The Fragility of Opinion Formation by Propagation

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A motivating experience

In 2014, a series of protests, political demonstrations, and civil insurrection began in Venezuela...

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- Following the death of President Hugo Chávez in 2013, Nicolás Maduro was elected
- Began in February 2014 following an attack on a student at a university campus
- The protests have not stopped since with a new height after 2018 presidential elections
- By mid-2019, over four million Venezuelans (13% of the country's population) had emigrated

https://en.wikipedia.org/wiki/Venezuelan_refugee_crisis

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Venezuela's government should address the people's legitimate grievances...

Asked all deaths and reports of abuses by the government security forces to be investigated...

We must respect the right to peaceful protest...

We trust that the government of President Maduro will preserve the constitutional order...

President of Syria Bashar al-Assad expressed his support in a letter to President Maduro,...

https://en.wikipedia.org/wiki/Reactions_to_the_2014-2017_Venezuelan_protests

What happens when we generalize
from this single occassion
to a whole learning process?

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- Or does the average Joe start by believing the right things and end up trusting in flat Earth?
- Intuition from complexity research: It may get tricky!

https://www.boredpanda.com/americans-place-european-countries-on-map

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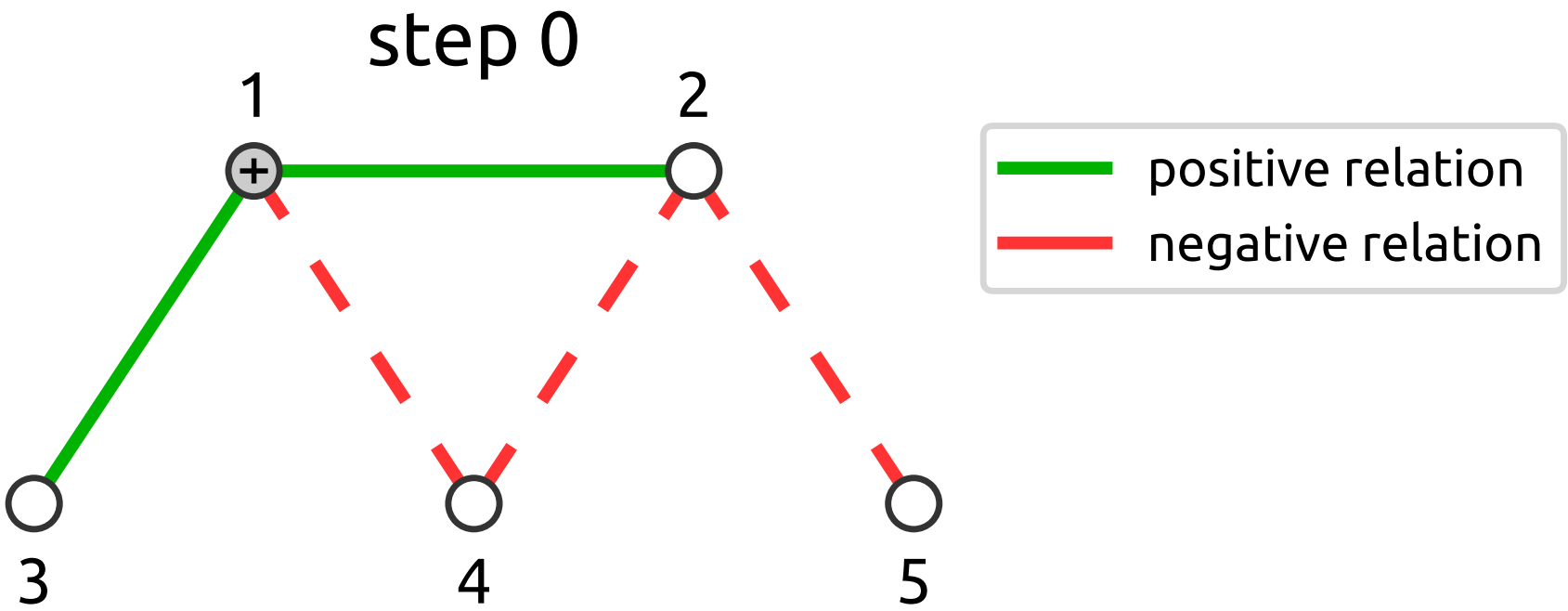
  3. Instead of making opinion about country leaders, the opinion making can be about news sources

Model at work



Nodes: entities on which opinion is to be made

Links: signed relations between the entities

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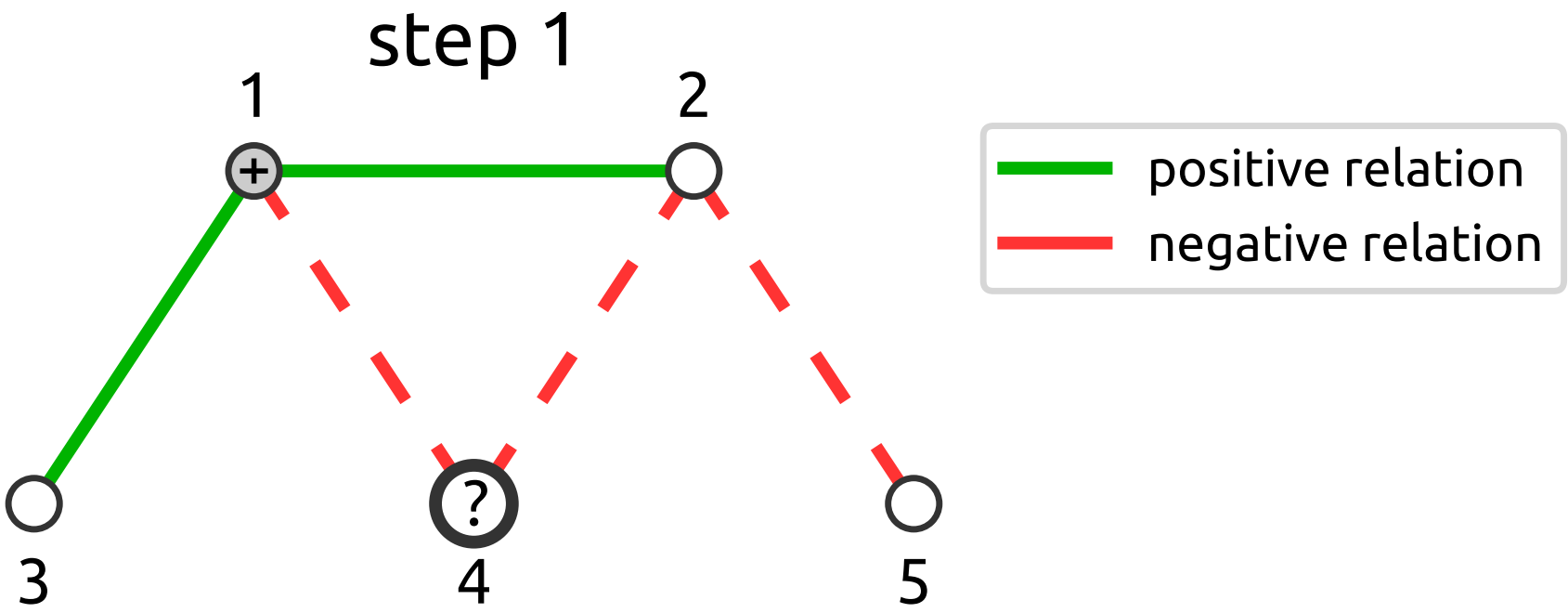

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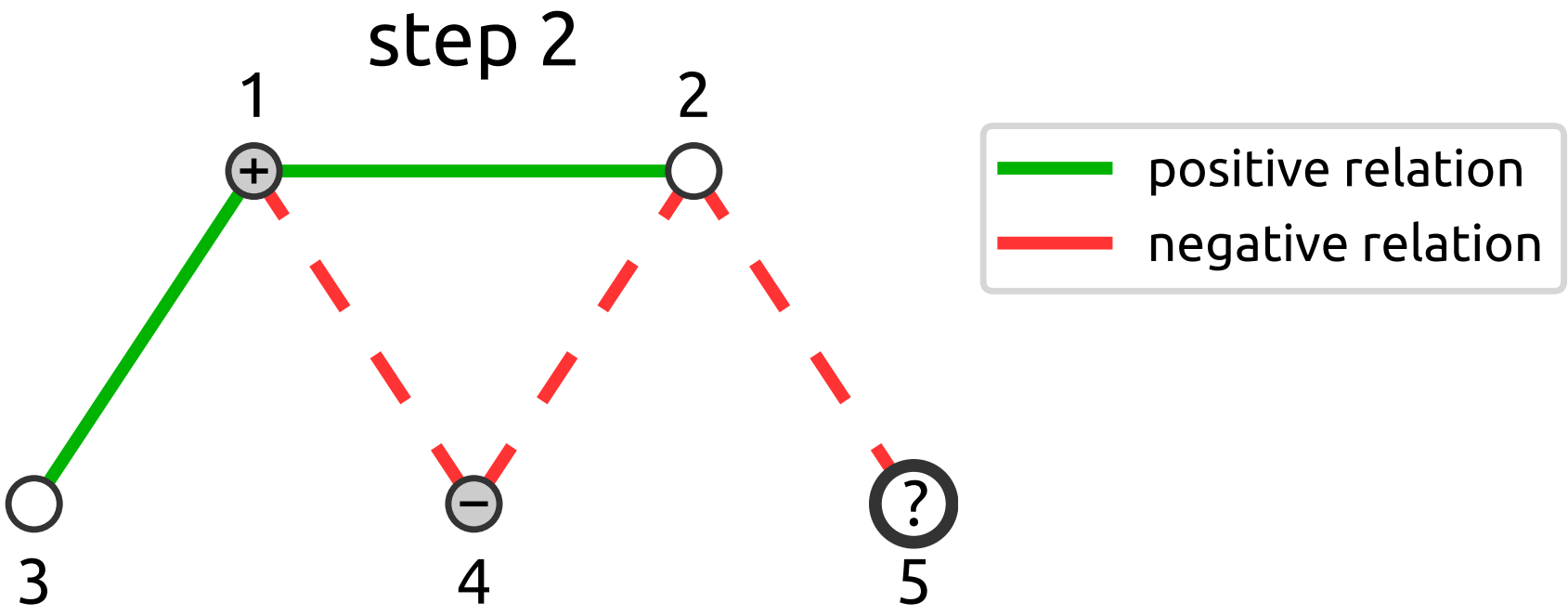

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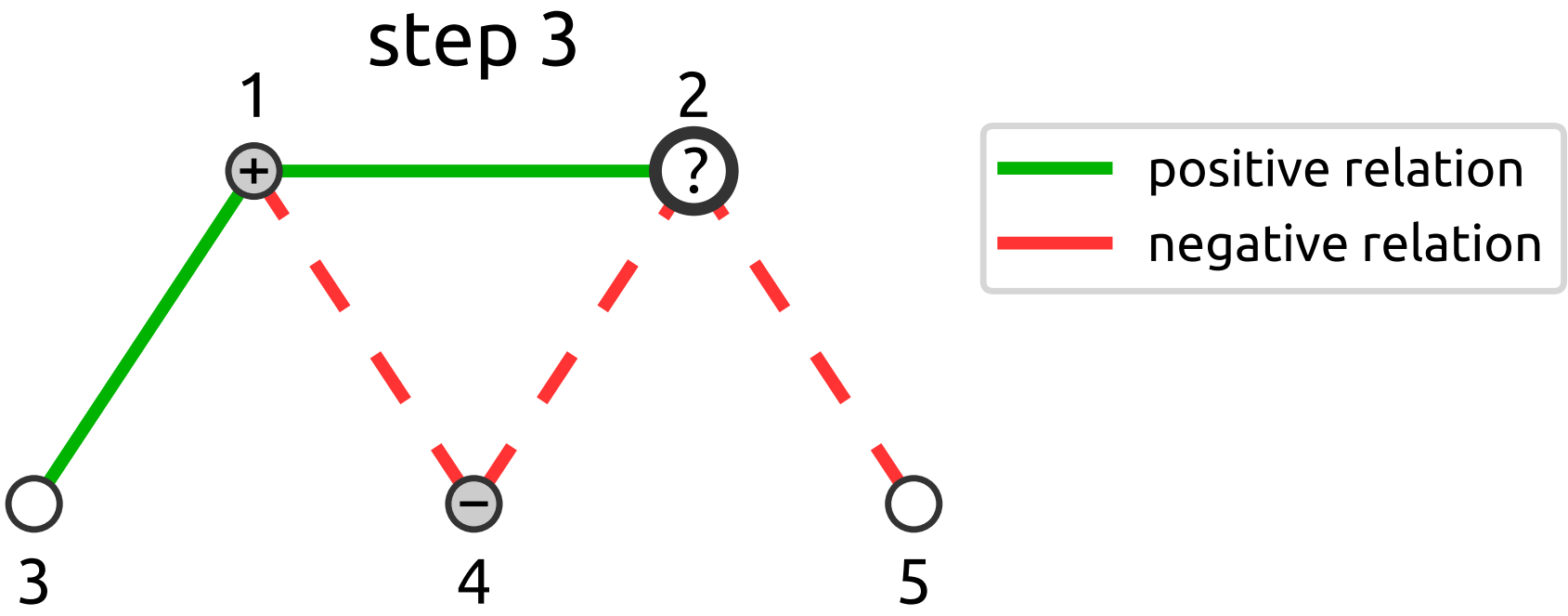

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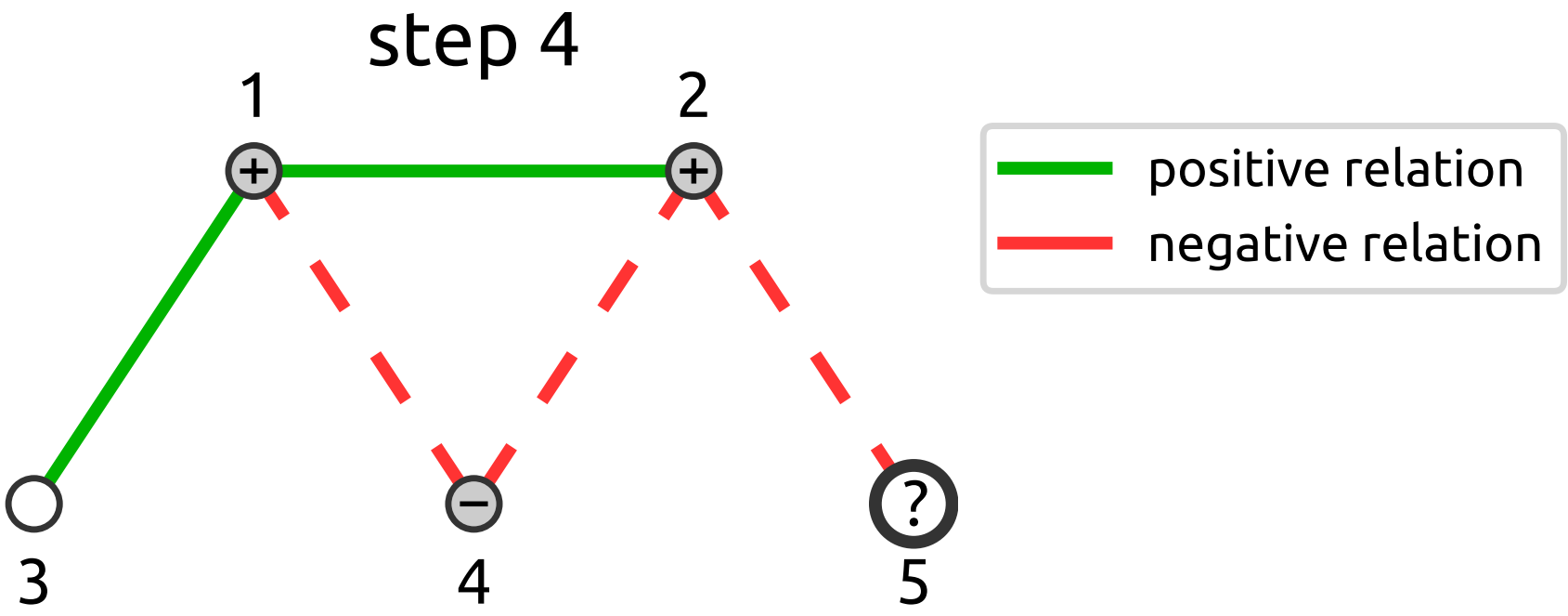

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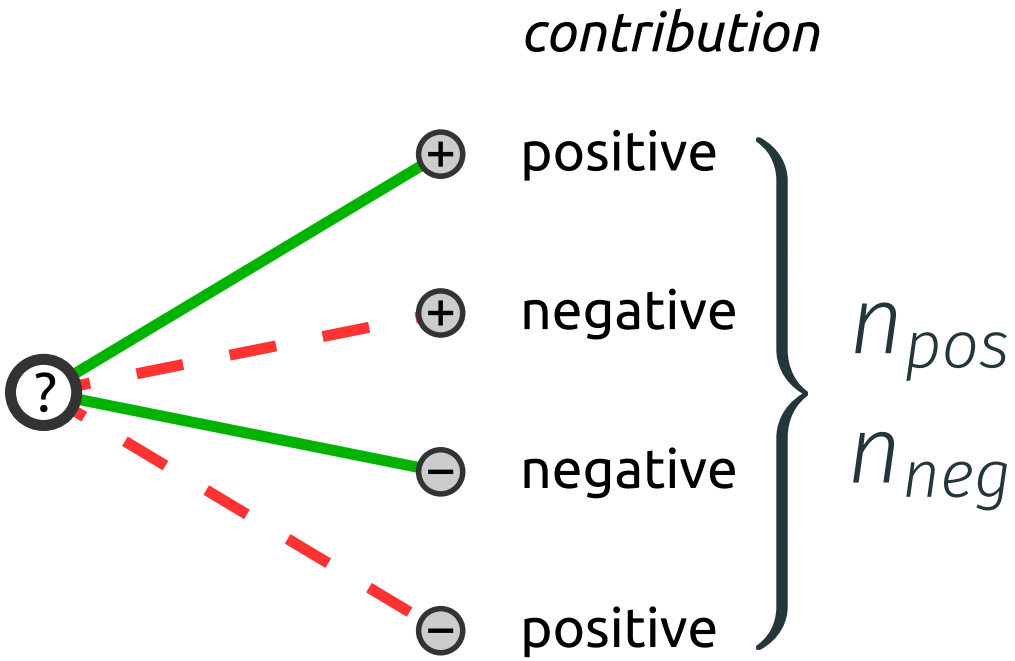
The person: outside, not a social network

Model basics



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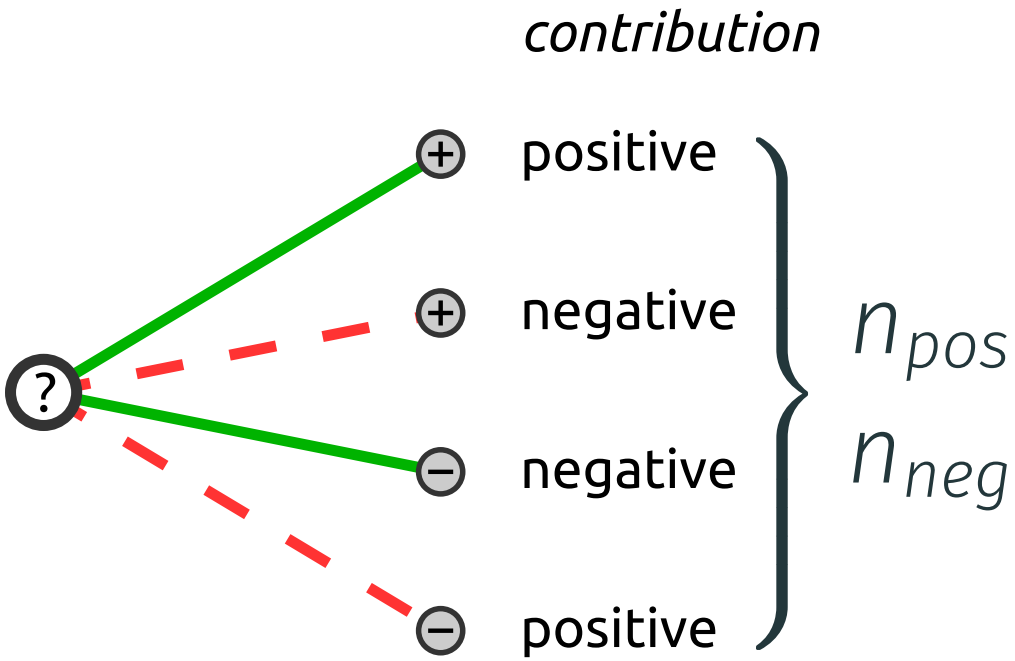

Two model variants:

1. Majority: Positive opinion if $n_{pos} > n_{neg}$
2. Probabilistic: Positive opinion with probability $\frac{n_{pos}}{n_{pos} + n_{neg}}$

Model basics

No social interactions

Gracie Williams/KANSAN

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N entities divided in two opposing camps:

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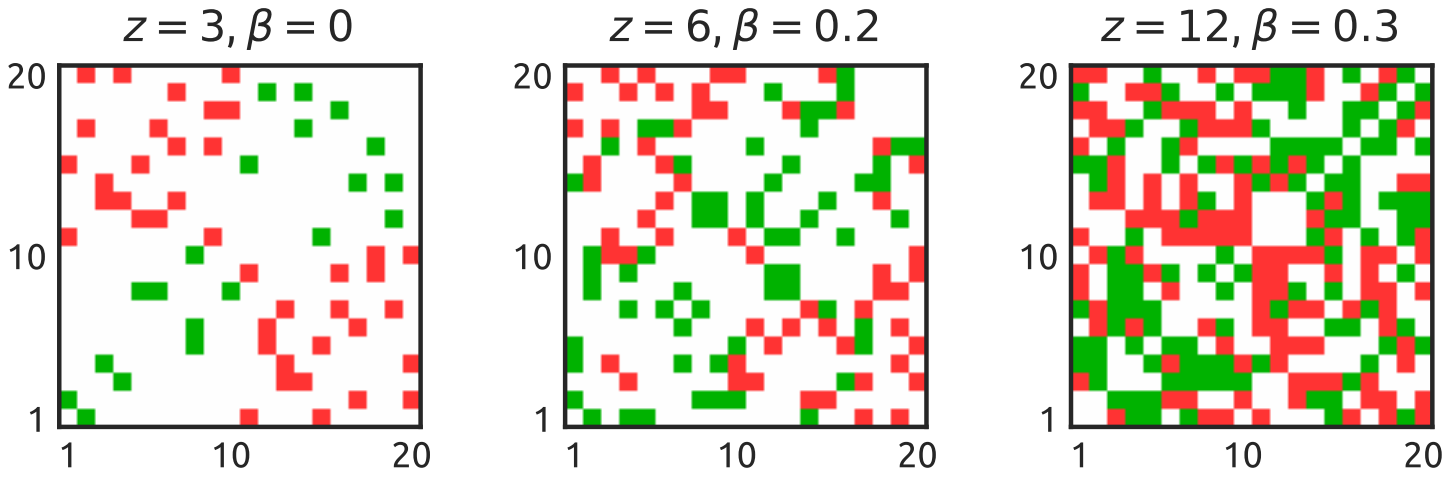

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- Opinion consistency

$$C = \frac{1}{N-1} \sum_{i \neq s} o_i T_i$$

where opinion $o_i \in \{+1, -1\}$ and $T_i = 1$ for $i = \{1, \ldots, N/2\}$ and $T_i = -1$ otherwise

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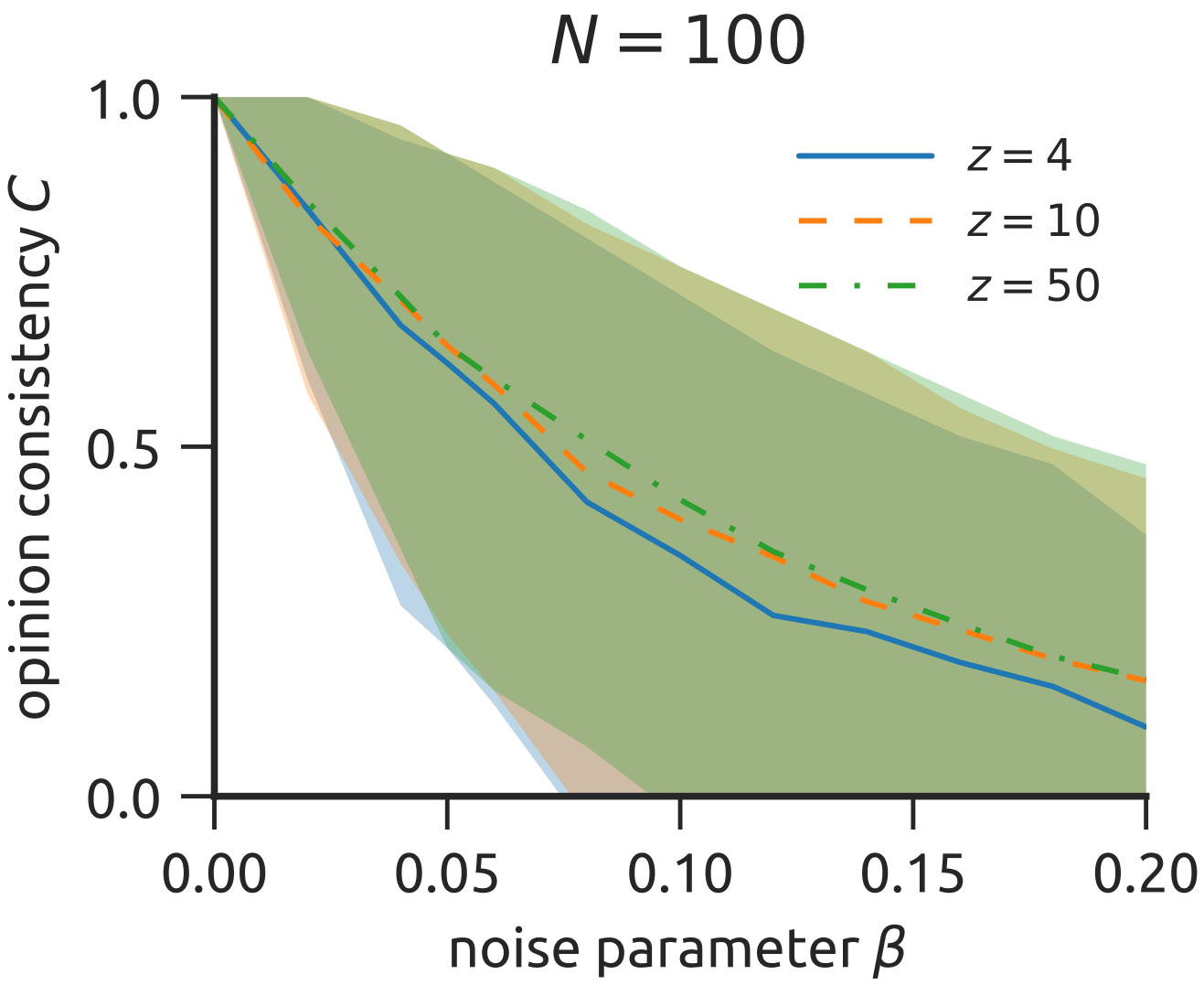
  - Opinion in line with the two-camp structure: $C = 1$
  - Random opinion: $C = 0$

Consistency in the two-camp scenario



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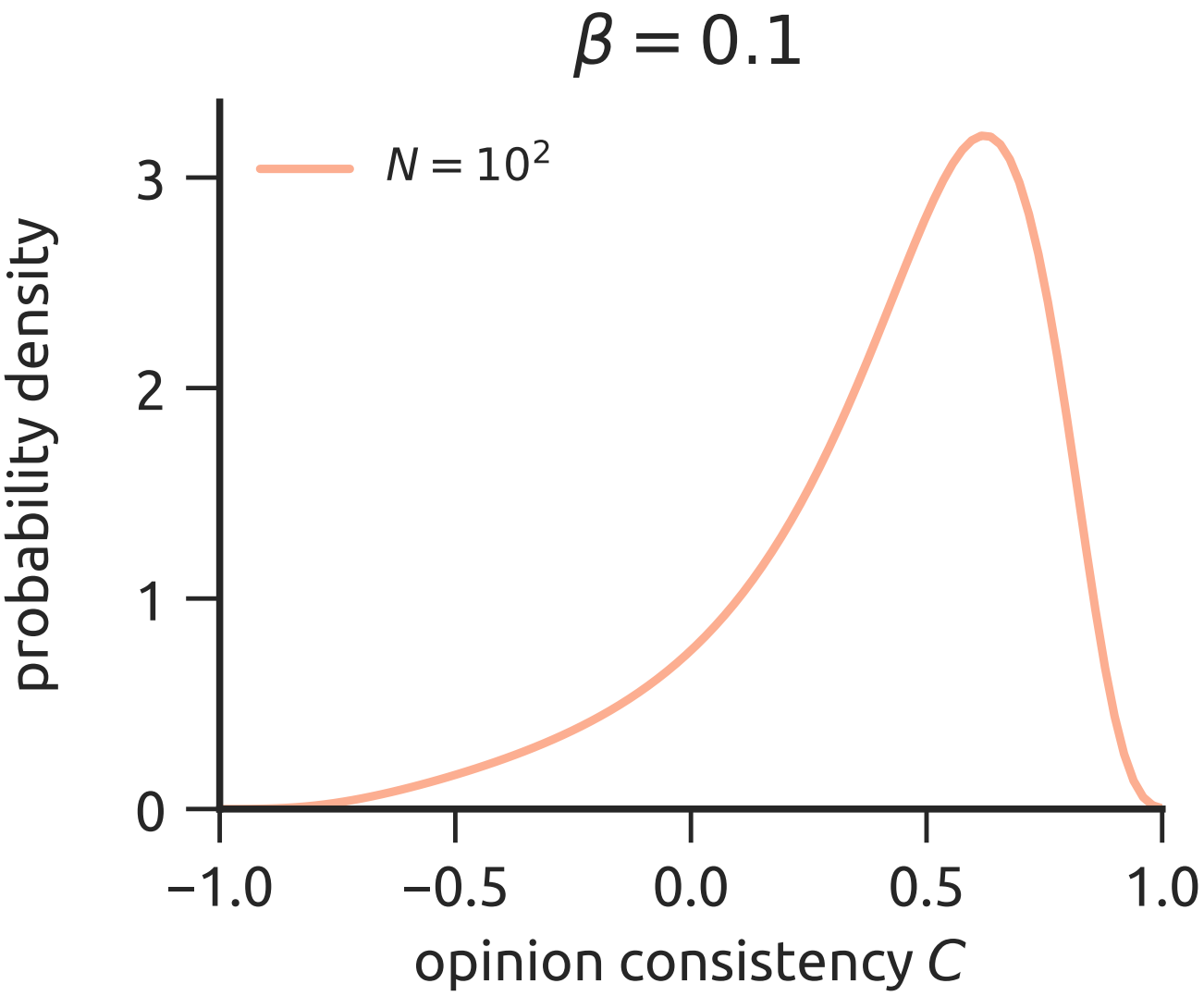

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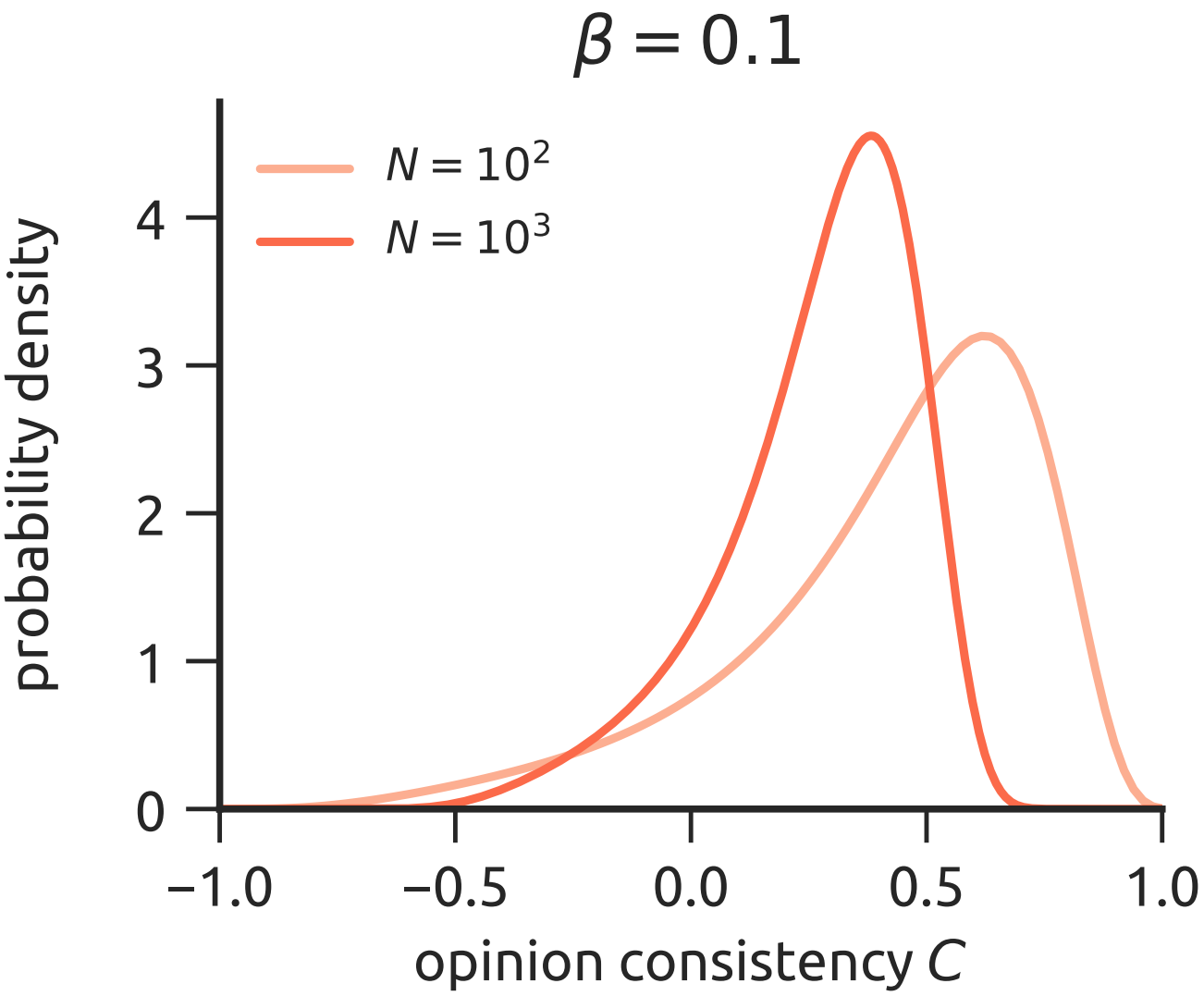

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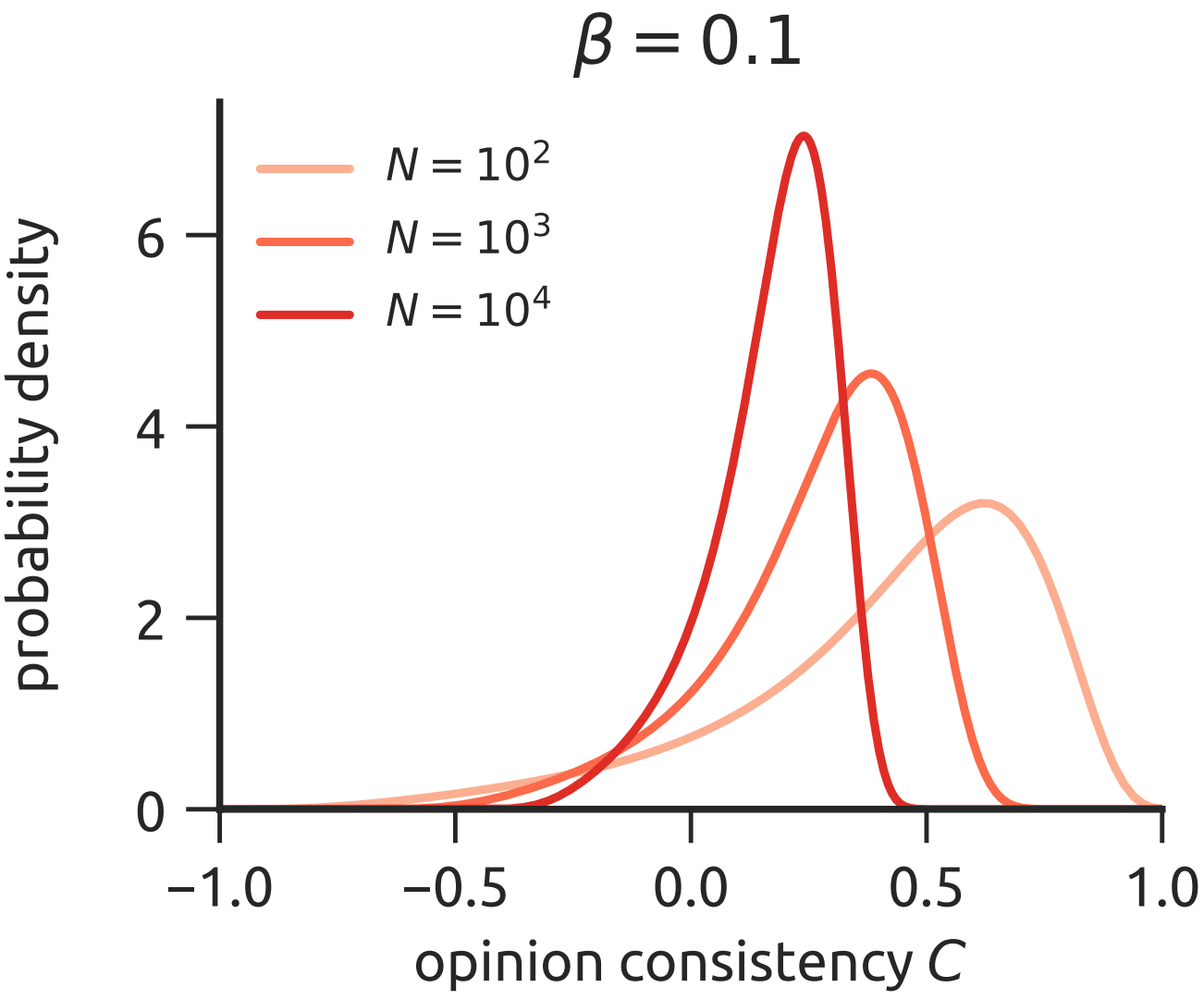

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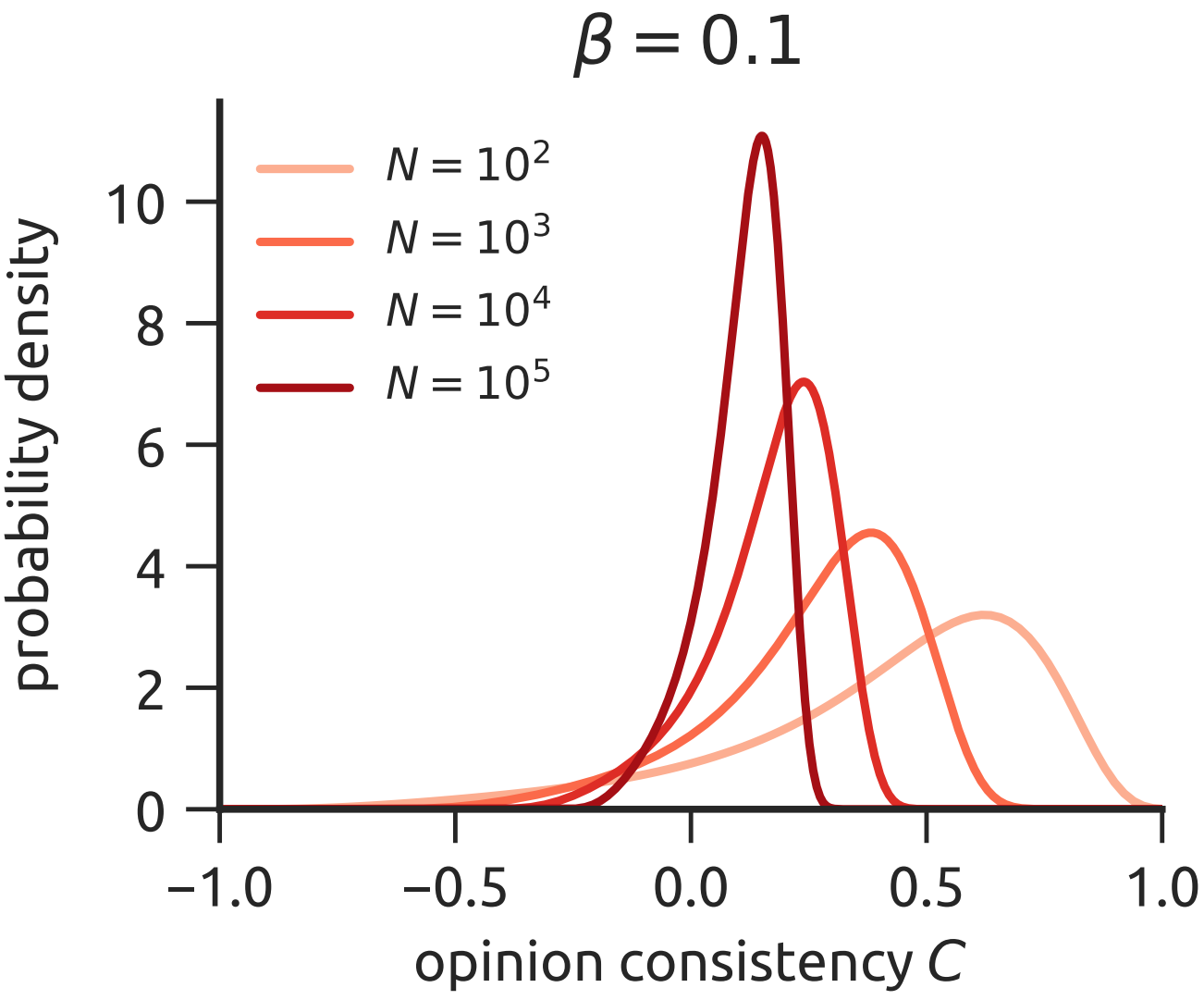

Master equation

- Analytical solution in terms of probability that c out of n opinions are consistent, $P(c; n)$

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$$P(c;n) = P(c-1;n-1)\,\frac{c(1-2\beta)+\beta(n+1)-1}{n-1} + P(c;n-1)\left[1-\beta-\frac{c(1-2\beta)}{n-1}\right]$$

$$\Downarrow$$

$$\mu(C) = \ldots, \qquad \sigma(C) = \ldots$$

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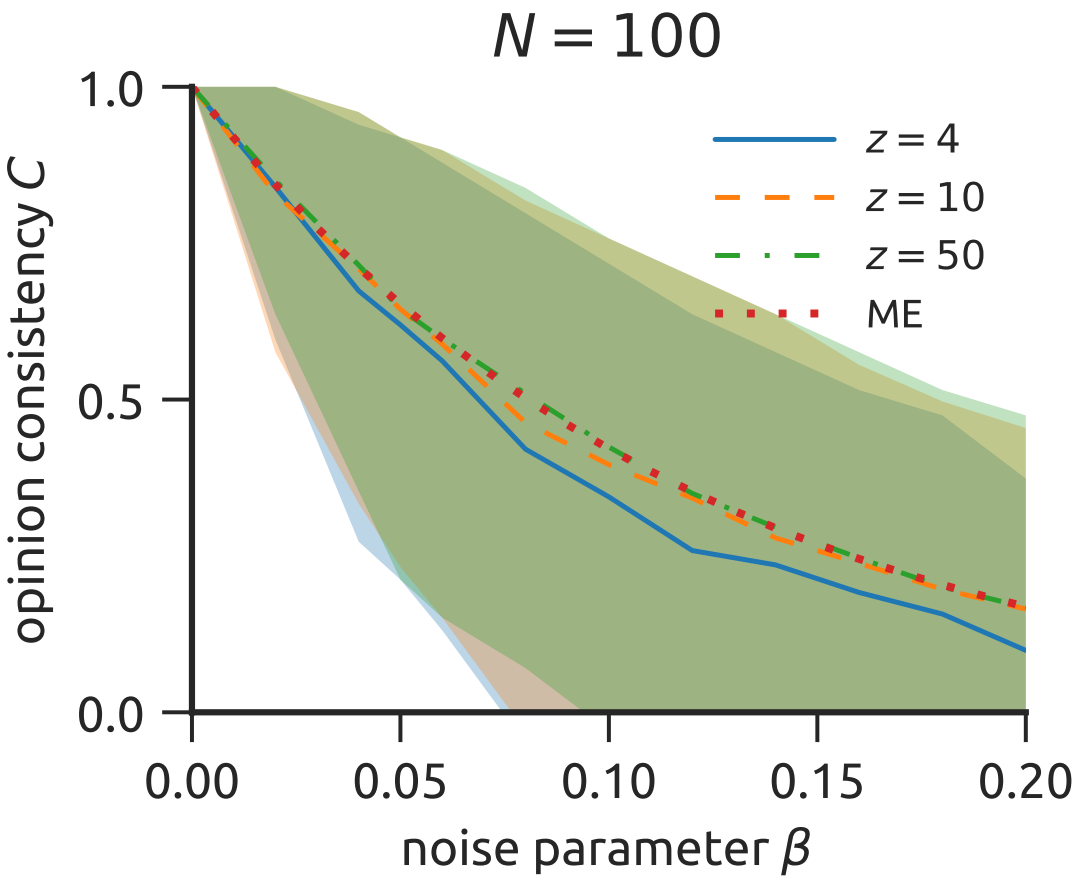

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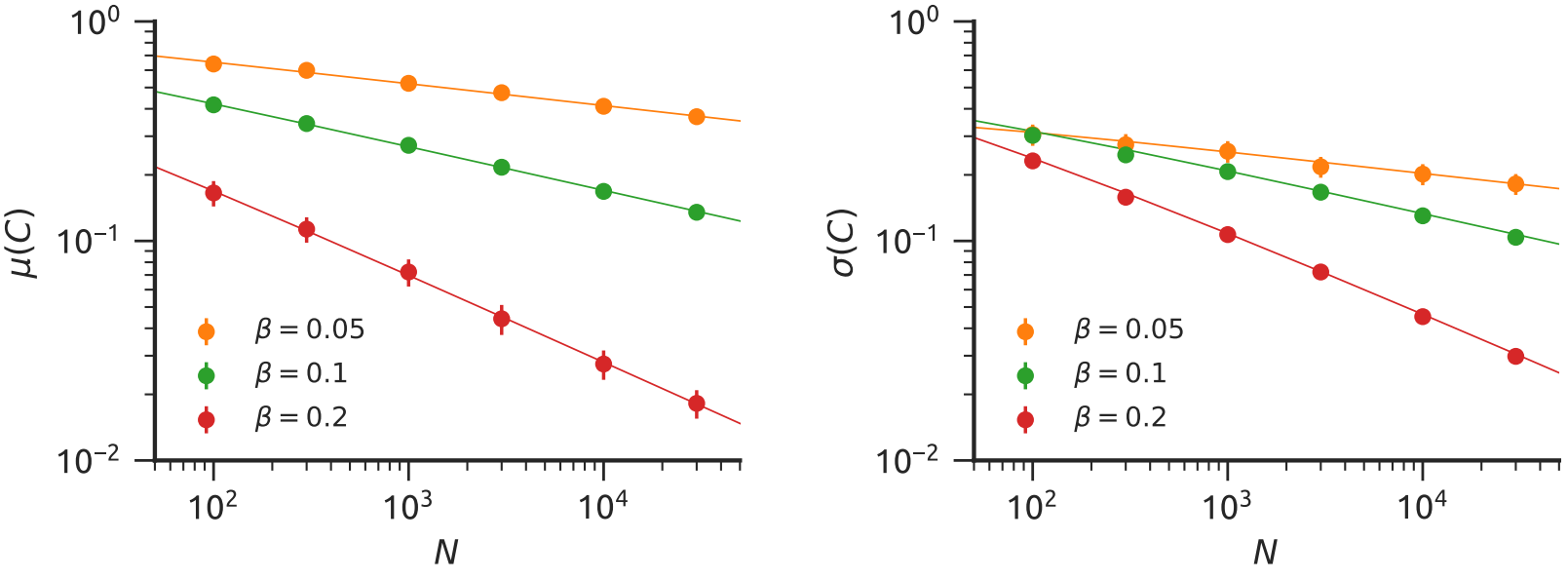


slope in both cases: -2β (for $\beta \leq 1/4$)

Lesson #1

Even at limited noise,
opinion propagation outcomes
show high inconsistency and variability

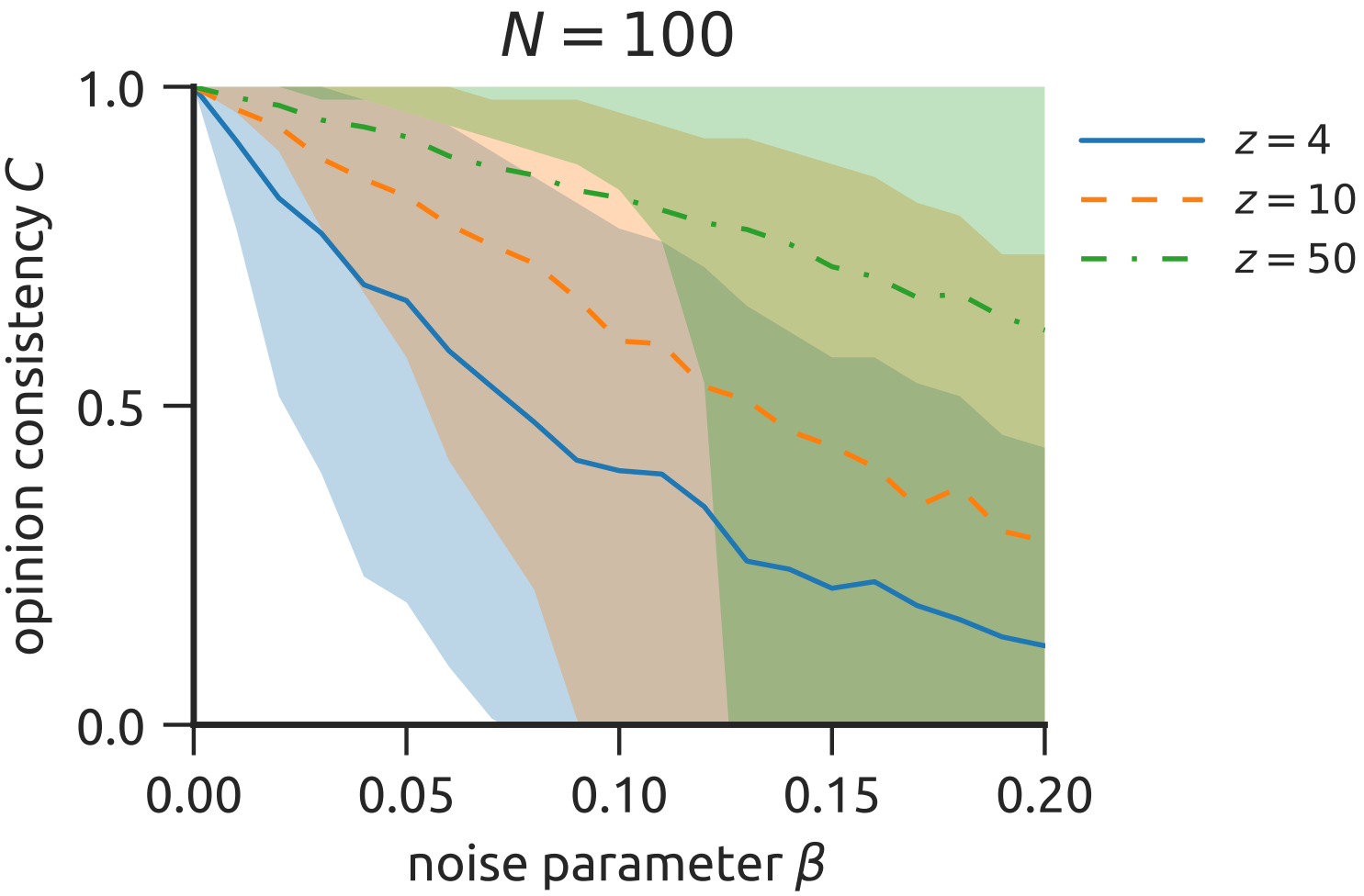
Lesson #2

As the system size grows,
limit opinion consistency is zero
regardless of how small the noise is

Lesson #2

It is difficult
to make sense
of a complex world

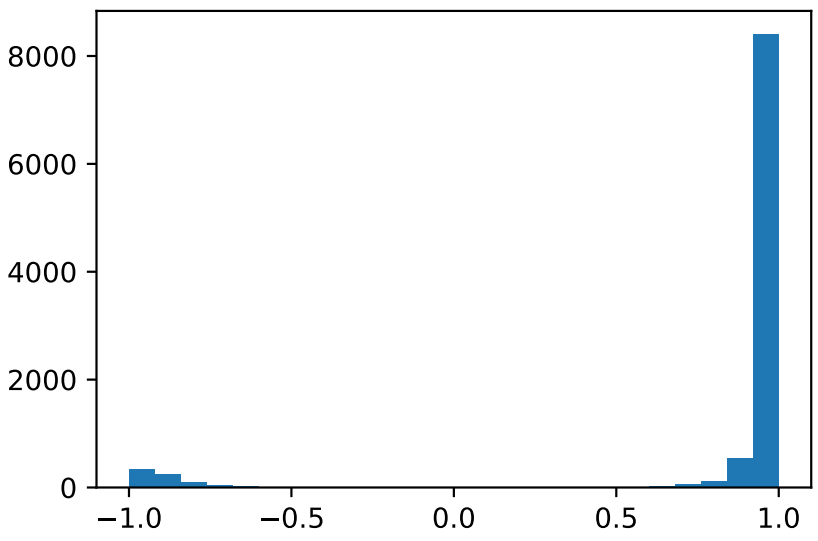
Majority rule



Majority rule

$$z = 50, \beta = 0.1$$

$N = 100$



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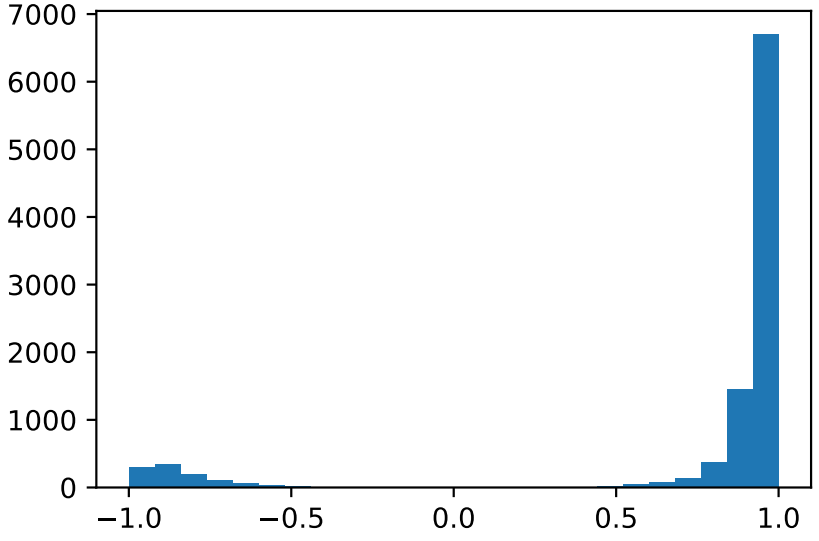

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$$z = 50, \beta = 0.25$$

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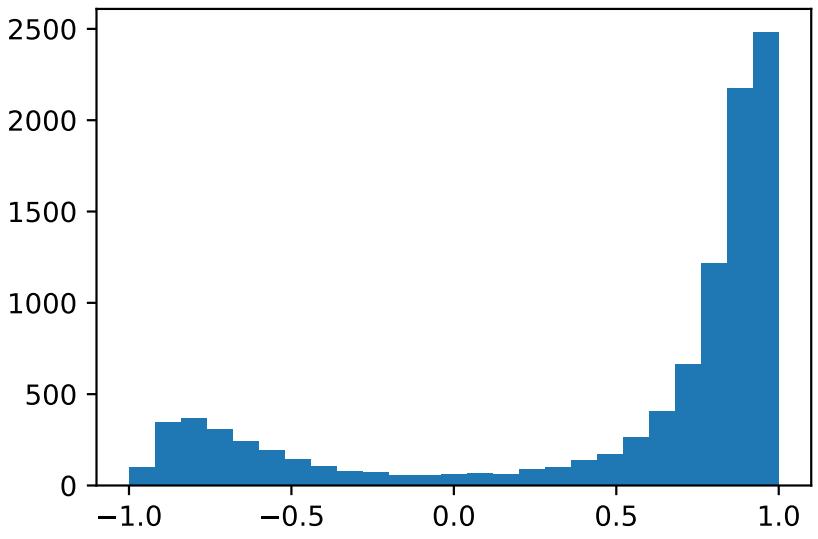

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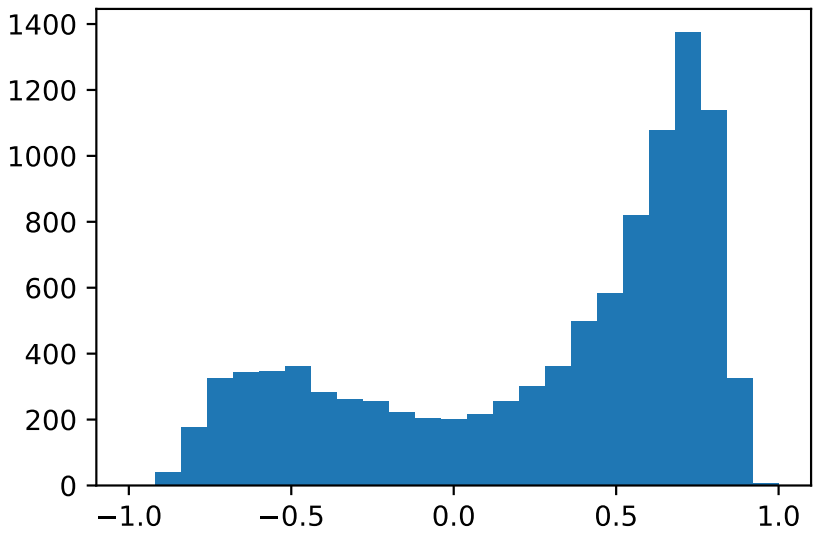

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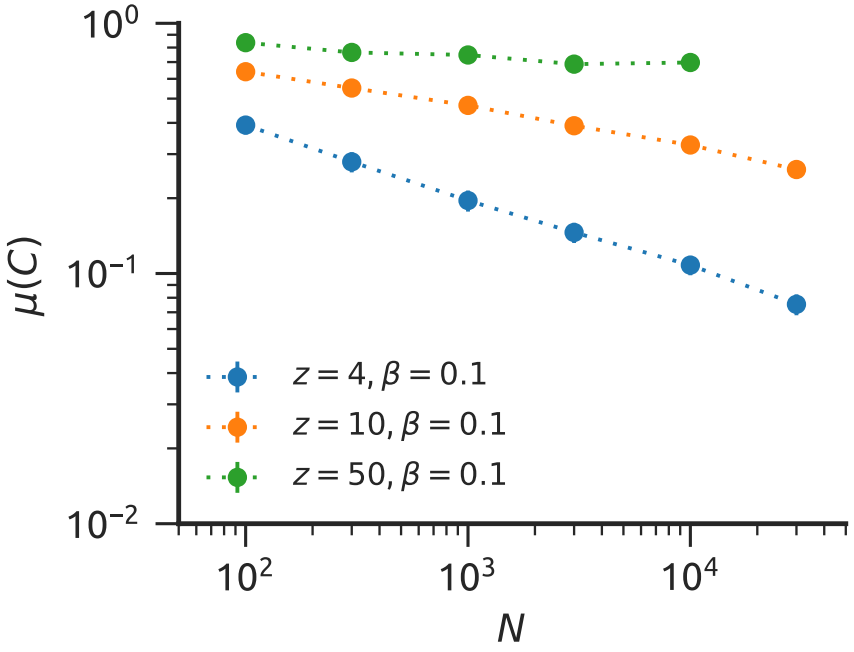

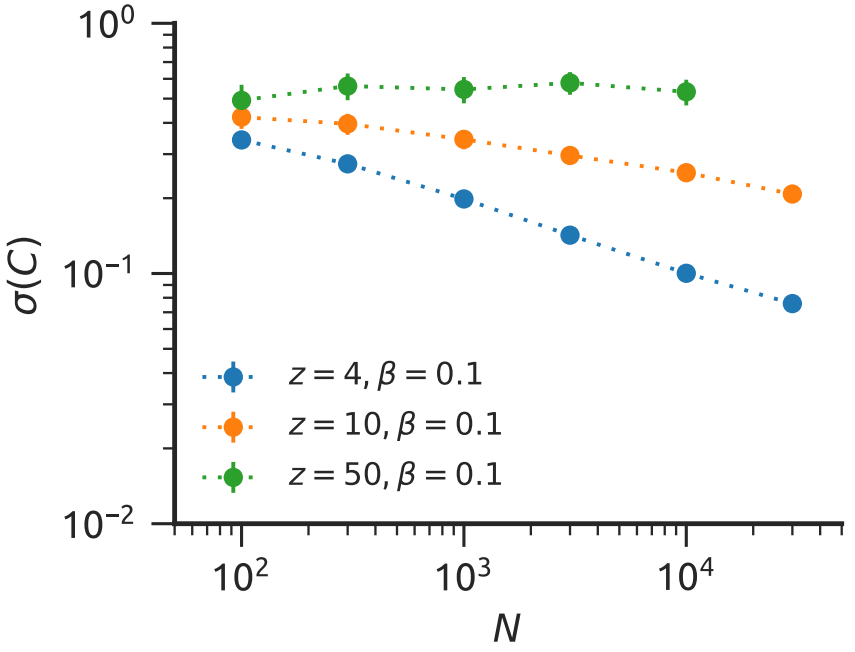

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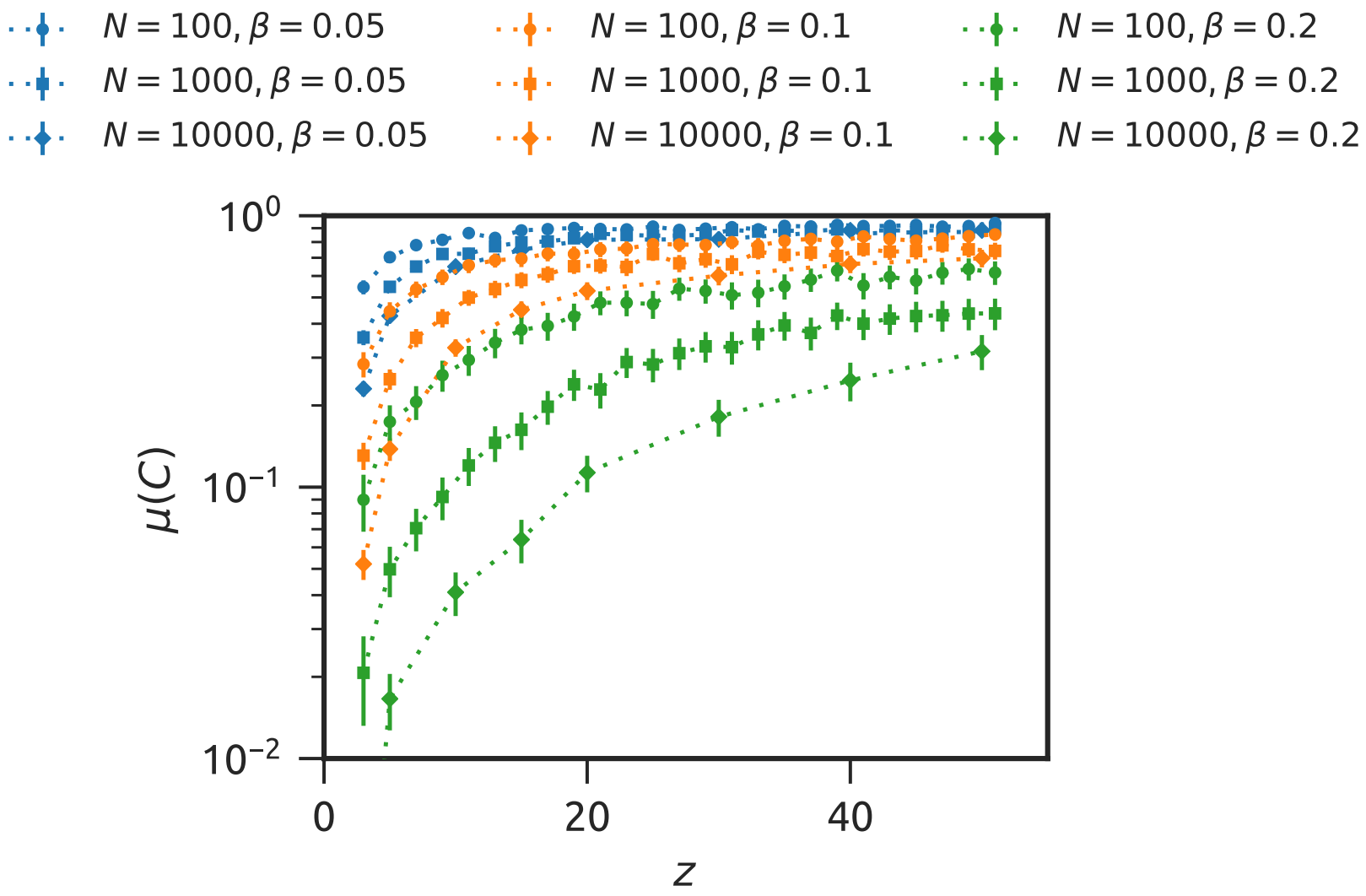

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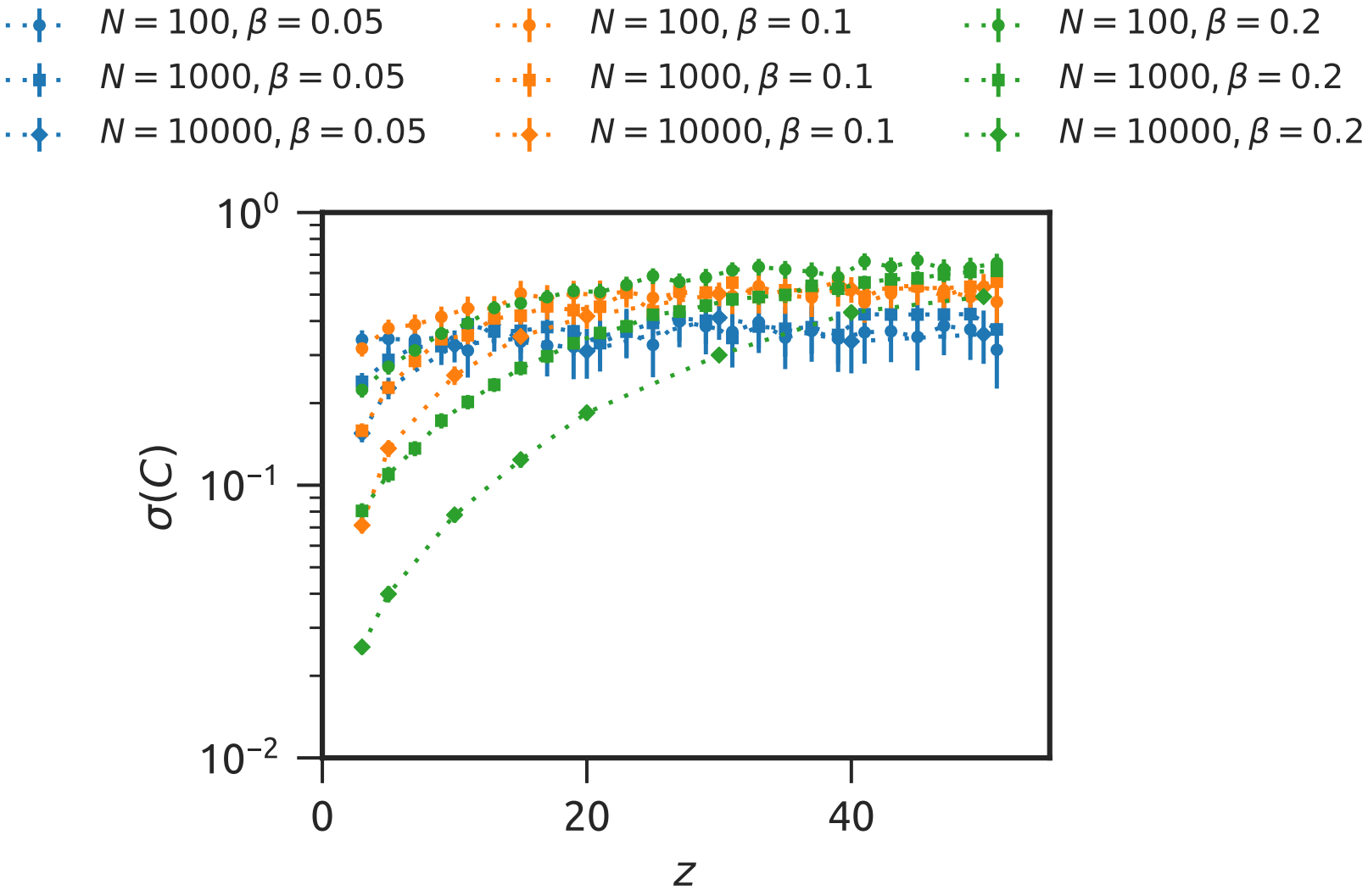


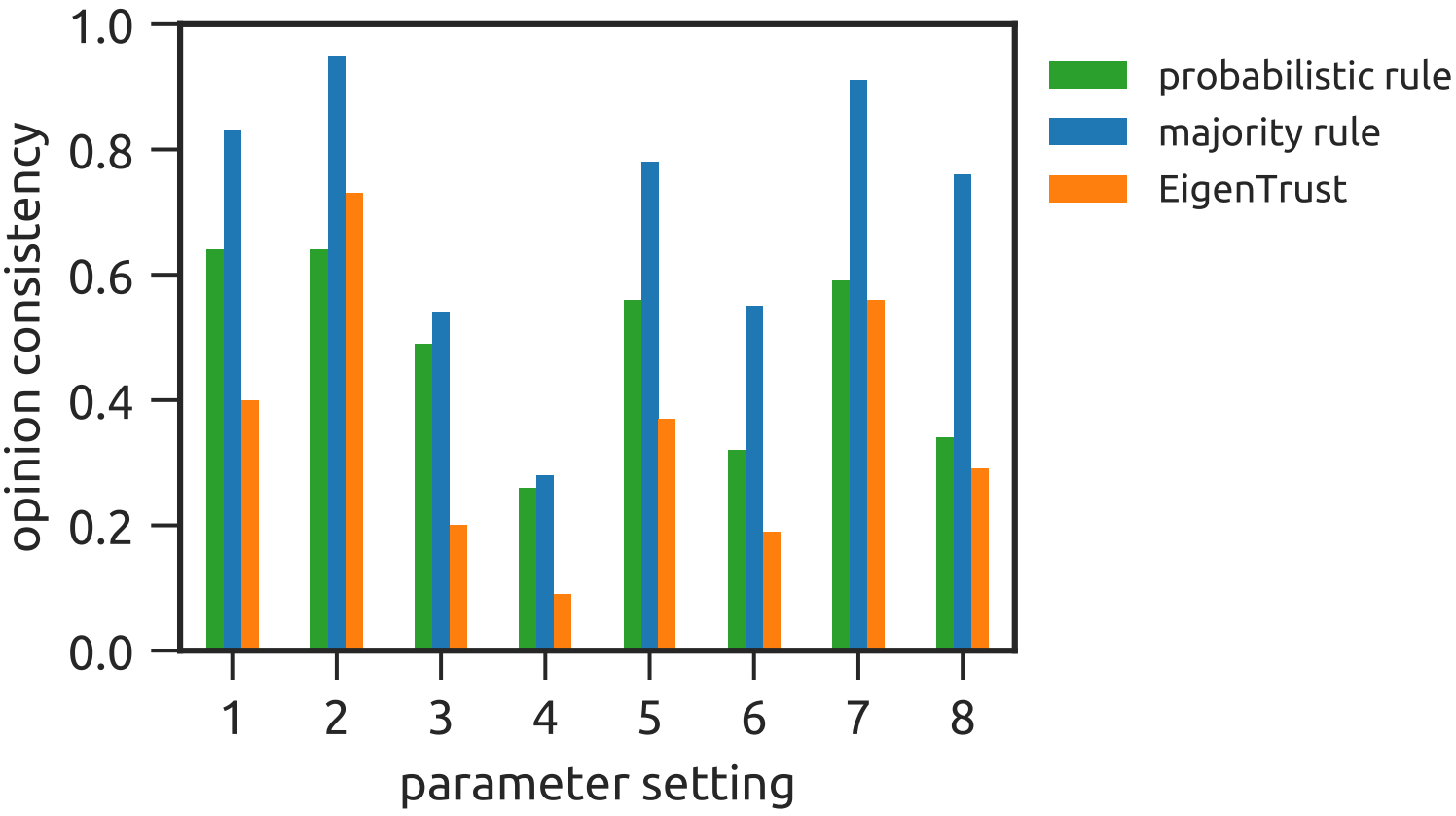
EigenTrust

- A reputation management algorithm for peer-to-peer networks (4000+ citations)
- Peers have weighted signed relations (from past good/bad interactions)
- Which peers to trust?

EigenTrust

$$t = (1 - a)C^T t + ap$$

EigenTrust


1.0
0.8
0.6
0.4
0.2
0.0
opinion consistency
1
2
3
4
5
6
7
8
parameter setting
probabilistic rule
majority rule
EigenTrust

Moving to the real world

- Can we run the model on real signed trust networks?
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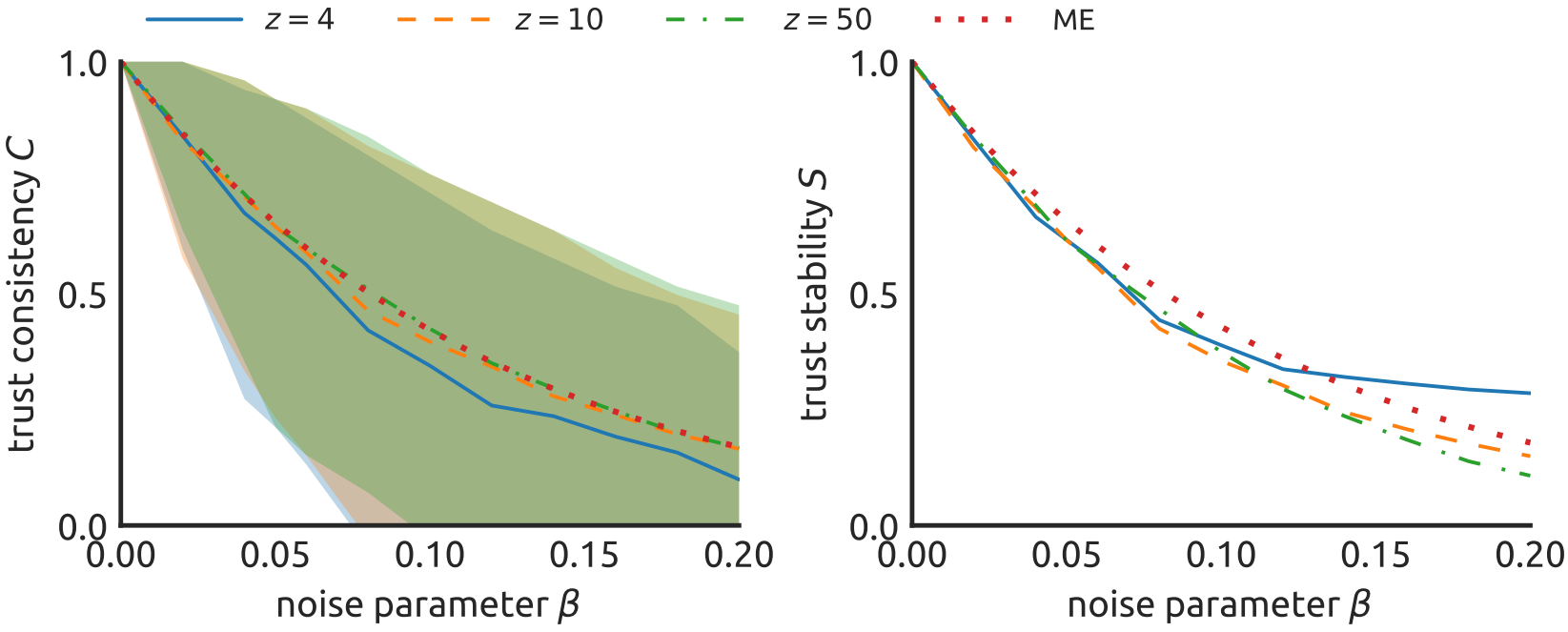
- $S' > 0$ also for random opinions, we thus transform

$$S_s = \frac{S'_s - \sqrt{2/(R\pi)}}{1 - \sqrt{2/(R\pi)}}$$

Opinion stability in the two-camp network

$N = 100$



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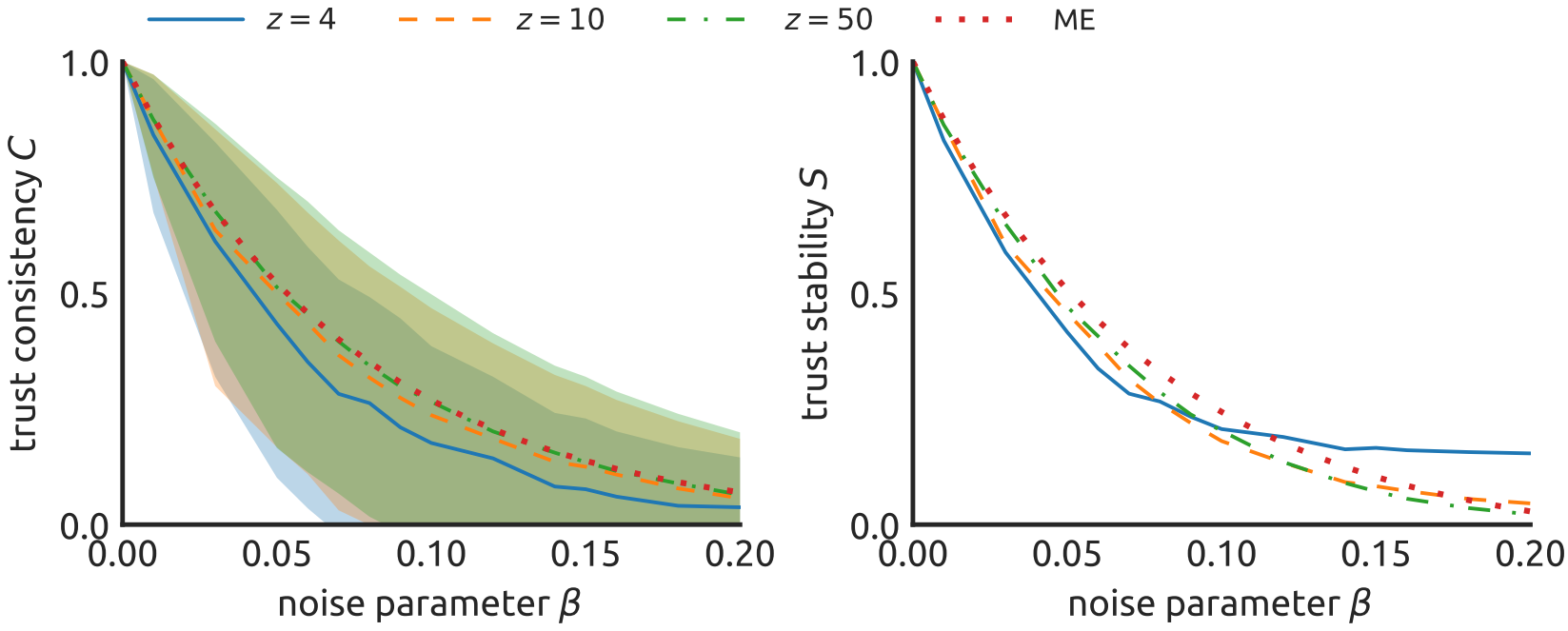

Stability in real data

1. Bitcoin Alpha trust weighted signed network[1]
   - Subset 1: 1448 nodes, 2705 links (1330+ / 1375−)
   - Subset 2: 1909 nodes, 3998 links (2634+ / 1364−)
   - Subset 3: 2337 nodes, 5529 links (4184+ / 1345−)
   - Subset 4: 3775 nodes, 14120 links (12934+ / 1186−)
2. Epinions social network[2]
   - Subset 5: 14937 nodes, 23845 links (12535+ / 11310−)
   - Subset 6: 8586 nodes, 10969 links (5662+ / 5307−)

[1] http://snap.stanford.edu/data/soc-sign-bitcoinalpha.html
[2] http://snap.stanford.edu/data/soc-sign-epinions.html

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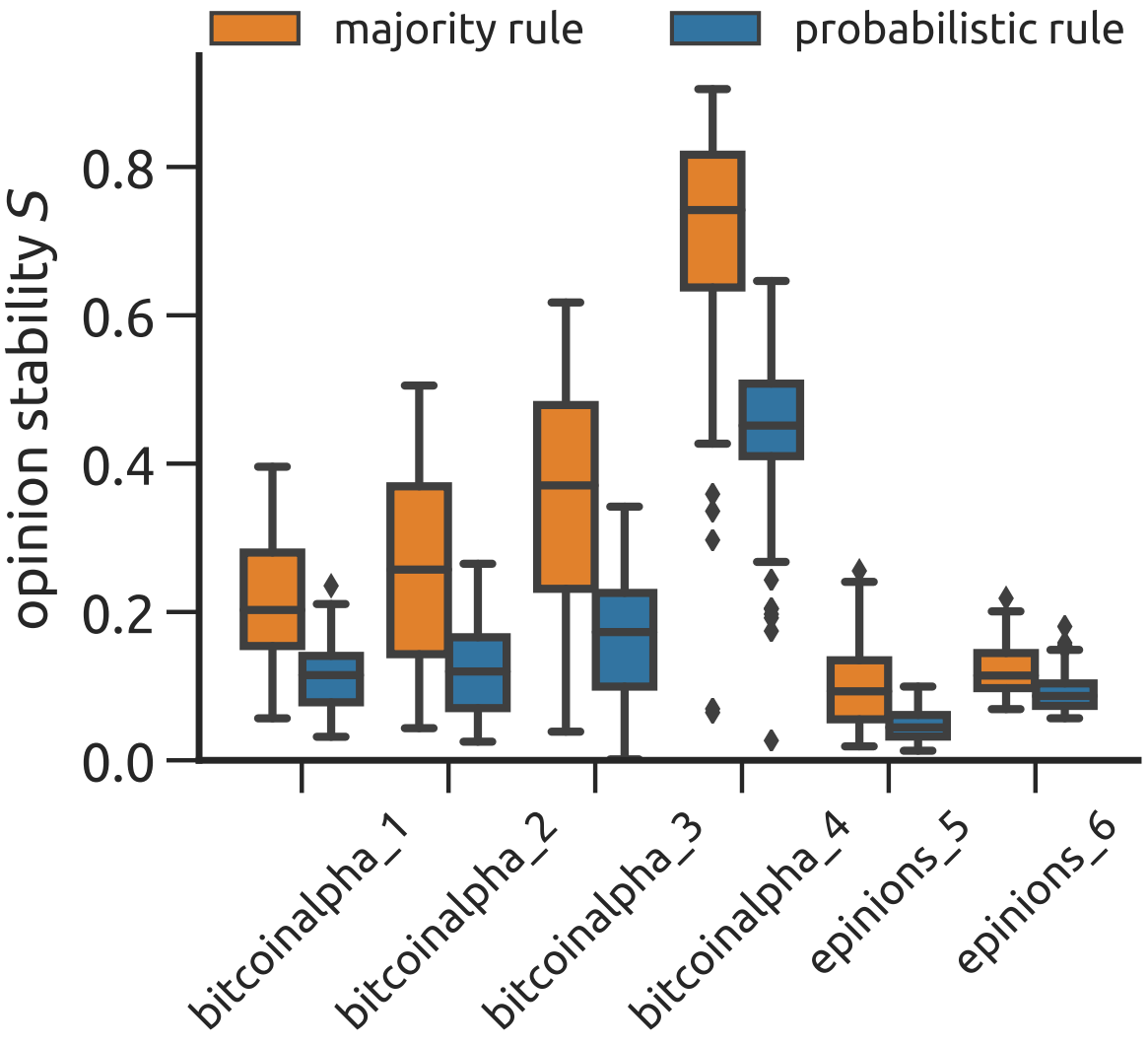

Summary

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- We studied a model where opinions are propagated among entities
- Resulting opinions are sensitive to noise in the system
- Master equation describes well the probabilistic rule
- Majority rule yields “better” opinions than probabilistic rule

Questions to ask

1. Vary the entity network:
    - Camps with different sizes and densities
    - The role of the network topology

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4. The model is local; compare with opinions established globally
5. Which rules lead to the most consistent opinions?
6. Other complications such as social learning, time effects, etc.

Thank you for your attention!

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