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MSW ZENTRUM FÜR METHODEN DER SOZIALWISSENSCHAFTEN

Bounded Confidence Simulation Models in Politics: How parties might evolve, drift and unite

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Workshop: “Brains, Games, and (Social) Neurons: Physics and Social Sciences in Discussion”
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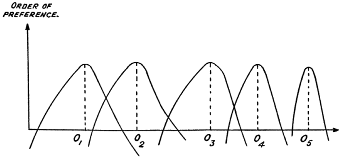
The spatial model

Assumptions

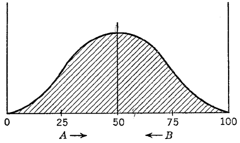
- Possible policies are on a 1d scale
- Voters have single-peaked preferences
- Parties are vote-seeking

Median Voter Theorem

- When 2 parties compete, they will both propose policies close to the median voter.
- The median voter is unbeatable in pairwise polls.

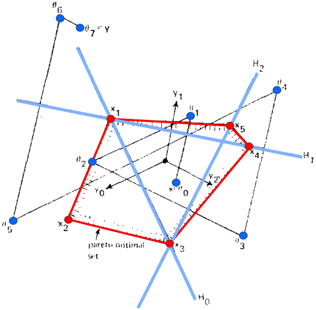


Single-peaked utility functions
Black, D., On the Rational of Group Decision-making, Journal of Political Economy, 1948



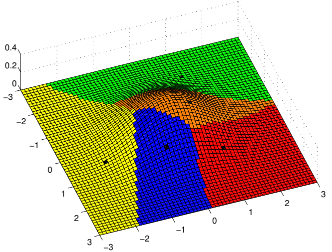
Distribution of voters ideal points
Downs, A., An Economic Theory of Democracy, 1957

Two Policy Dimensions, Chaos Theorem, Many Parties



Chaos Theorem In 2d policy spaces, the agenda-setter can (almost sure) find a seqeunce of polls to every policy. No equilibrium.

McKelvey, R., Intransitivities in multidimensional voting models and some implications for agenda control, Journal of Economic Theory, 1976

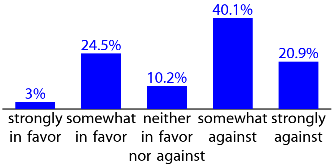


Adaptive parties in multi-party system
Agent-based model with HUNTER, AGGREGATOR, PREDATOR or STICKER strategies for parties. Complex dynamics with few agents.

Laver, M., Policy and the Dynamics of Political Competition, American Political Science Review, 2005

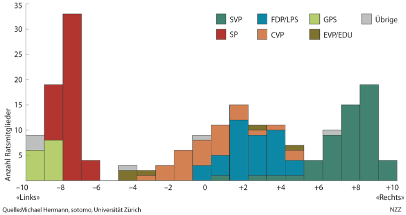
Empirical Stylized Fact: Bi-, Tri-modal distributions

How much are you in favor or against bailout payments for over-indebted EU countries?



Survey in Germany among 4,499 persons.

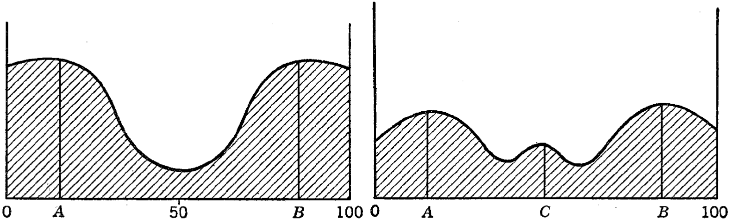
Bechtel, M.M., Hainmueller, J., Margalit, Y.M., Sharing the Pain: What Explains Public Opinion Towards International Financial Bailouts?, MIT Political Science Working Paper, 2012



Political positions Nationalräte Schweiz

Michael Herrmann, sotomo, Universität Zürich, in NZZ

Theoretical Necessity: Multimodal distribution of voters' ideal points



Downs, A., An Economic Theory of Democracy, 1957

Rational Extremists might abstain (1) as a threat to the closer party to not move central, or because (2) small differences of central parties are indistinguishable.

⇒ Many-party systems arise under proportional voting when ideal points are multimodal

⇒ Empirical multimodality is likely as many-party systems exist empirically

How do multimodel landscapes of ideal points form?

Idea: Multi-agent dynamics of adaptive voters adjusting their ideal points

Adaptive strategies/heuristics for voters

- Aim to **agree with others** but keep some trust in current position (Coordination Game)
  - $\to$ utility from minimizing distances to positions of others and own
  - $\to$ with (singlepeaked) utility functions $u(y) = -\sum_k (y - x_k)^2$ myopic agents choose **arithmetic average** as new position $y = \frac{1}{\#\{k \mid k \text{ relevant}\}} \sum_k x_k \rightsquigarrow x_i(t+1) = \frac{1}{\#\{k \mid k \text{ relevant}\}} \sum_k x_k(t)$

    Groeber, P., Lorenz, J., Schweitzer, F., A microfoundation of social influence in models of opinion formation, "minor revision" at Journal of Mathematical Sociology, 2012

- Aim to avoid others which are far away (**Homophily**)

  Feld, S., Grofman, B., Homophily and the focused organization of ties, Oxford Handbook Analytical Sociology, 2009
  - $\to$ Agent i chooses agent k as relevant when $|x_i - x_k| < \varepsilon_i$ (**bounded confidence**)

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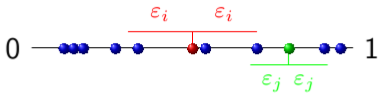
Bounded Confidence Opinion Dynamics Models

- N agents (e.g. $N = 250$)
- Each agent starts with an **initial opinion** x_i between 0 and 1
- Each agent has an initial **bound of confidence** $\varepsilon_i > 0$ (e.g. $\varepsilon_i = 0.2$)

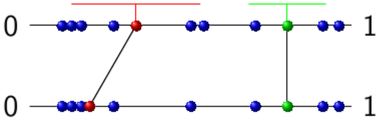


- **Bounded Confidence Models**: Each agent is only willing to adjust towards opinions within its area of confidence

Survey: Lorenz, J. Continuous Opinion Dynamics under bounded confidence: A Survey, International Journal of Modern Physics C, 2007

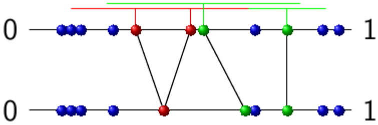
Two Models: Different Communication Regimes

- Interaction with whole group **Hegselmann-Krause Model**



Hegselmann, R., Krause, U., Opinion Dynamics and Bounded Confidence, Models, Analysis and Simulation, Journal of Artificial Societies and Social Simulation, 2002

- Pairwise interaction **Deffuant-Weisbuch Model**



Deffuant, G., Neau, D., Amblard, F., Weisbuch, G., Mixing Beliefs among Interacting Agents Advances in Complex Systems, 2000

Simulation

Netlogo-Model

Lorenz J., Continuous Opinion Dynamics under Bounded Confidence,
http://ccl.northwestern.edu/netlogo/models/community/bc, March 2012

Dynamics

1. Extermists move towards center
2. Density at extremes rises
3. Dense regions attract agents from center
4. Clusters emerge close to extremes
5. And so on, until the center is reached

Basic Facts and Questions

- A stable configuration of opinions emerges
- The stable configuration is clustered
- Prerequisite for a simulation (external parameters):
  - Initial profile of opinions $x_i(0)$
  - Bounds of confidence ε_i
- What is the impact on the final configuration?
  - Number of parties
  - Location of parties
  - Size of parties

From agents to densities of agents

Regard density function on the opinion space

$$P(t, \cdot) : [0, 1] \to \mathbb{R}_{\geq 0}$$

for all $t \in \mathbb{N}$

$$\int_0^1 P(t, x)dx = 1.$$

Density evolution in the Hegselmann-Krause model[1]

$$P(t+1,x) = P(t,x) + \int_S \underbrace{\delta(x - M_1(y, P(t,\cdot),\varepsilon))P(t,y)}_{\text{fraction joining state x}} - \underbrace{\delta(y - M_1(x, P(t,\cdot),\varepsilon))P(t,x)}_{\text{fraction leaving state x}} dy$$

with ε-local barycenter

$$M_1(x, P(t,\cdot), \varepsilon) = \frac{\int_{x-\varepsilon}^{x+\varepsilon} yP(t,y)dy}{\int_{x-\varepsilon}^{x+\varepsilon} P(t,y)dy}.$$

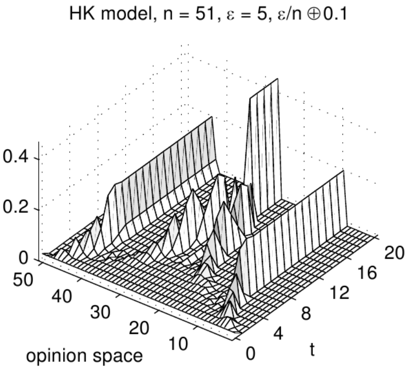
[1] Fortunato et al, IJMPC 2004, Lorenz, MSO Conference, 2004

Density evolution in the Deffuant-Weisbuch model[2]

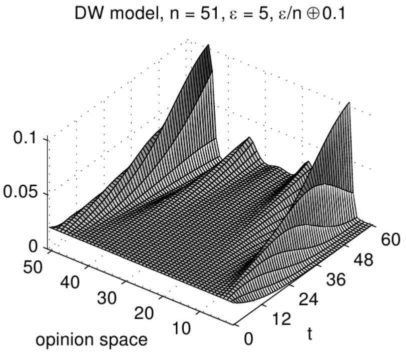
$$P(t+1,x) = P(t,x) + \int_S \int_{||x_1 - x_2|| \leq \varepsilon} P(t,x_1)P(t,x_2) \Bigg(\underbrace{\delta(x - \frac{x_1 - x_2}{2})}_{\text{fraction joining state x}} - \underbrace{(\delta(x - x_1) + \delta(x - x_2))}_{\text{fraction leaving state x}} \Bigg) dx_2 dx_1$$

[2] Ben-Naim et al, Physica D 2003

Computation with discrete approximation [3]



- HK model converges in finite time



- DW model converges smoothly

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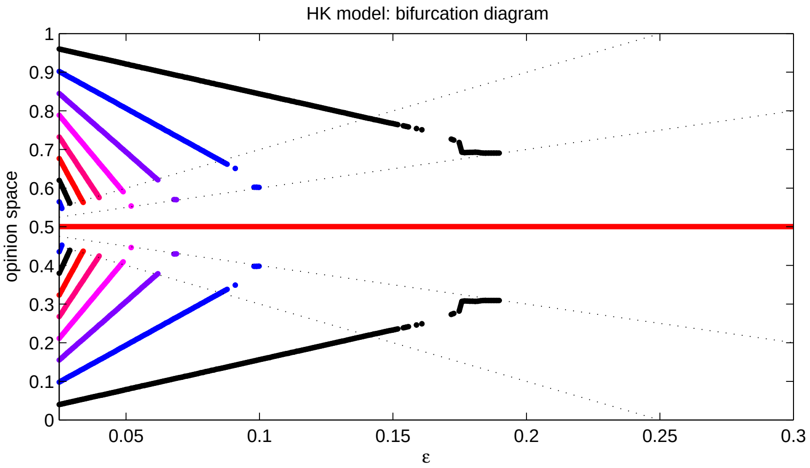
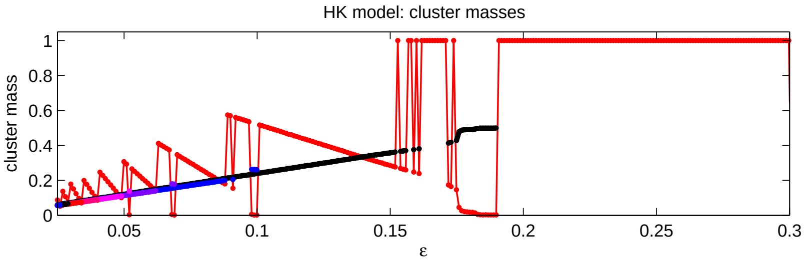
[3] Jan Lorenz, MSO Conference 2004, Jan Lorenz, JASSS 2006

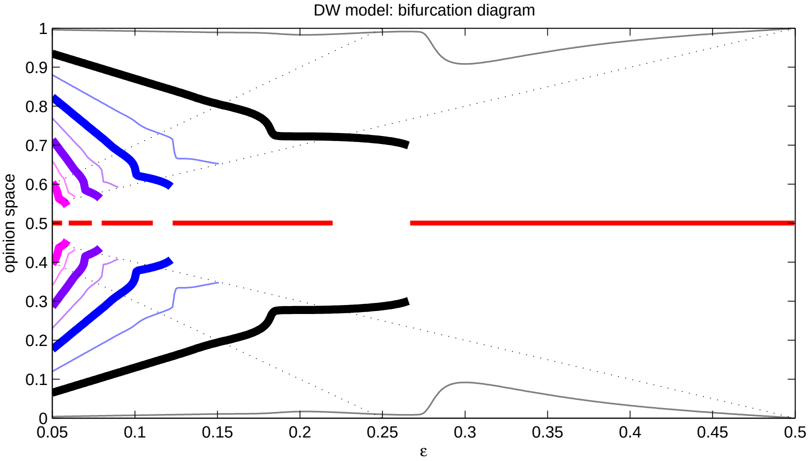
Cluster Location Bifurcation in Hegselmann-Krause



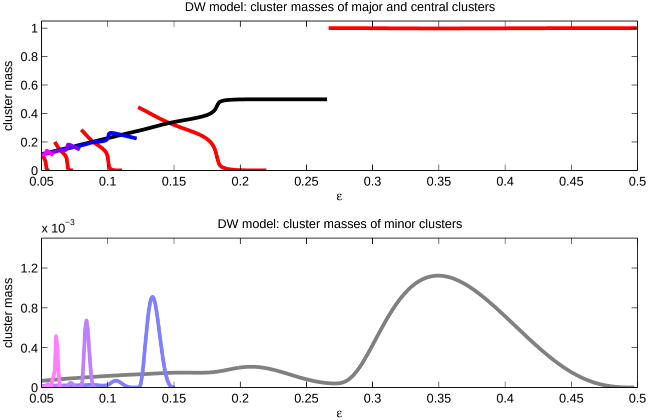
Cluster Sizes in Hegselmann-Krause



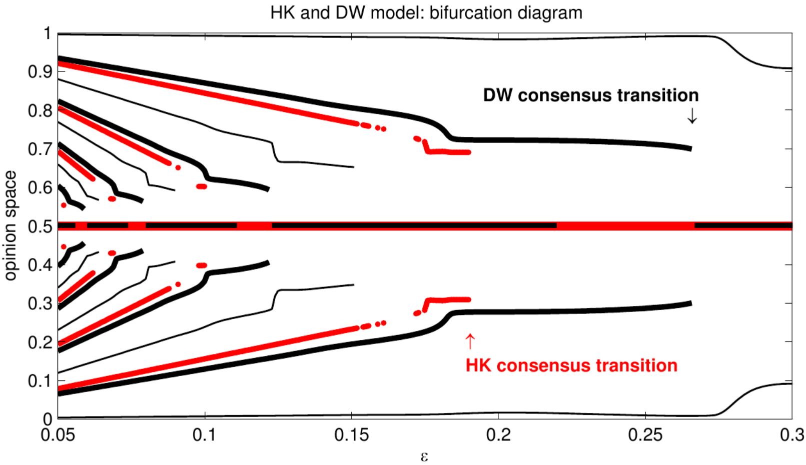
Cluster Location Bifurcation in Deffuant-Weisbuch



Cluster Sizes in Deffuant-Weisbuch



Consensus Transition



Extensions and Simulation

- **Random Exit, Entry of new opinions** With small probability p an agent chooses a new opinion from the intial distribution
- **Heterogeneous bounds of confidence** Agents differ in their willingness to take opinions of others into account
- **Extremists** Agents with extreme opinions do not change opinion by definition

- **Higher-dimensional policy spaces** With budget restriction or not?
- **Other sources of noise** Check robustness of clustering dynamics!
- **Smooth-bounded confidence**

Research Collaboration

Open interdisciplinary agenda for researchers with backgrounds in **many-particle physics** or **political science**

- Develop **spatial models** of **political deliberation** based on
  - bounded rationality (e.g. myopic agents)
  - incomplete information (e.g. due to limited attention or information processing capabilities)
  - heuristic strategies (e.g. for adaption, adjustment, choice of communication partners)
- Analyze **eigendynamics** of these models with
  - Monte Carlo simulation and
  - rate equations
- Far aim: Produce policy implication for communication and decision in a deliberative democracy
  - e.g. **How to foster consensus using eigendynamics?**