A Model of Policy Formation through Simulated Annealing

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Introduction

- Why was the 113^{th} U.S. Congress so unproductive?
- Do diversity and policy divides result in deadlock and dissatisfaction?

Traditional Modeling

Congressional voting reflects ideology, influences and committee dynamics.

Our Contribution

- General model, broadly applicable to complex behaviors of policy-making organizations
- Computational model of policy development in which ideology is arbitrary
- The process optimizes satisfaction within a system of competing preferences

Simulated Annealing

Non-deterministic method to fit proposals to preferences

Model and its Cases

- A model of policy formation through simulated annealing
- Each 'session' is a unique mix of legislators; new network
  - a legislator proposes a solution to an issue
  - others append positions on other issues to make the draft favorable
  - once among peers and again in committee
  - final vote
- We measure productivity, satisfaction, *etc* at the session level

Initialization

- Generate a `State` object to hold scenario parameters
- Includes 100 heterogeneous legislators
- Organizes legislators into a network, committees
- Party and state priorities are set

Model Environment

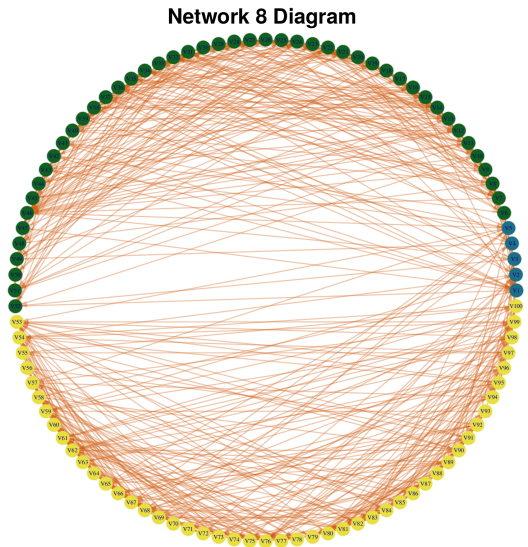
- Party "platforms" are positions and priorities of key issues
  - includes and state-level priorities
  - random sample of other issues
- Platforms are seeds for stochastic generation of legislator preferences

Legislators

- Legislator issue priorities assigned with stochastic preference to state seed values
  - Power-law distributed priority set for each legislator
  - Have one of $2^4 = 16$ possible positions on each issue
- Creates heterogeneous set of legislator agents with correlated issue priorities within a party

Network

- Final step: legislators networked through homophily, preferential attachment (PA)
  - PA $m = 5$ new edges randomly selected from *pdf* from potential allies
  - Preference-weighted likelihood over all issues
- Produces "small world" network, like Congress



Simulation

- Legislators begin to legislate
- Up to 200 proposals for each session
- Session stops if all 75 issues pass

Proposal

- Random legislator selected
- Proposes a draft with their position on any issue not passed into law

Draft Circulation

- Peers (first-order connections) co-sponsor the bill
- Co-sponsors revise the draft via SA
  - may add issues
  - may revise positions

Committee Review

- Draft goes to committee
- Legislators with core issue as high-priority makeup the committee
- Committee revises sponsored draft via SA (same rules)

Floor Vote

- Bill referred to floor
- Legislators vote 'yes' if their satisfaction
- Simple majority passes bill into law
  - issue removed from future work
  - model logs statistics for analysis

Simulated Annealing

- Implemented as Metropolis algorithm
- Energy is the cumulative dissatisfaction of all reviewers, over all dimensions
- Dissatisfaction increases of 0.1 accepted with 50% probability at max temperature
- Higher satisfaction energy states accepted automatically

Calibration

- Calibrated primarily with `satisfaction_threashold` parameter
- Adjusted to match real-world 4%, average in recent history

Experiments

Table : Simulation Parameter Space

Parameter	Description	Value [Variation]
`Unaffilitated_Fraction`	Fraction of the legislative population with no ideological party affiliation.	[0.05, 0.5, 1.0]
`Green_Fraction`	Fraction of the party-affiliated population belonging to the *Green* party. Remainder belong to the Yellow party.	[0.5, 0.75, 1.0]
`Ideology_Issues`	Ideological platform issues for the parties.	[0, 5]
`State_Priorities`	High-priority issues for all legislators, regardless of affiliation.	[0, 5]

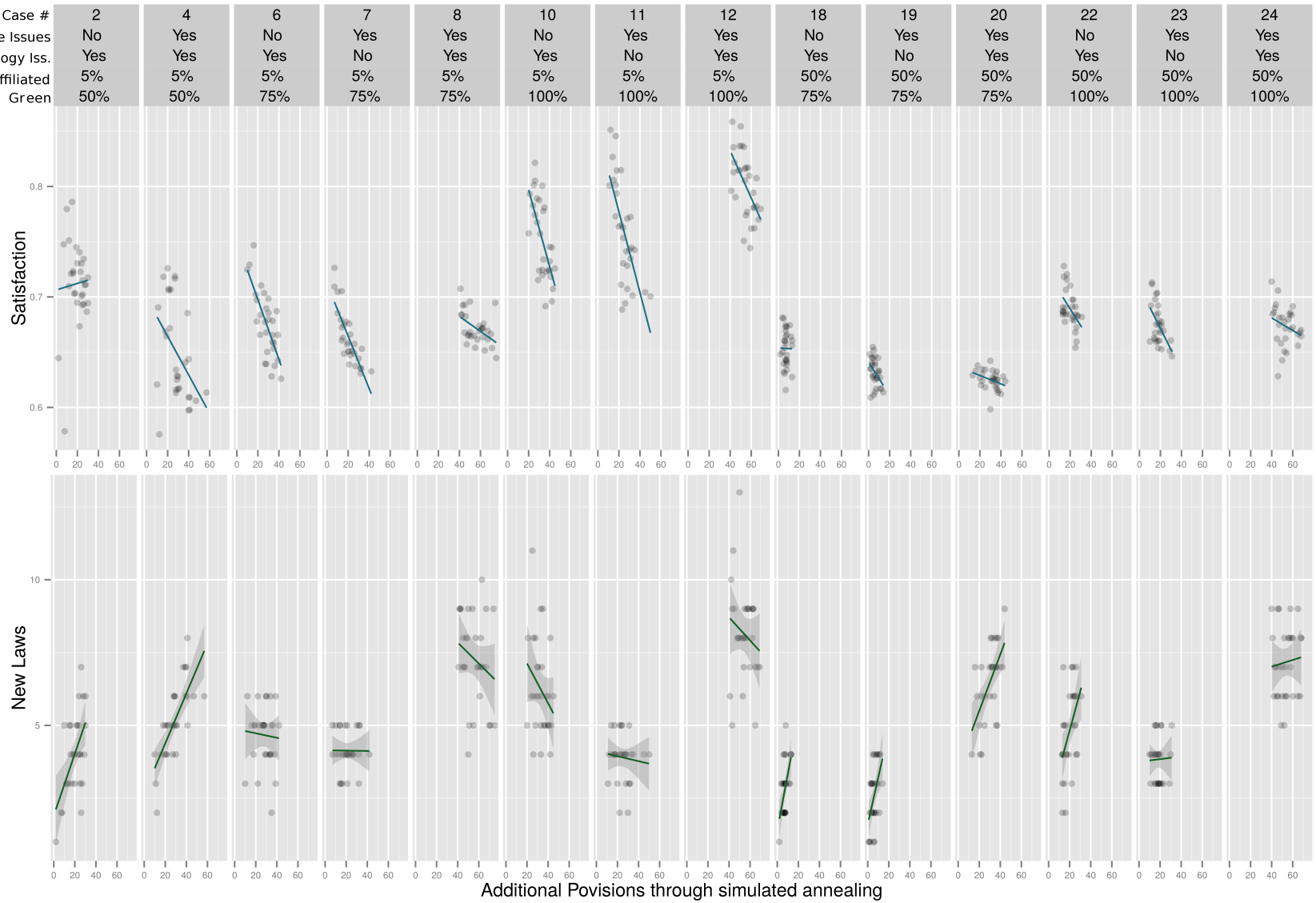
- 28 unique experiment combinations
- 30 simulations per experiment

Results

On dysfunction:

Fourteen of 28 cases produced **NO** laws

- All four cases with no party structure
- Scenarios with 50% unaffiliated, 25% Green, 25% Yellow
- Scenarios with no external priorities
- One other case with 5% unaffiliated, 50% Green and no ideology-based priorities


Case #
State Issues
Ideology Iss.
Unaffiliated
Green
2 4 6 7 8 10 11 12 18 19 20 22 23 24
No Yes No Yes Yes No Yes Yes No Yes Yes No Yes Yes
Yes Yes Yes No Yes Yes No Yes Yes No No Yes No Yes
5% 5% 5% 5% 5% 5% 5% 5% 50% 50% 50% 50% 50% 50%
50% 50% 75% 75% 75% 100% 100% 100% 75% 75% 75% 100% 100% 100%
Satisfaction
New Laws
Additional Povisions through simulated annealing

Findings

Finding #1

Higher correlation of preferences results in higher productivity.

Evidence

Compare cases 6 and 7 to cases 8, 10 and 12, for example.

Findings

Finding #2

Higher productivity requires increased number of additional provisions.

Evidence

Nine of 14 cases show positive correlation; 3 others show high threshold minimum.

Findings

Finding #3

Partisanship is not necessarily an impediment to productivity.

Evidence

See cases 2 and 4.

Findings

Finding #4

Bipartisan networks (even division of party-affiliated legislators) with more external priorities can be more productive than majorities or super-majorities with fewer external priorities.

Evidence

Compare cases 4 to cases 11, 18, 19, and 28.

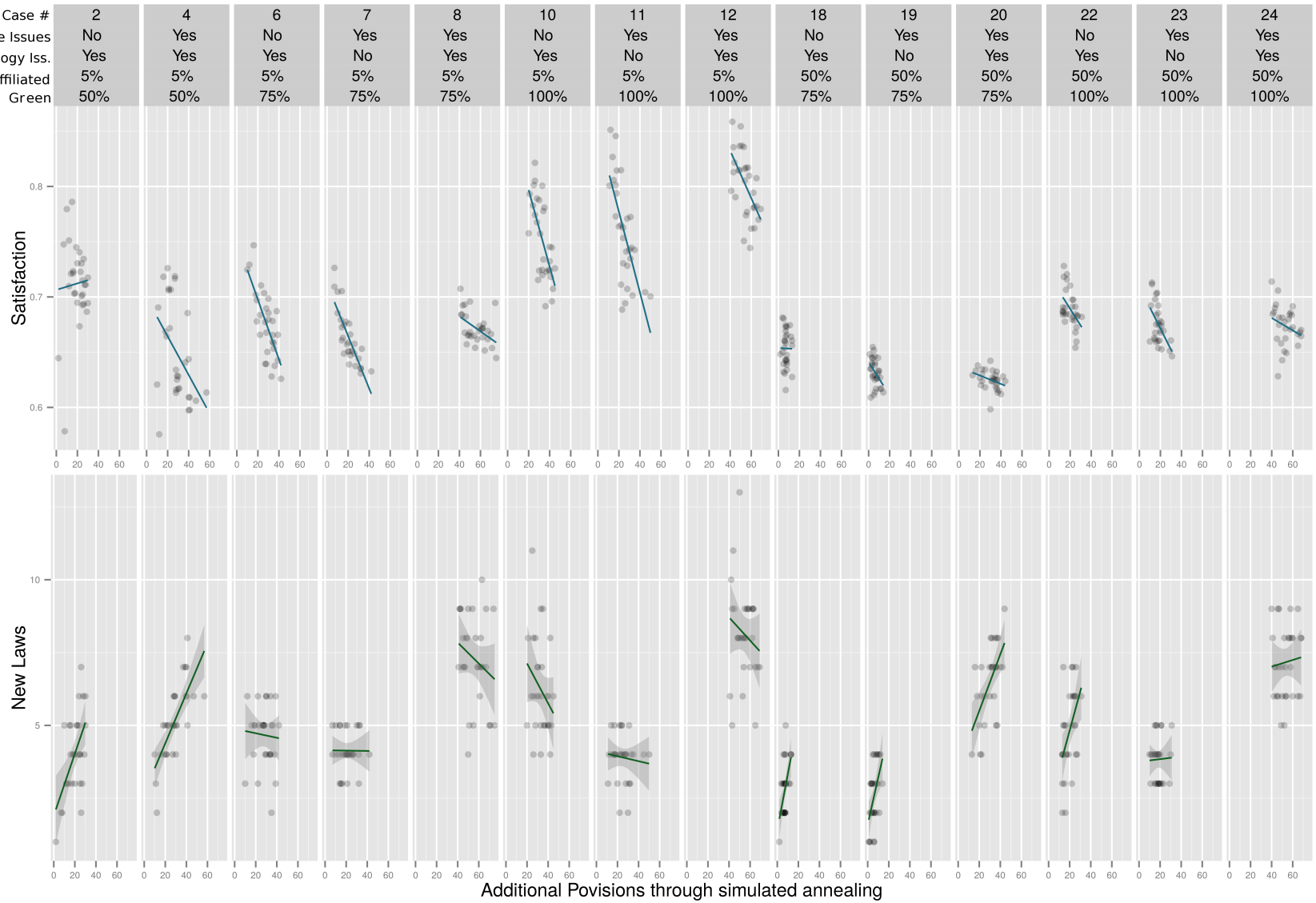
Findings

Finding #5

Overall satisfaction decreases with increases number of additional provisions, but productivity is higher.

Evidence

Cases 4, 7, 18, 19, 20, 22, 23, and 24.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Discussion

- Externally-defined priorities
- Impact of polarization
- Efficiency vs productivity and the additional provisions
- More provisions reduces satisfaction

External Priorities

- Having external priorities is important for productivity
  - The more, the better (observed in our experiments)
  - Absence of external priorities correlates with no productivity
- Future research should look at role of leadership

Polarization

- We expected evidence that polarization reduces productivity and satisfaction
  - Findings #3 and #4 do not support this hypothesis
  - Dysfunction of the 113^{th} U.S. Congress may be caused by something else

Productivity

- Riders on bills is the "cost of doing business"
  - Can increase productivity
  - Usually decrease satisfaction
- Also decreases system efficiency

Satisfaction

- Compromise leads to minimum of satisfaction
  - Perhaps some bills start off with low satisfaction and add provisions to garner votes?
  - How much of a majority is required to overcome dissatisfaction levels?
- Can leadership intervention overcome unproductive structures? (ideology or priorities?)

Implications for Future Research

- Network structures and characteristics
  - Experiment with finer resolutions to find tipping points in system behaviors
  - Can we find thresholds that produce both productivity and satisfaction?
- External priorities
  - How much leadership intervention will overcome unproductive structures?
  - How many state priorities are required to ensure preference correlation?

Summary

- We modeled policy-making with SA as complex problem with interdependent constraints
  - Case study: U.S Congress legislation process
  - Method is applicable to other social processes
- Partisanship
  - Alone, does not impede productivity and satisfaction
  - Overcome with priority and preference alignment
- Simulated Annealing
  - Useful to model policy-making computationally
  - Recommended for other research