High-threshold complex contagion and negative ties in the diffusion of stigmatized health measures: an empirical agent-based model

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Low adoption of malaria preventive measures in hard-to-reach populations

- **Malaria** is still to be fully eradicated: Epicenters are often located among **hard-to-reach populations** in the Global South
- Geographical marginalization + low socio-economic status —> poor access to health care
- resistance to instituzionaled health practices (cultural/religious beliefs) despite top-down policy —> **low adoption rate of key preventive measures**
- **Meghalaya (North-Eastern India)**: mountainous area with patches of tropical forest - **Tribal population** (Garo and Khasi-Jaintia)
- Challenge 1: lack of fine-grained data

# Threshold-based diffusion + negative influence

- Obstacles to preventive measure (**insecticidal cream**) **adoption**:

  - stigmatized (misalignment with traditional health culture)

  - easily observable behaviour

  - small, tight community (tribal villages)

- **Dual-side diffusion mechanism**:

  - **Positive influence**: strong reinforcement from **adoption** by **positive ties** (**threshold**-based contagion; Centola & Macy, 2007)

  - **Negative influence**: **adoption** by **negative contacts**

- Assuming **idiosyncratic** case characteristics:

  - positive impact of within-household adoption (fixed effect)

  - Positive tie with ASHA increases propensity to adoption

  - Positive tie with the traditional healer decreases propensity to adoption

- **Challenge 2: estimating unobserved thresholds**
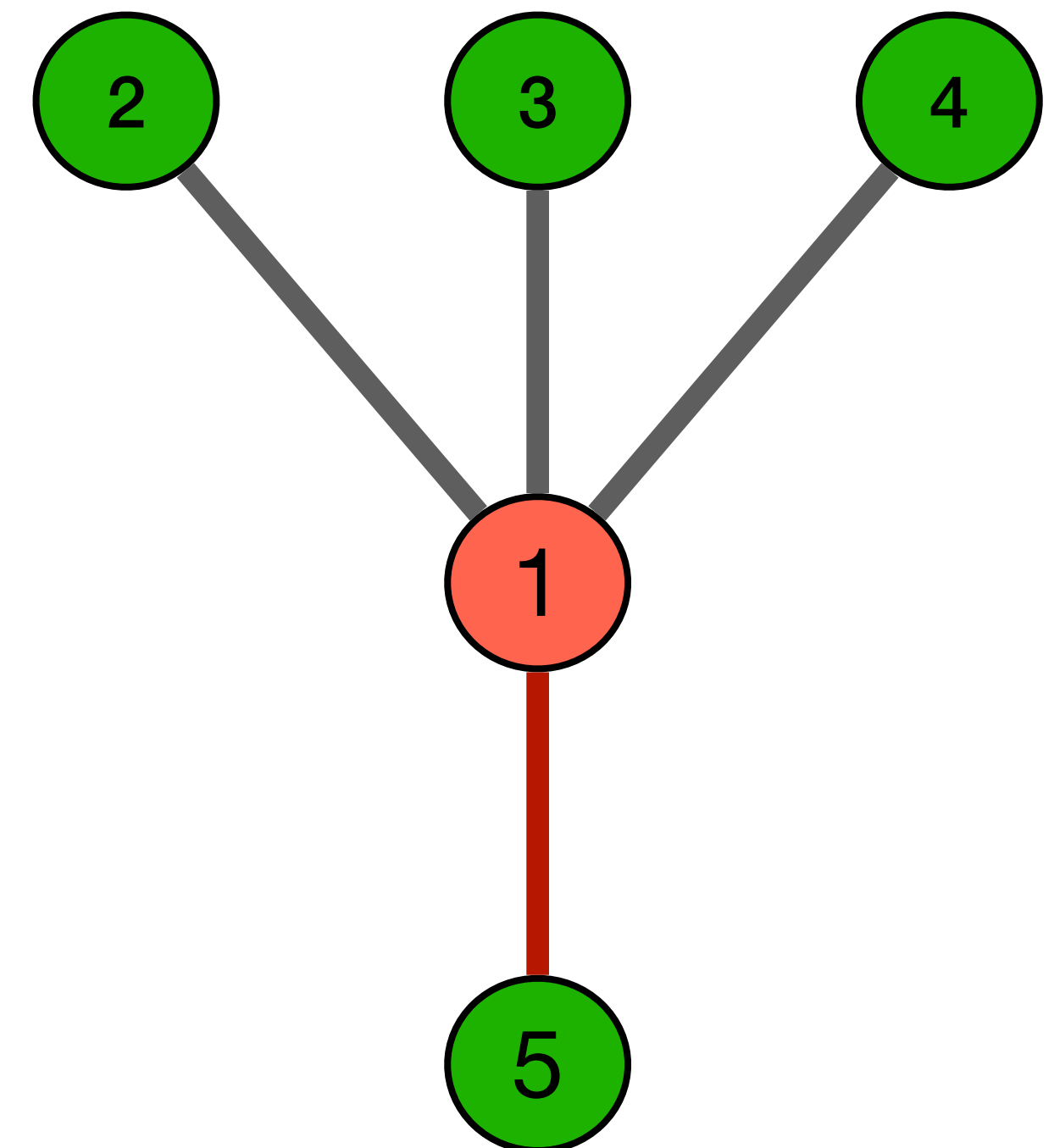
ABM estimating unobserved behaviour

- ABM of the diffusion process in the empirically-observed networks (Bianchi & Renzini, *forthcoming*)

- Model of villagers' cream **adoption** (binary choice) as a discrete-choice model (Mc Fadden, 1978): **logistic objective function** of personal networks' composition

- **Estimating**:

  - **threshold levels** for uptake contagion

  - impact of threshold-based **positive influence**

  - impact of **negative influence** (= adoption by one negative contact)

- **Assuming:**

  - positive impact of within-household adoption (fixed effect)

 - ASHA and traditional healers as stubborn agents
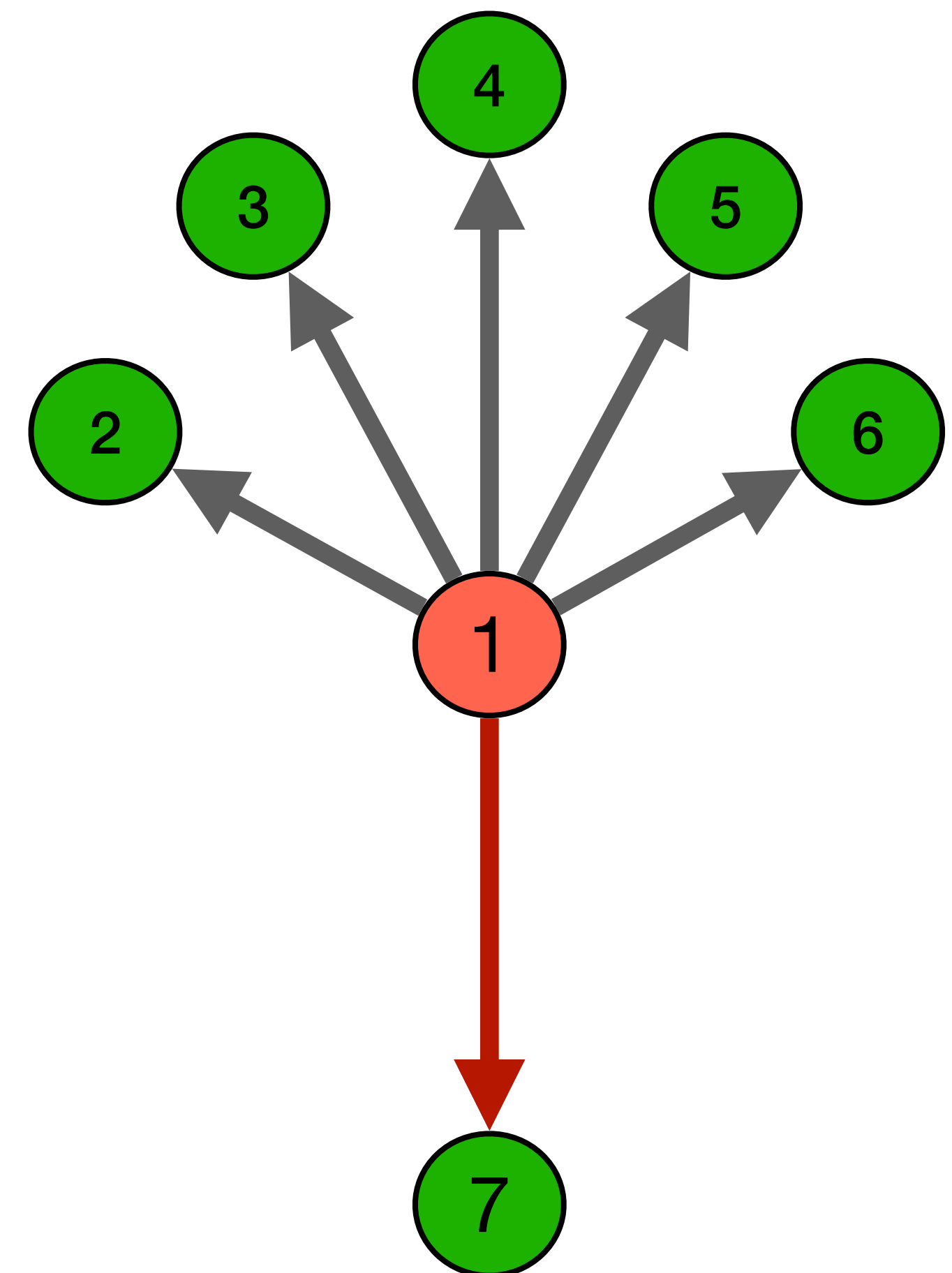
Data calibration

- Data collection: 2020-2021 face-to-face questionnaire administration
- Network data:
  - **Positive ties**: Who do you talk to about health?
  - **Negative ties**: Who do you avoid talking to about health?
- Behaviour: Cream use

Descriptives:

- **cream adoption rate = 14.96%**
- # individuals (nodes) = 254
- # positive ties =
- avg. degree (positive ties) = 2.41
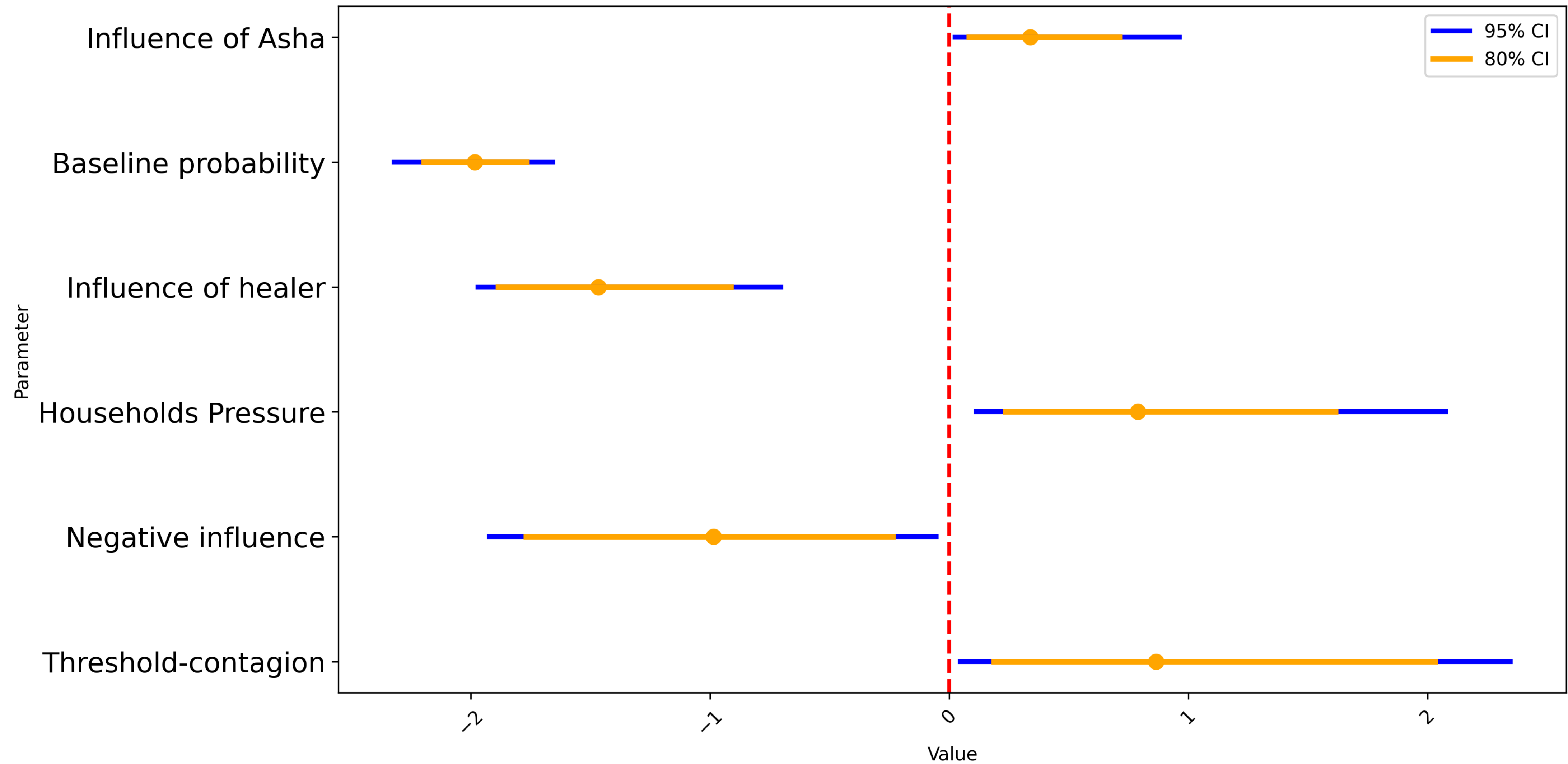- # negative ties = 15
- avg. degree (negative ties) = 0.06
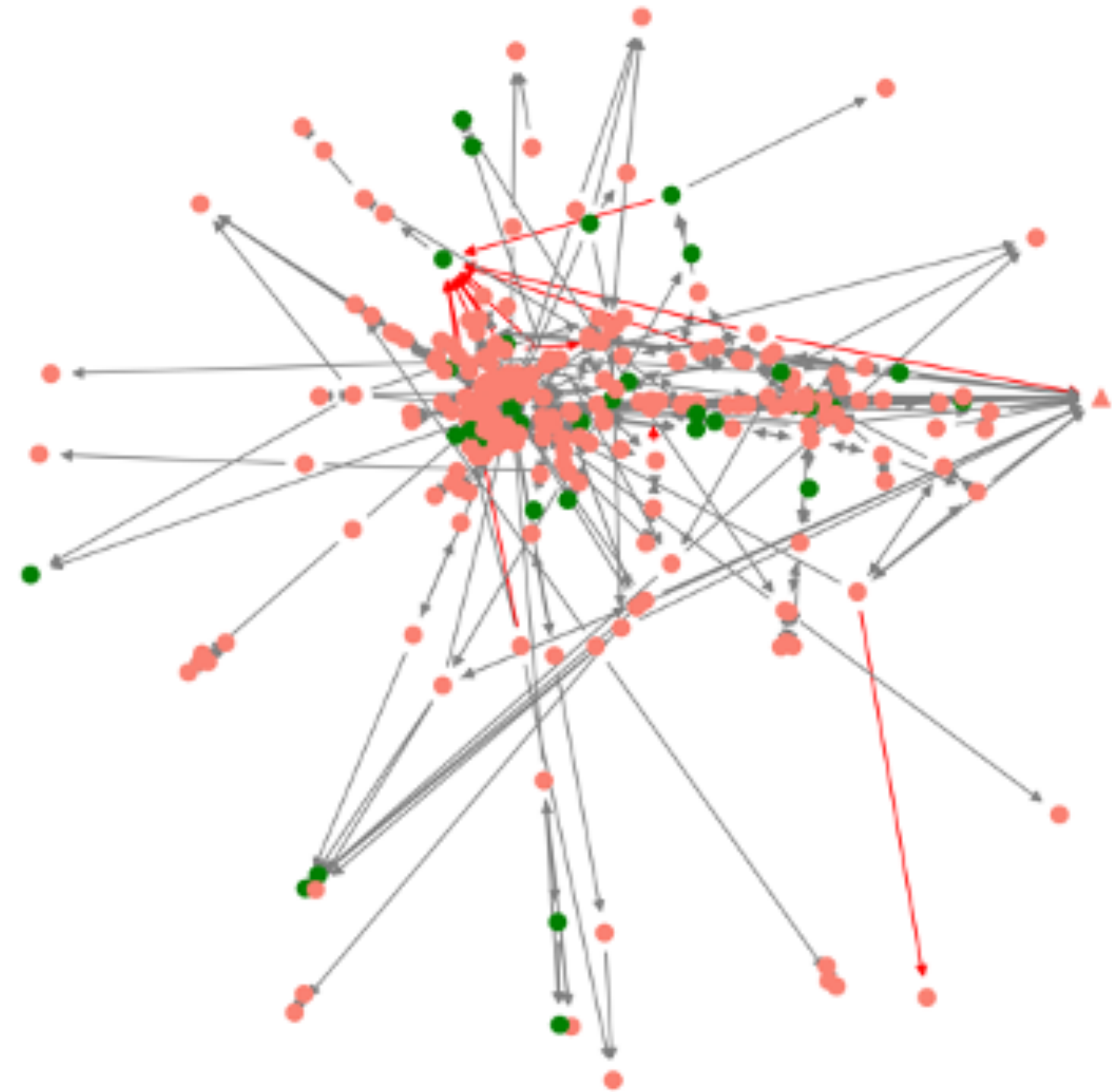
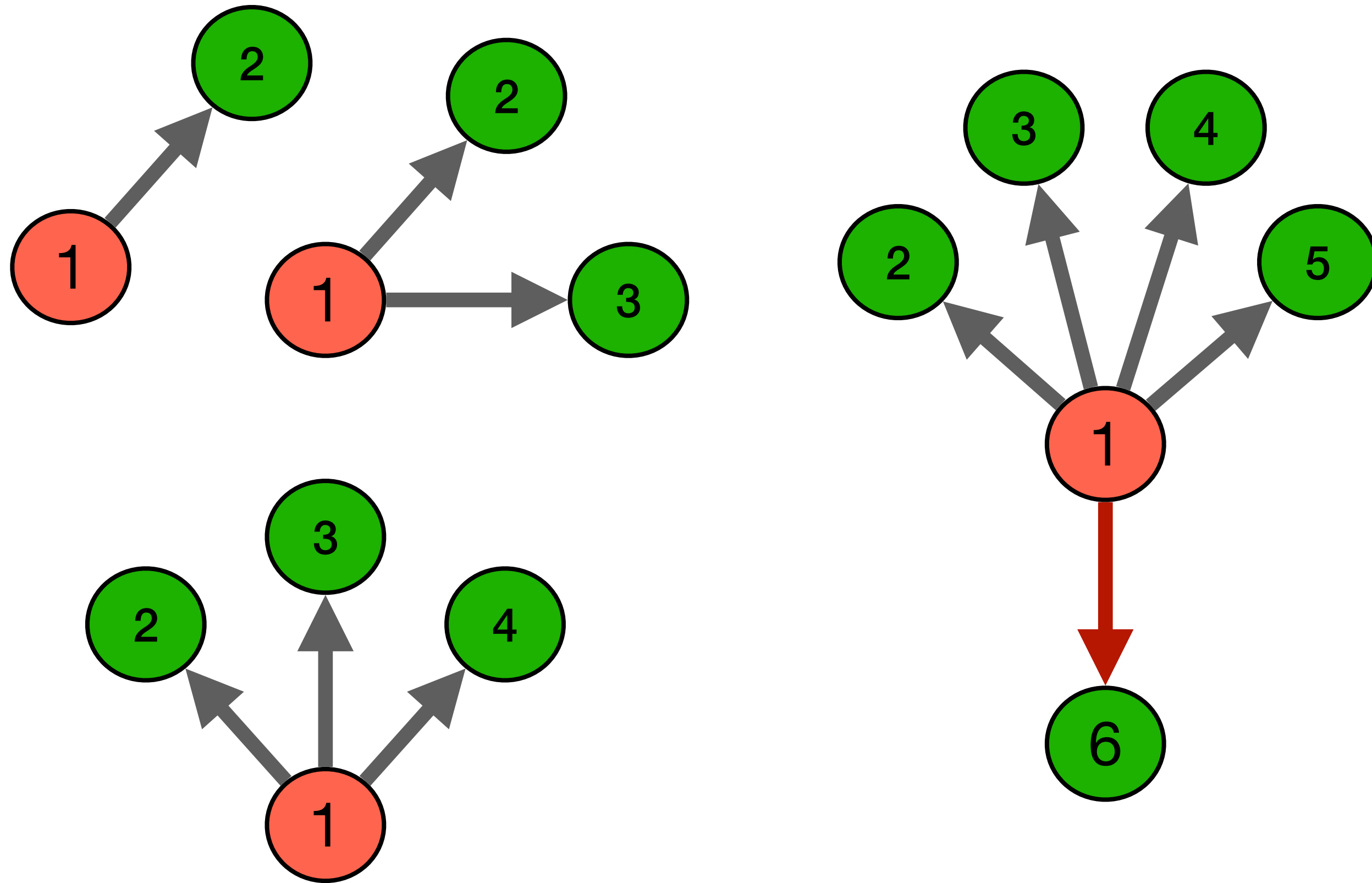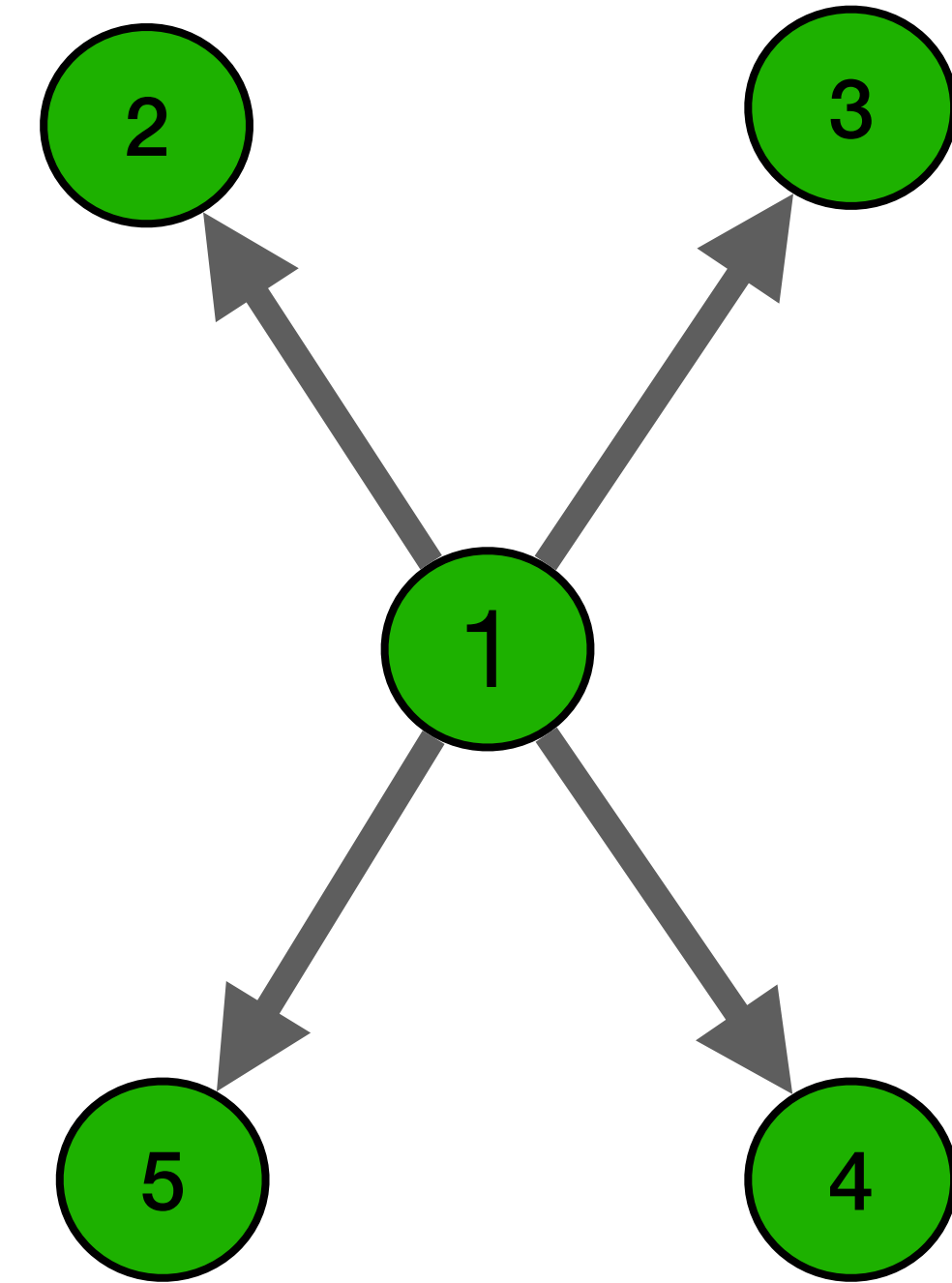# Estimated threshold
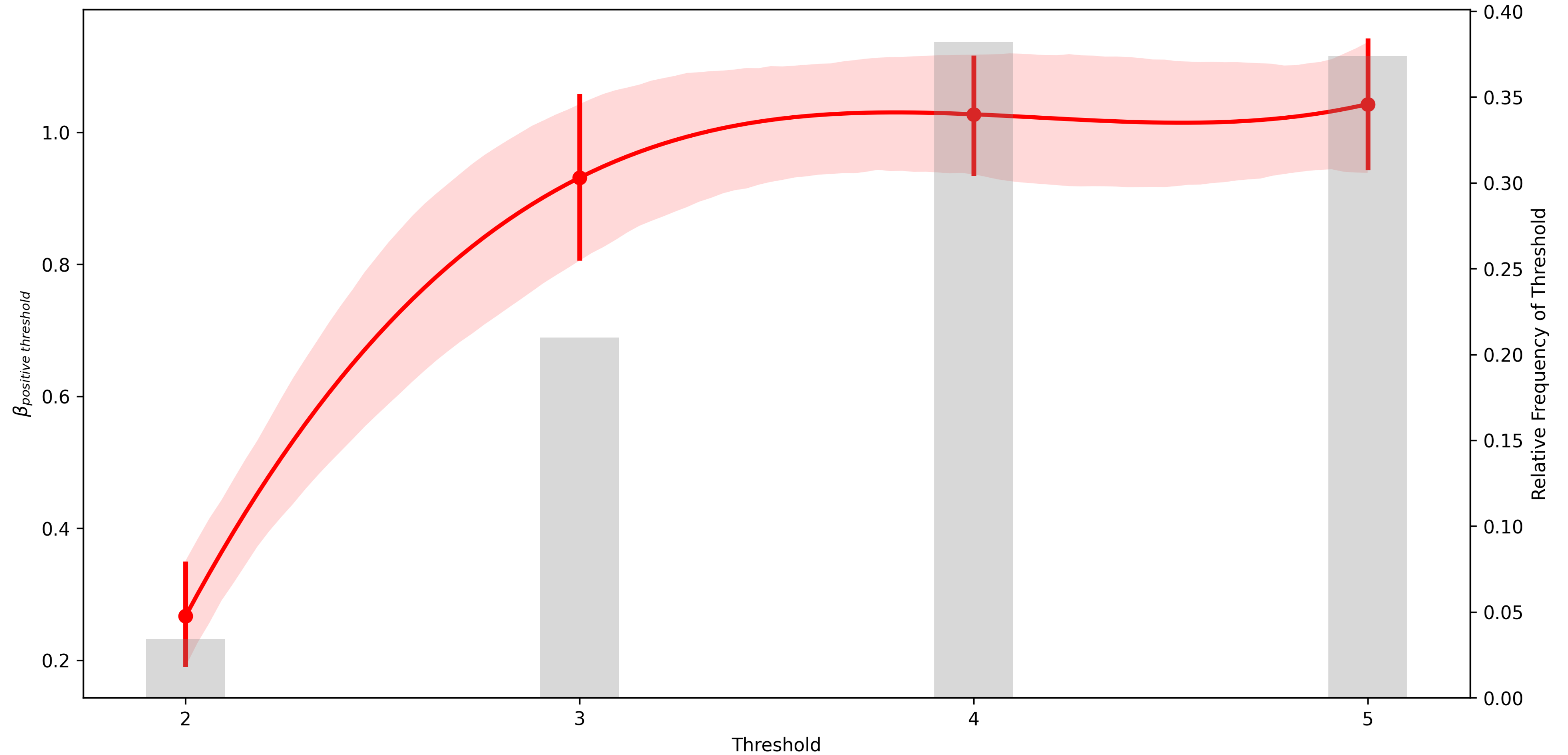
Impact of diffusion mechanism

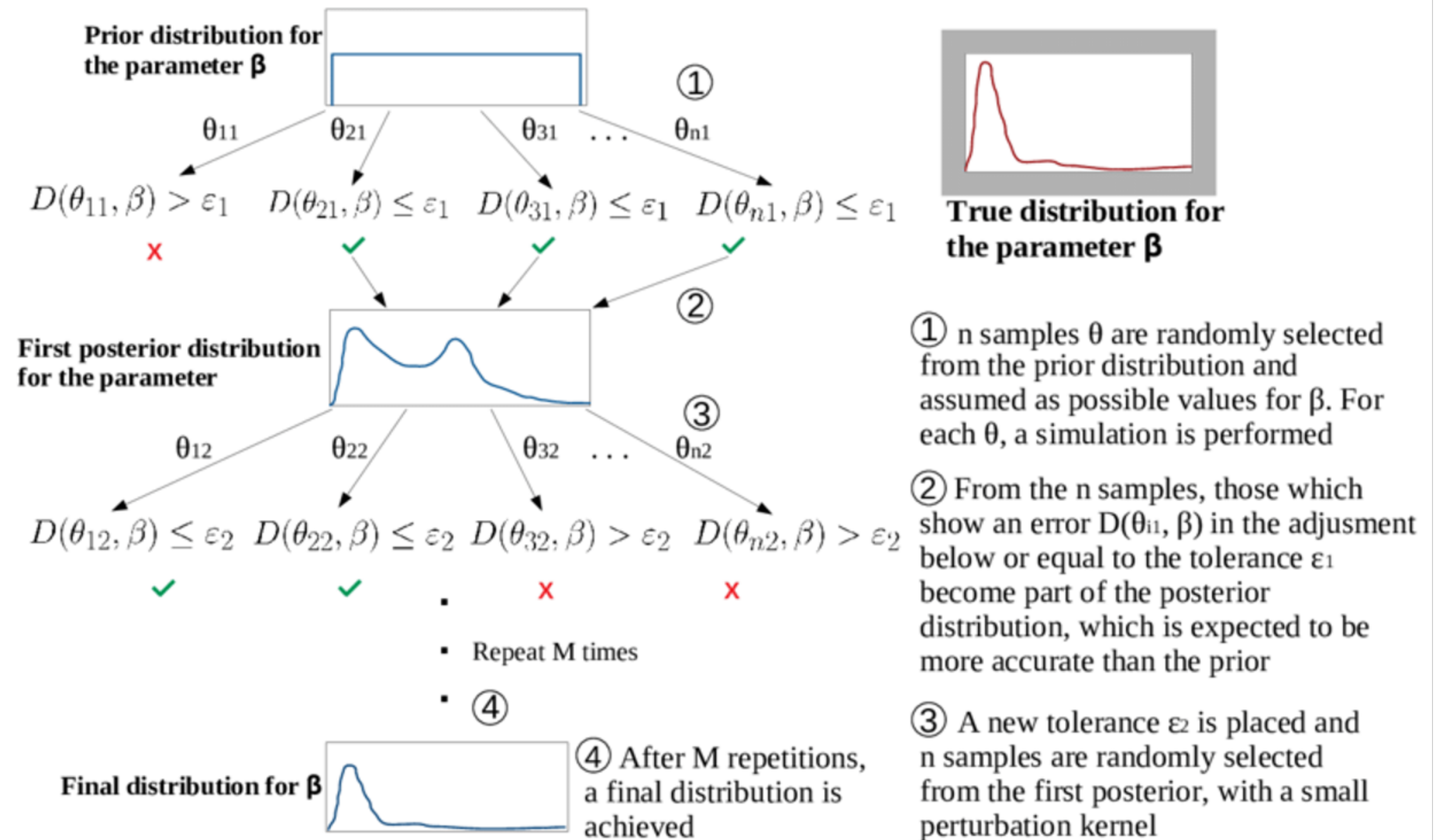# Building on shifting sands

No adoption

Adoption

Estimation method

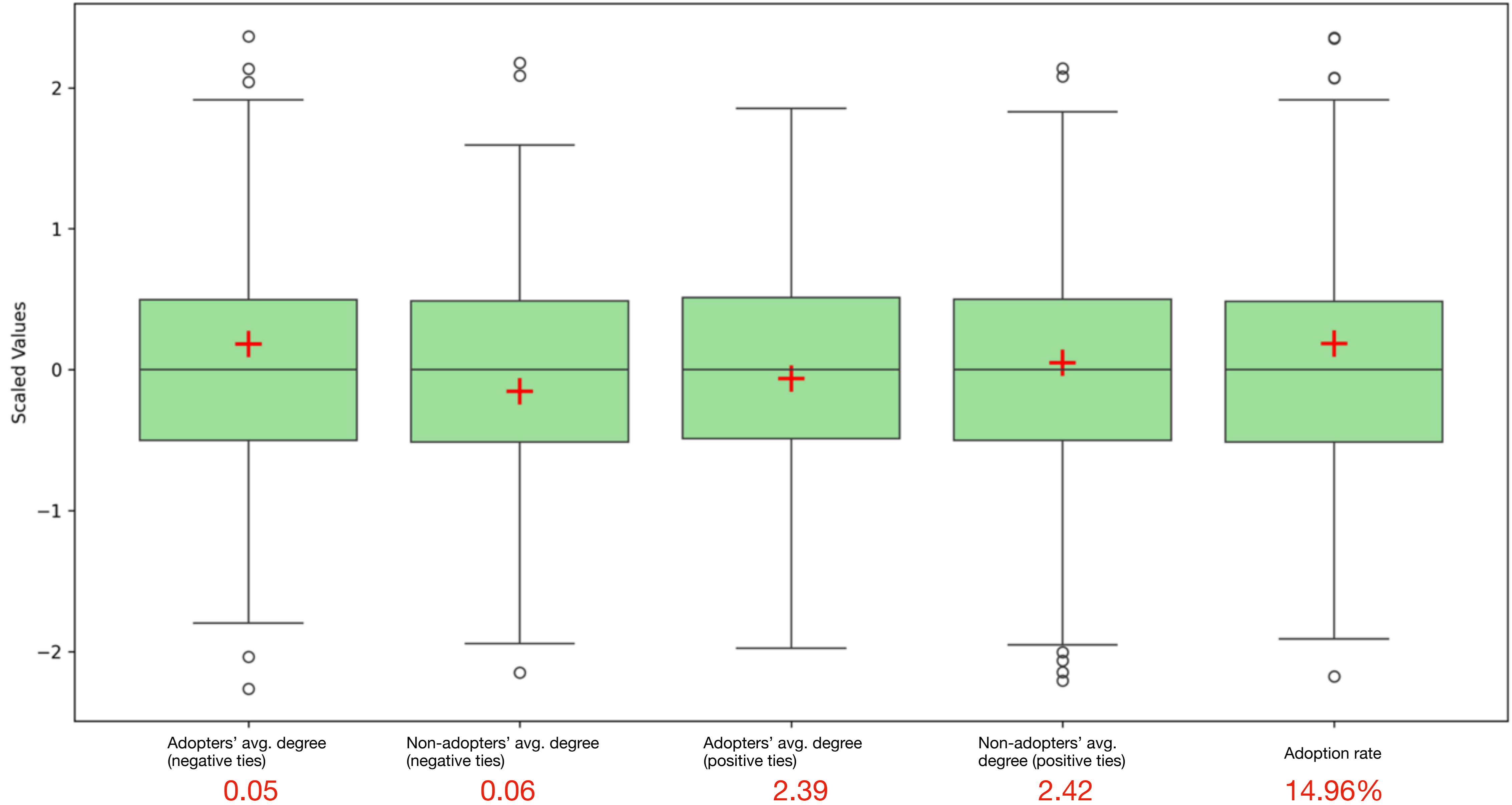Approximate Bayesian Computation (Hartig et al., 2011)

Weakly informative priors (tested with predictive checks)

- Baseline: uniform [-3, 0]

- Threshold: {2, 3, 4, 5}

- Positive influence: uniform [0, 2.5]

- Negative influence: uniform [-2, 0]

Prior distribution for the parameter β

θ_{11} θ_{21} θ_{31} ... θ_{n1}

$D(\theta_{11}, \beta) > \varepsilon_1$ $D(\theta_{21}, \beta) \leq \varepsilon_1$ $D(\theta_{31}, \beta) \leq \varepsilon_1$ $D(\theta_{n1}, \beta) \leq \varepsilon_1$

①

②

First posterior distribution for the parameter

θ_{12} θ_{22} θ_{32} ... θ_{n2}

$D(\theta_{12}, \beta) \leq \varepsilon_2$ $D(\theta_{22}, \beta) \leq \varepsilon_2$ $D(\theta_{32}, \beta) > \varepsilon_2$ $D(\theta_{n2}, \beta) > \varepsilon_2$

③

Repeat M times

④

Final distribution for β

④ After M repetitions, a final distribution is achieved

True distribution for the parameter β

① n samples θ are randomly selected from the prior distribution and assumed as possible values for β. For each θ, a simulation is performed

② From the n samples, those which show an error $D(\theta_{i1}, \beta)$ in the adjustment below or equal to the tolerance ε_1 become part of the posterior distribution, which is expected to be more accurate than the prior

③ A new tolerance ε_2 is placed and n samples are randomly selected from the first posterior, with a small perturbation kernel

Model fit

Boxplot of Centered and Scaled Summary Statistics

Adopters' avg. degree (negative ties)	Non-adopters' avg. degree (negative ties)	Adopters' avg. degree (positive ties)	Non-adopters' avg. degree (positive ties)	Adoption rate
0.05	0.06	2.39	2.42	14.96%

Conclusions

- Diffusion of collectively beneficial, yet stigmatized behaviour might suffer from two pulling forces in one's personal network:

  - **Strong reinforcement** (high **threshold** levels)

  - High sensitivity to **negative influence**

- **Empirical ABM** can reliably estimate **unobserved (or unobservable) behaviour**

- Next step: **validation** on other villages

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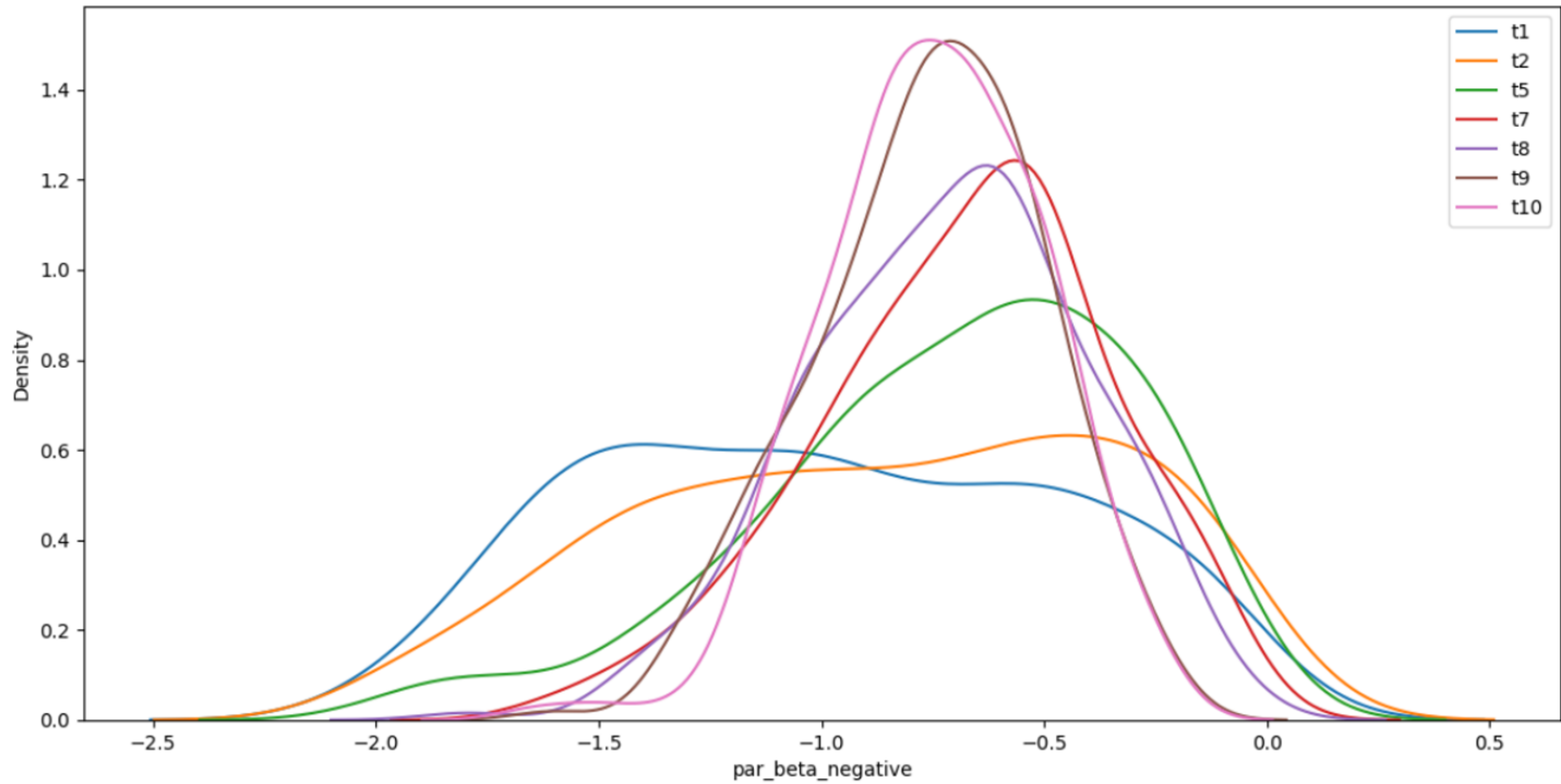
- We ran predictive checks

- Sampling from the prior distributions, simulating 1000 times the model, then comparing summary statistics distributions to the observed ones