DYNAMICAL PROCESSES IN COMPLEX NETWORKS

“SUDDEN TRANSITIONS IN COUPLED OPINION AND EPIDEMIC DYNAMICS WITH VACCINATION IN A NETWORK”

TEAM: SMRUSH

CONTENT

Citation:

MARCELO A PIRES, ANDRÉ L AND NUNO CROKIDAKIS. “SUDDEN TRANSITIONS IN COUPLED OPINION AND EPIDEMIC DYNAMICS WITH VACCINATION.”

OBJECTIVES

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Understand Opinion Dynamics:

- Use continuous opinion dynamics to model public attitudes on vaccination.
- Examine how opinions affect vaccination rates and disease transmission.

OBJECTIVES

Model Epidemic Dynamics:

- Apply the SIS model to simulate disease spread.
- Investigate how vaccination campaigns impact epidemic patterns.

OBJECTIVES

Explore Transition Points:

- Detect critical shifts in disease control influenced by public opinion and vaccine effectiveness.
- Utilize Monte Carlo simulations to explore sudden transitions in opinion and epidemic dynamics.

UNDERSTANDING OF THE PROJECT

Approach:

- Use the Susceptible-Infected-Susceptible (SIS) model with continuous opinion dynamics along with vaccination state to analyze their interaction.

The success or failure of a vaccination campaign is not solely reliant on factors like vaccine accessibility, vaccine effectiveness, and epidemiological variables. Public opinion about vaccination also plays a significant role. We adress these opinions as a continuous factor.

While the use of discrete opinions (yes or no) is usually used, a continuous opinion is more appropriate because:

Reinforcing opinions based on interactions with peers

Opinions are not constant and change with time

Real world opinions are more complex. Thus we need to incorporate extreme and moderate views.

We assume, based on kinetic models of collective opinion formation, that the opinion dynamics are governed by the equation:

$$o_i(t) = o_i(t-1) + \epsilon o_j(t-1) + wI(t-1),$$

which considers that the opinion of each agent i at an instant t depends on:

1. His previous opinion

2. A peer pressure exerted by a randomly selected agent j, modulated by a stochastic variable ε uniformly distributed in the interval [0, 1], that introduces heterogeneity in the pairwise interactions

3. The proportion of Infected agents I(t - 1) modulated by an individuals' risk perception parameter w.

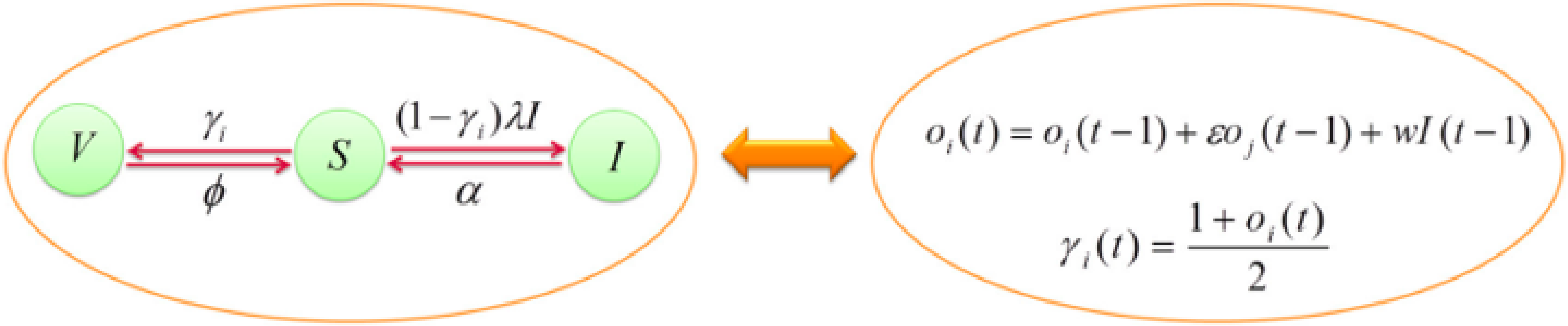
MODEL

Individuals can undergo the following transitions among the epidemic compartments:

- $S \xrightarrow{\gamma_i} V$: a Susceptible individual i becomes Vaccinated with probability γ_i;
- $S \xrightarrow{(1-\gamma_i)\lambda} I$: a Susceptible individual i becomes Infected with probability $(1-\gamma_i)\lambda$ if he is in contact with an Infected agent;
- $I \xrightarrow{\alpha} S$: an Infected individual i recovers and becomes Susceptible again with probability α;
- $V \xrightarrow{\phi} S$: a Vaccinated individual i becomes Susceptible again with the resuscepti-bility probability ϕ.

Coupled vaccination and continuous opinion dynamics schematics.
The coupling between opinion and epidemic goes in both ways. The opinions influence the vaccination probability, by changing γ(i) .

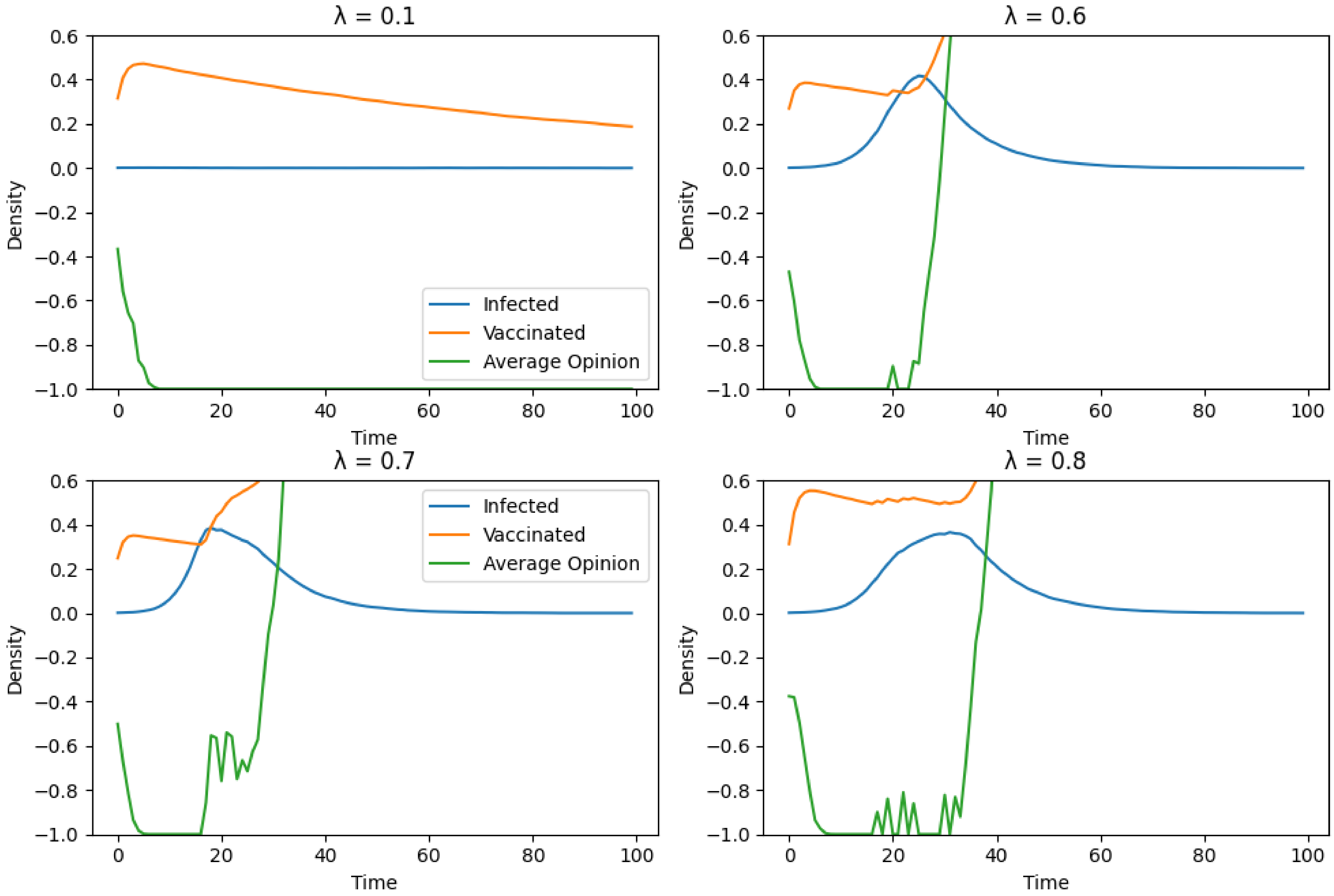
The epidemic spreading increases the propensity of an agent getting vaccinated, through the term wI

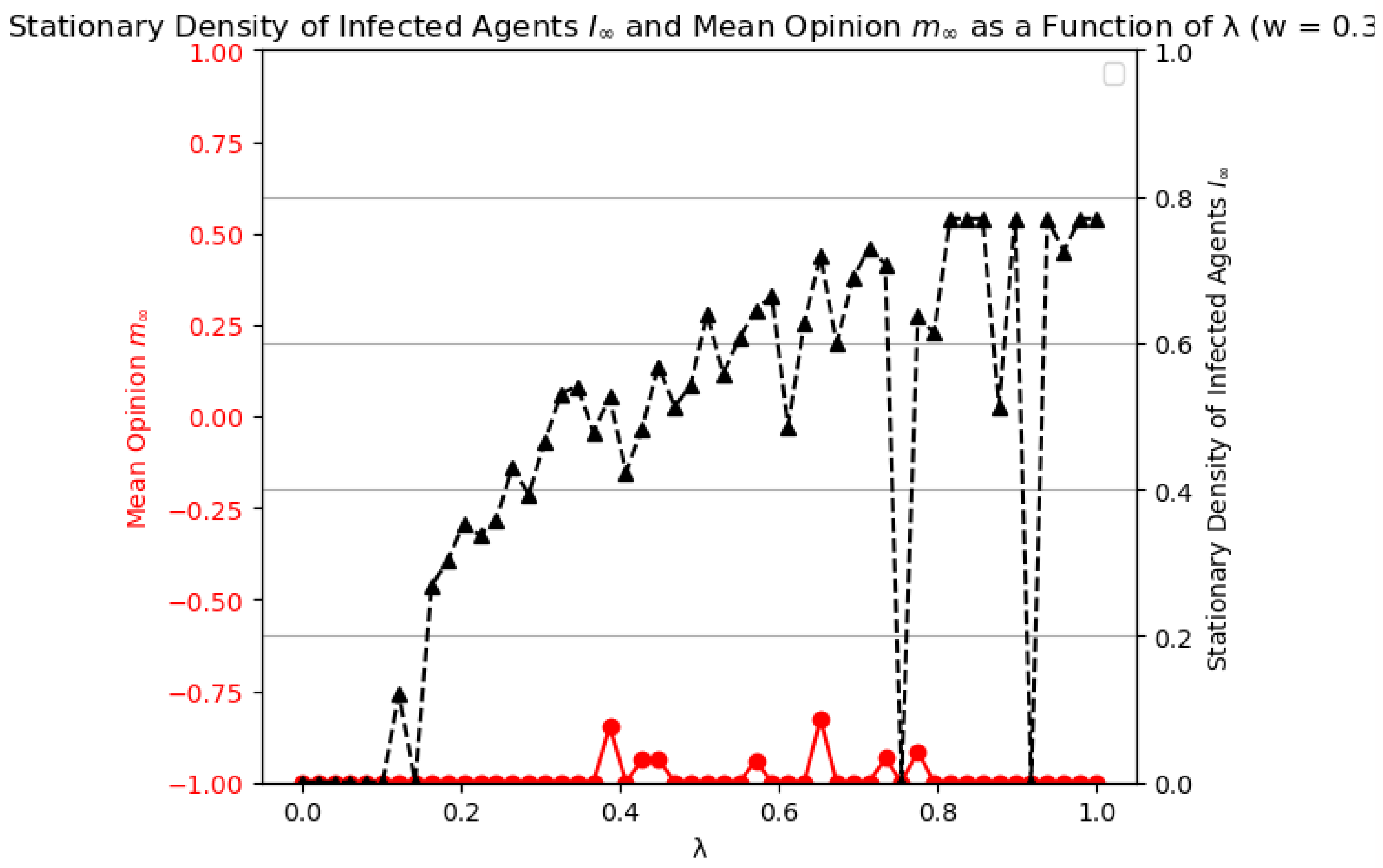


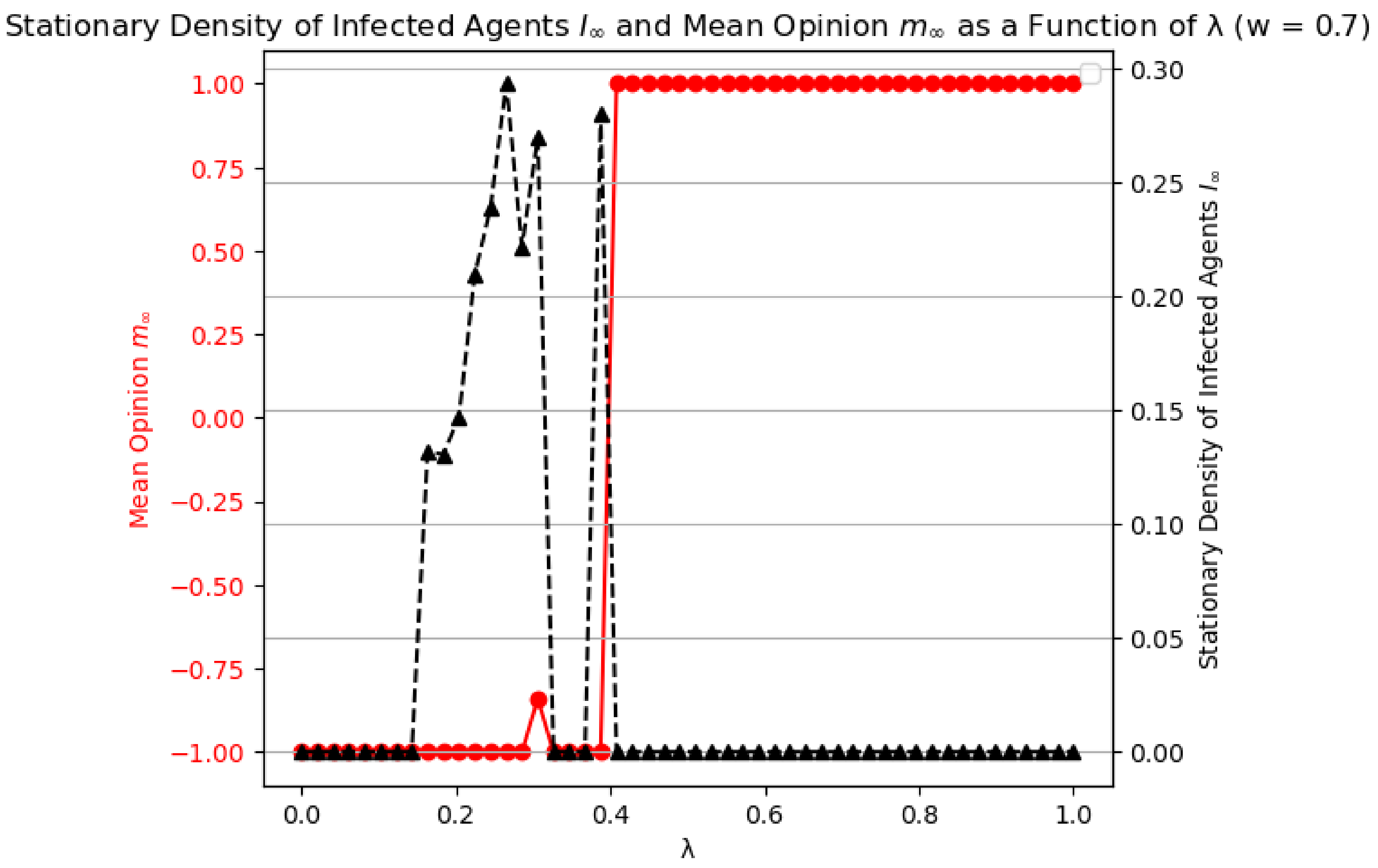
RESULTS

BASELINE SIMULATION

Tuning λ and plotting different temporal evolutions for I(t) , V (t) and m(t) .




Stationary Density of Infected Agents I_∞ and Mean Opinion m_∞ as a Function of λ (w = 0.3
Mean Opinion m_∞
Stationary Density of Infected Agents I_∞
λ


Stationary Density of Infected Agents I_∞ and Mean Opinion m_∞ as a Function of λ (w = 0.7)
Mean Opinion m_∞
Stationary Density of Infected Agents I_∞
λ

NOVELTY

ERDOS-RENYI NETWORK SIMULATION

Mathematical model that explores how public opinion can influence the course of an epidemic. Essentially, the equation tracks how the opinion of an individual can be influenced by:

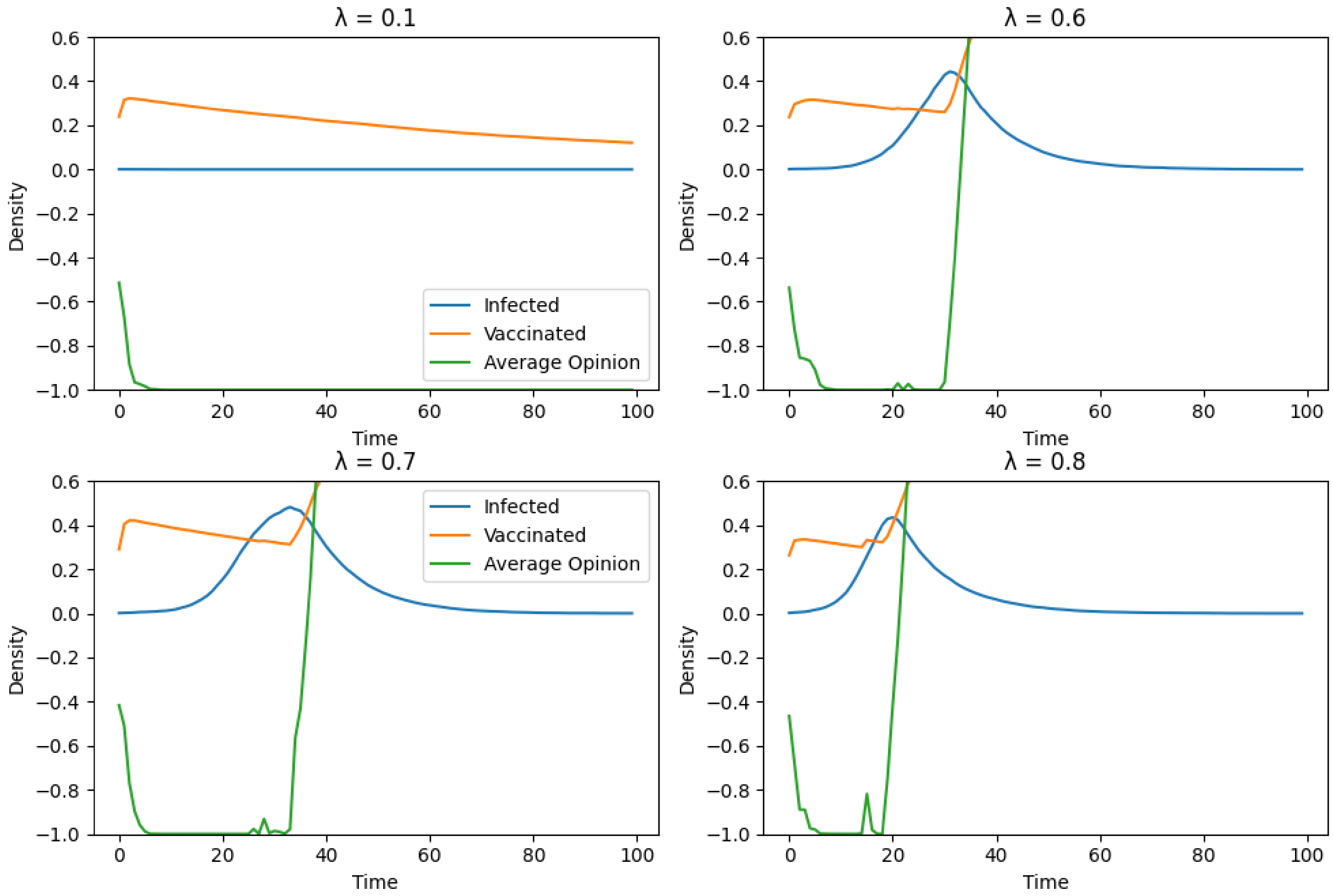
- Their own current opinion (O_i(t))
- The influence of their neighbors (Σj=1 A_ij O_j(t)) weighted by the adjacency matrix (A_ij)
- A general influence term (Σj=1 W K_j A_ij(t)) modulated by the risk perception parameter (W)

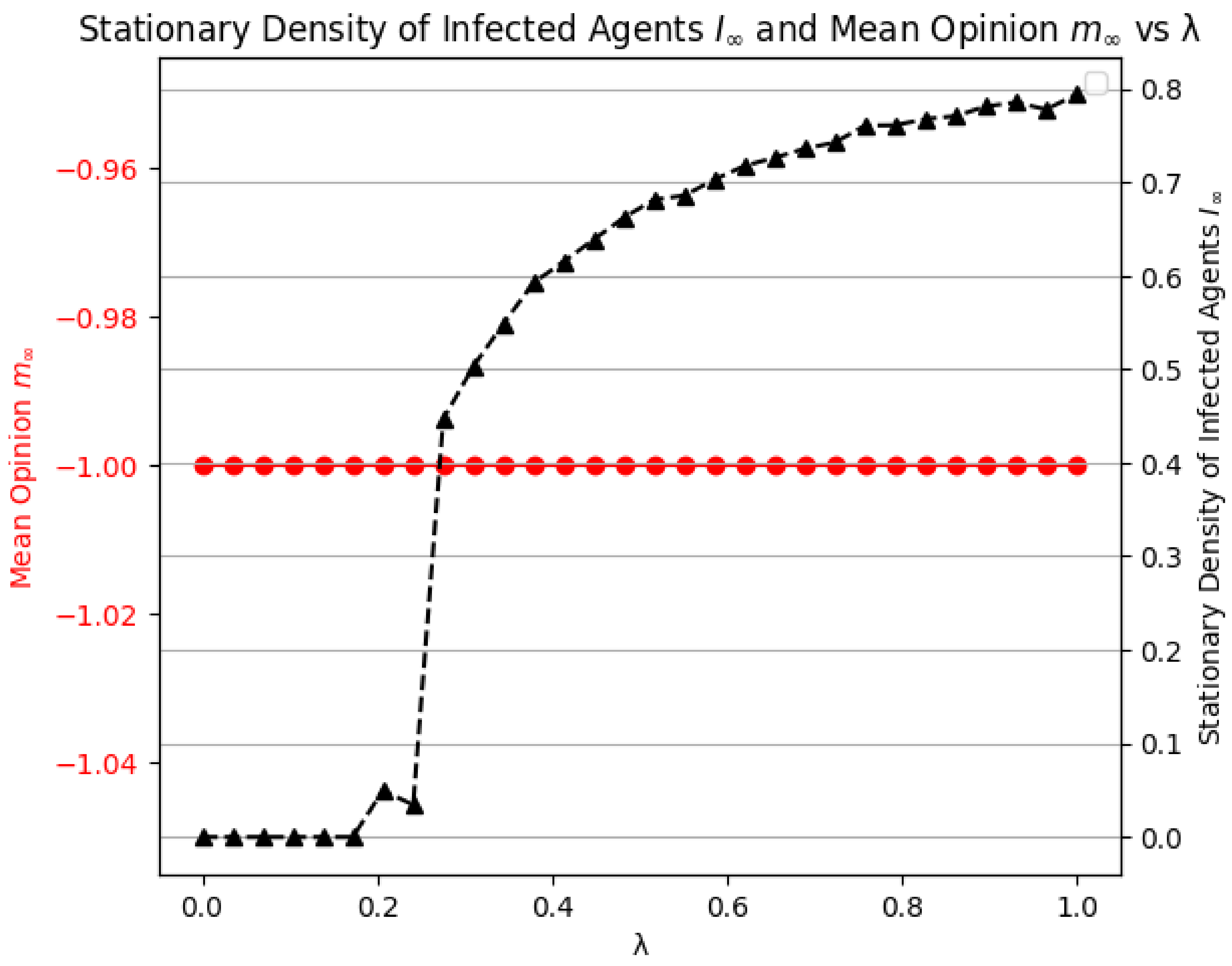
Overall, the model suggests that an individual's opinion about a certain topic can be impacted by their own perspective, how those around them view it, and their perceived risk associated with the topic.

$$O_i(t+1) = O_i(t) + \frac{\epsilon}{K_i}\sum_{j=1}^{N} A_{ij}O_j(t) + \frac{w}{K_i}\sum_{j=1}^{N} A_{ij}I_j(t)$$

ER NETWORK RESULTS

Tuning λ and plotting different temporal evolutions for I(t) , V (t) and m(t) .



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D = 0.20
w = 0.8
alpha = 0.1
phi = 0.01
N = 10000
mcs = 100
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THANK YOU

TEAM REWARD

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