurrent elections. This idea is captured in Party Identification (PID), a concept containing the notion that a voter counts herself among the electoral basis of a party. It is measured by asking a person to self-classify as partisan. PID predicts many aspects of political behavior.

PID has declined since the 1970s in Western democracies, raising concerns about increasingly unstable electorates. Other work has explored how swings in PID can alter the connection between parties and the social groups forming their electoral base.

While usually relatively stable, PID is receptive to interpersonal influence:

- Mutual influence between spouses, within families and among close friends both with regard to uptake and directionality of PID
- Homogeneous social contacts intensify transmission
- Physical relocation leads to adjustment of PID to new surroundings

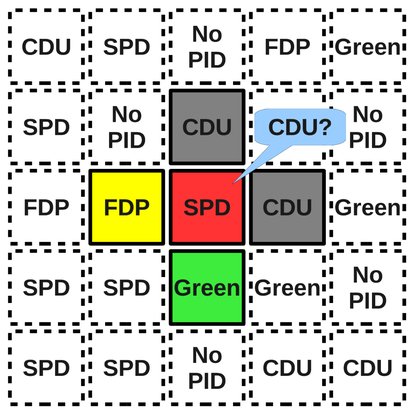
Concrete process of transmission is not fully resolved, but mechanism suggested is:

- Exchange in social networks favors majority attitudes
- People characterize as group members based on common traits (e.g. gender, religion, race, ...) and infer (political) norms from observed similarities
- Membership favors norm acceptance → favors convergence → favors ...
- PID may thus be resolved by looking to significant others, inferring from them what "people like me" are like and what party is "appropriate" for them

Model and Data

We model interpersonal transmission of PID by adapting the Ising model from Statistical Physics. Agents are located on a square grid and exchange information on their PIDs. Interaction is confined to nearest neighbors and governed by a matrix capturing conditional probability of PID change in an observed electorate.

- Attraction strength between humans unknown → matrix as approximation
- Probability as "attractiveness" of PID: Agent i considering to change from current $PID_{i,c}$ to proposed $PID_{i,p}$ may obtain agent j's opinion by $p(PID_{i,p}|PID_j)$
- Probability of neighborhood change to $PID_{i,p}$ ≈ "appropriateness" of $PID_{i,p}$



		PID_{t+1}				
		no PID	SPD	CDU	FDP	Greens
PID_t	no PID	0.782	0.098	0.091	0.011	0.019
	SPD	0.182	0.774	0.020	0.005	0.019
	CDU	0.171	0.021	0.795	0.010	0.002
	FDP	0.254	0.046	0.092	0.597	0.011
	Greens	0.183	0.108	0.015	0.005	0.690

$$p(\mathrm{PID}_{i,p}|\mathrm{PID}_{i,c}) = min\left(\frac{(\prod_{<i,j>} p(\mathrm{PID}_{i,p}|\mathrm{PID}_j))^\beta}{(\prod_{<i,j>} p(\mathrm{PID}_{i,c}|\mathrm{PID}_j))^\beta}, 1\right)$$

$$p(\mathrm{CDU}|\mathrm{SPD}) = min\left(\frac{(0.795 \cdot 0.795 \cdot 0.015 \cdot 0.092)^\beta}{(0.021 \cdot 0.021 \cdot 0.108 \cdot 0.046)^\beta}, 1\right) = 1$$

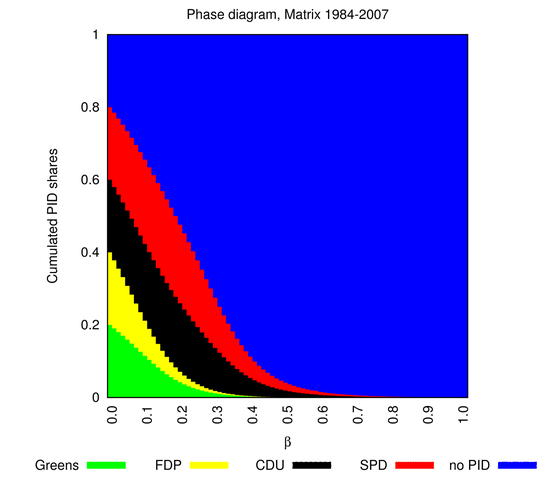
Simulation step ($PID_{i,c}$ = SPD; $PID_{i,p}$ = CDU) with averaged probabilities of PID change 1984-2007 and example calculation.

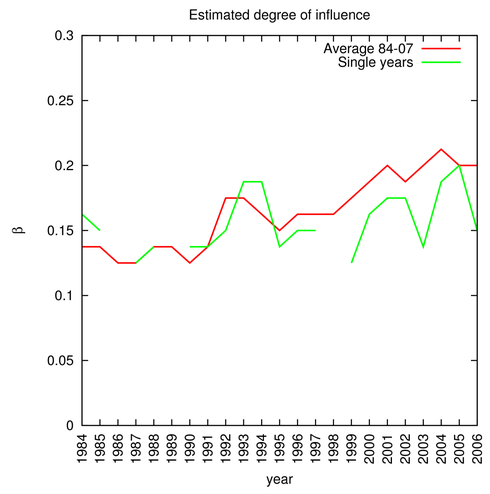
- Parameter β to control degree of social influence (β = 0 → no interaction)
- Matrix estimated from survey data (SOEP, West Germany, 1984-2007)
- Model is propelled through state space by Metropolis-Hastings Monte Carlo
- Drawback: Estimation conflates interpersonal and non-interpersonal effects

Results

The model exhibits a qualitatively stable behavior for most of the simulated years (inspected for system size, initial conditions, simulation length and neighborhood size). Enforcing consensus by rasing the degree of social influence leads to a homogeneous population with no PID as ground state. No critical point is hit.

- Parties differ in size → party size tied to temporal stability of PID
- Fitting model to empirical PID distribution suggests growing social influence

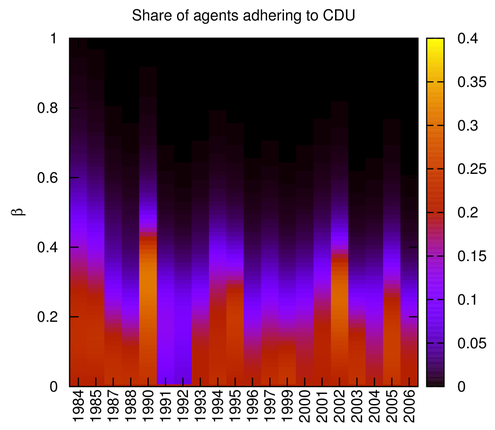


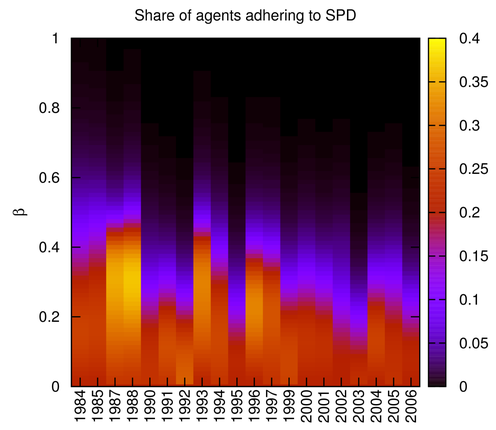


Phase diagram for matrix 1984-2007 (left) and degree of influence estimation for matrix 1984-2007 (red) and yearly rates (green).

For single year matrices qualitative behavior is the same but allows for more detailed picture. Party shares roughly follow political tides of the time:

- SPD strong in opposition until end of Kohl-Era, declining thereafter
- CDU spikes after reunification, followed by downturn; upturn for Agenda 2010
- For fixed β general rise in no PID corresponds to trend in data
- Aligning model and empirical data indicates best-fitting results quite close to Markov chain prediction based on Matrices alone

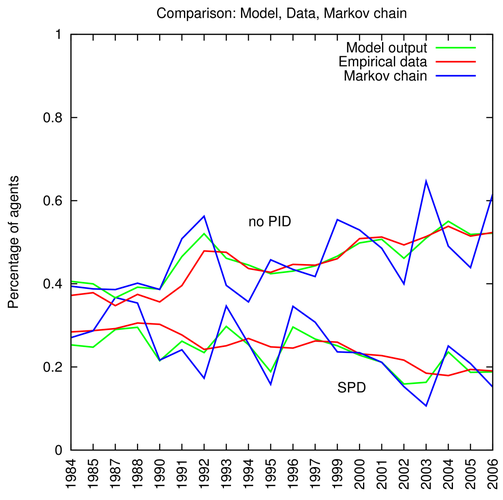


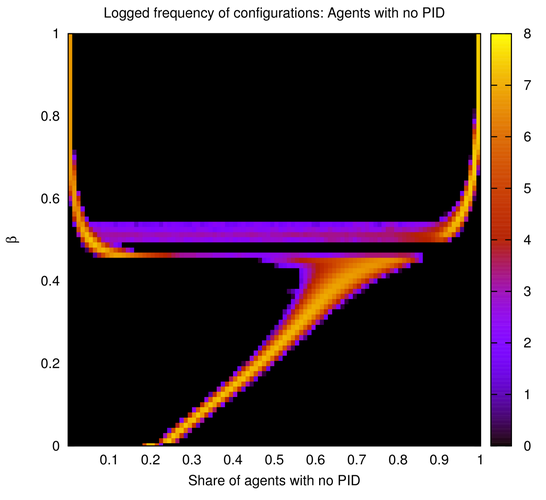


Share of parties for single simulation years against social temperature β for both major parties. Color indicates size of share.

For 1986, 1989 and 1998, the model converges to a CDU-dominated ground state. For the latter two years this change is also accompanied by a critical point with majorities altering between no PID and CDU.

- Ground states shift from no PID to CDU as dominant PID for both critical years
- Alteration independent of system size in 1998





Comparison: Best fit model output, empirical data and Markov chain prediction for no PID and SPD (left) and bifurcation plot of Matrix 1998/1999 (right, color indicates frequency of model configurations with given share of no PID and β).

Discussion and Outlook

Interpretation of model and critical points can be based on analogy to Ising-model

- Ising: Symmetric attractive forces (no external field) → critical point
- Here: Matrix = attraction may be asymmetric → critical point may be lacking
- Appearance of critical point could indicate symmetry between involved PIDs
- Underlying hierarchy (no PID on top) seems to change
- Possibly due to heightened salience of politics (1989, weakening of no PID) and rocky start of Schröder-government (1998, strengthening of CDU)

Simulating voters as complex system from data is a viable option in voting research

- Model is generalizeable: Agent-based modeling may possibly be used as tool for data analysis
- Possible modifications include: Change topology, subdivide category "no PID" and seek ways to disentangle individual and social factors and devise explicit rules governing PID-transmission.

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