Contact Network Heterogeneity and Persistence of Endemic Disease

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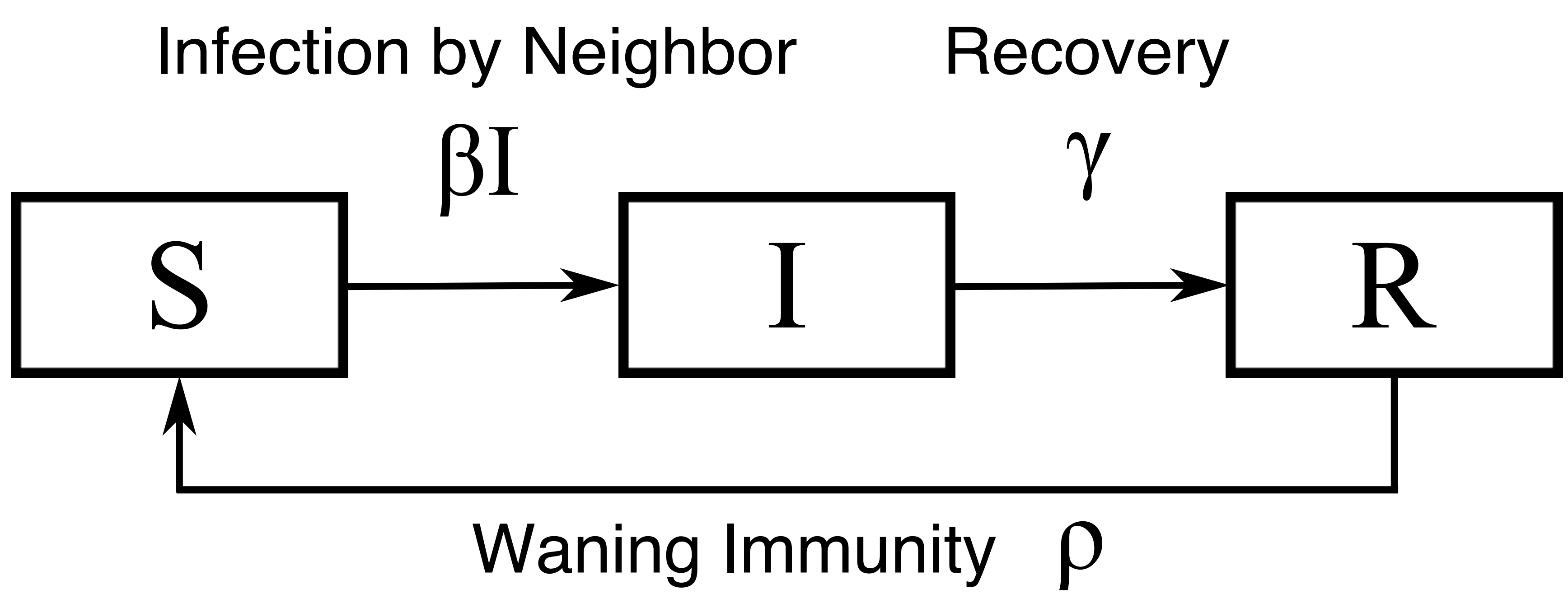
Endemic Infection

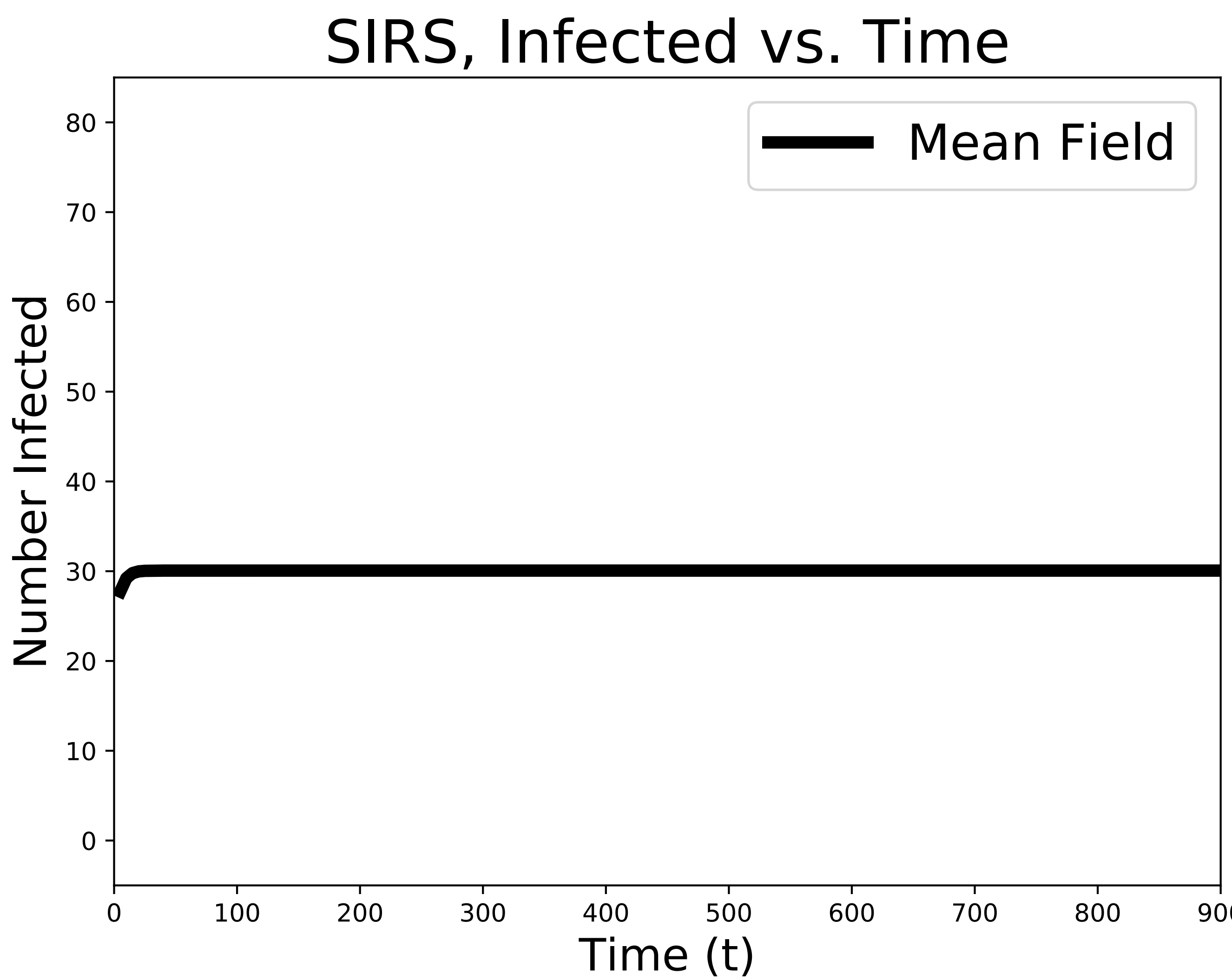
- Susceptibles are replenished
- Example: SIR with waning immunity



- Persistence of infected individuals in a population

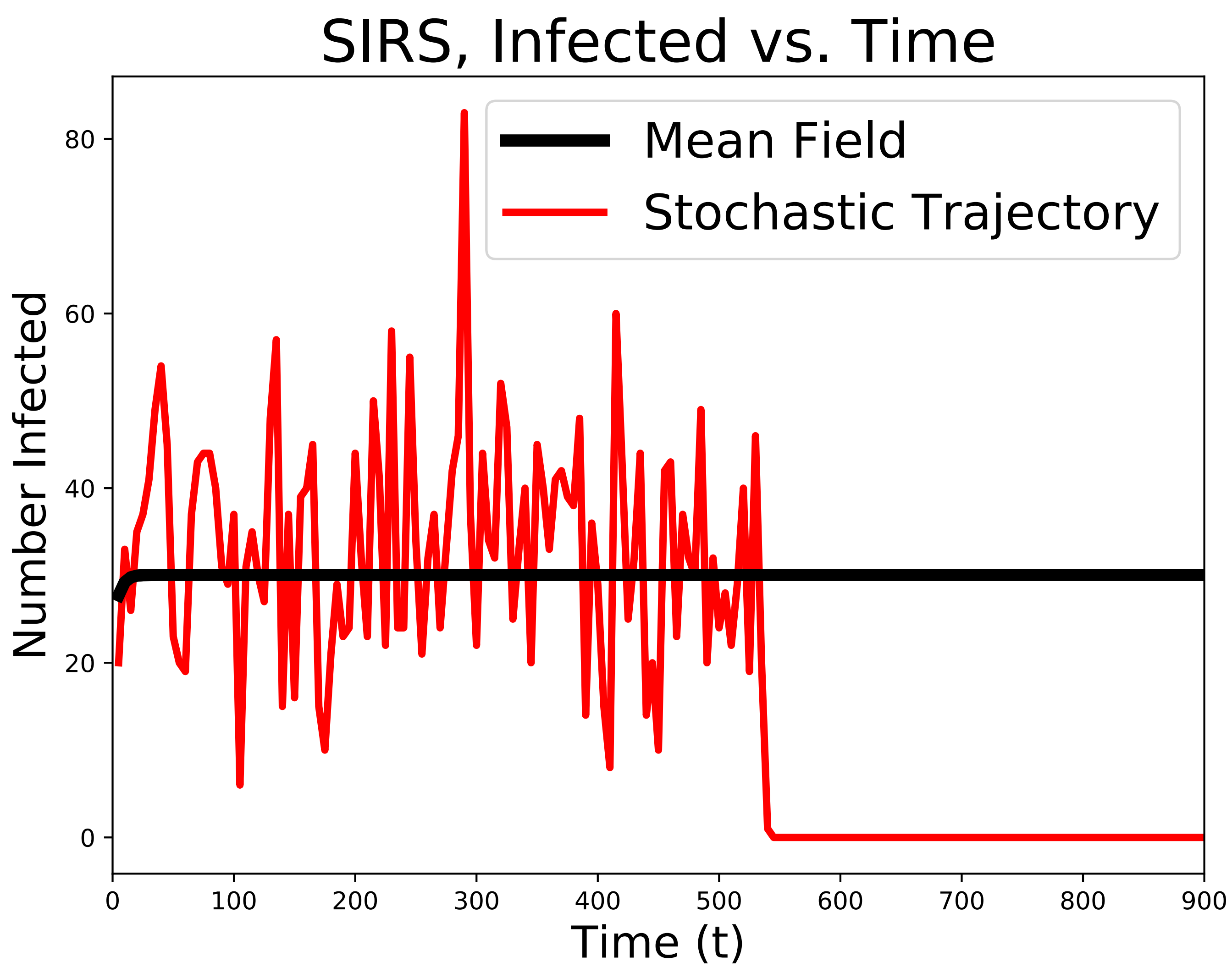
Spontaneous Extinctions

- Endemic states not stable in finite populations



Spontaneous Extinctions

- Endemic states not stable in finite populations
- Stochastic fluctuations bring infection level to 0



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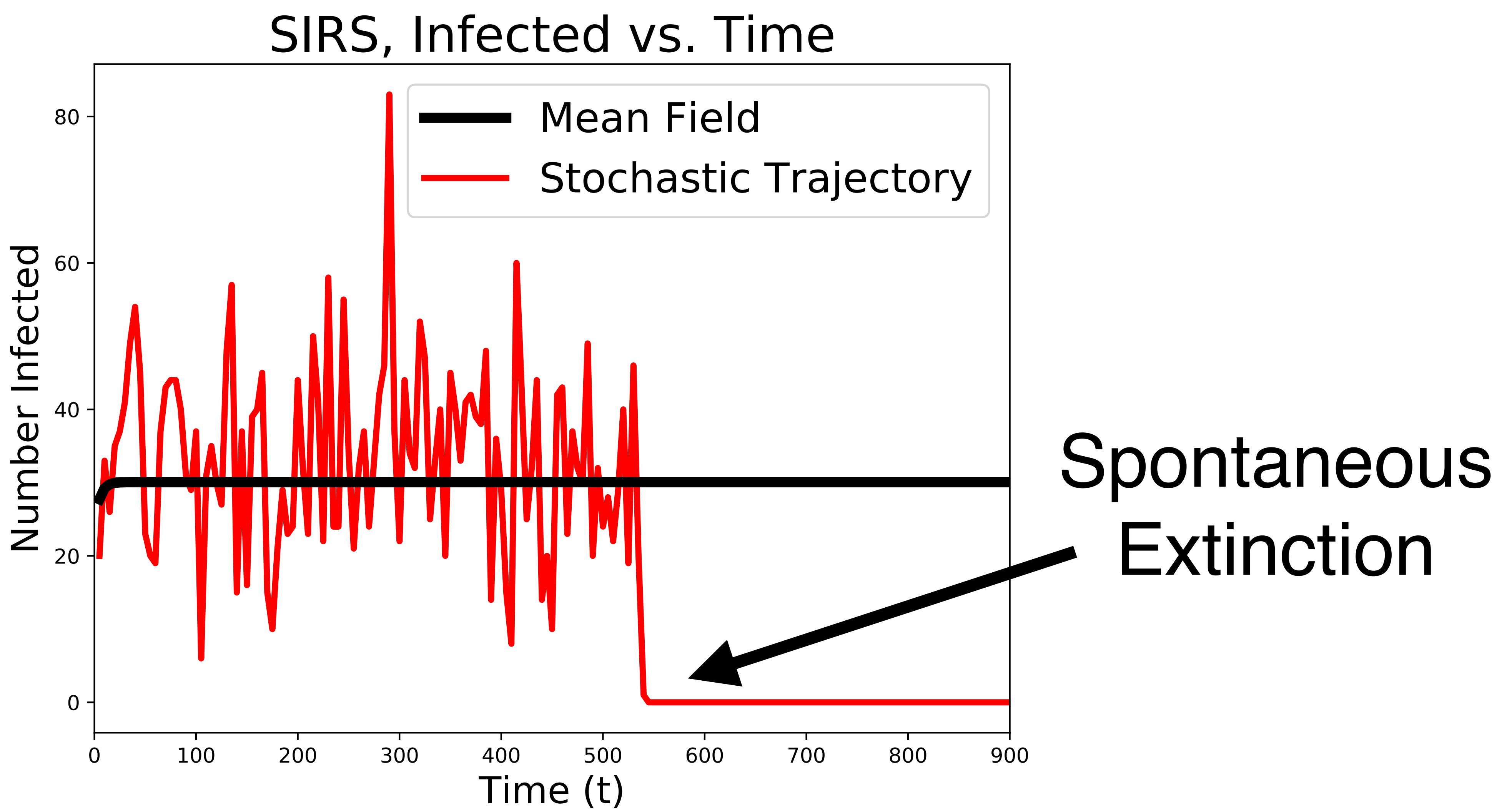
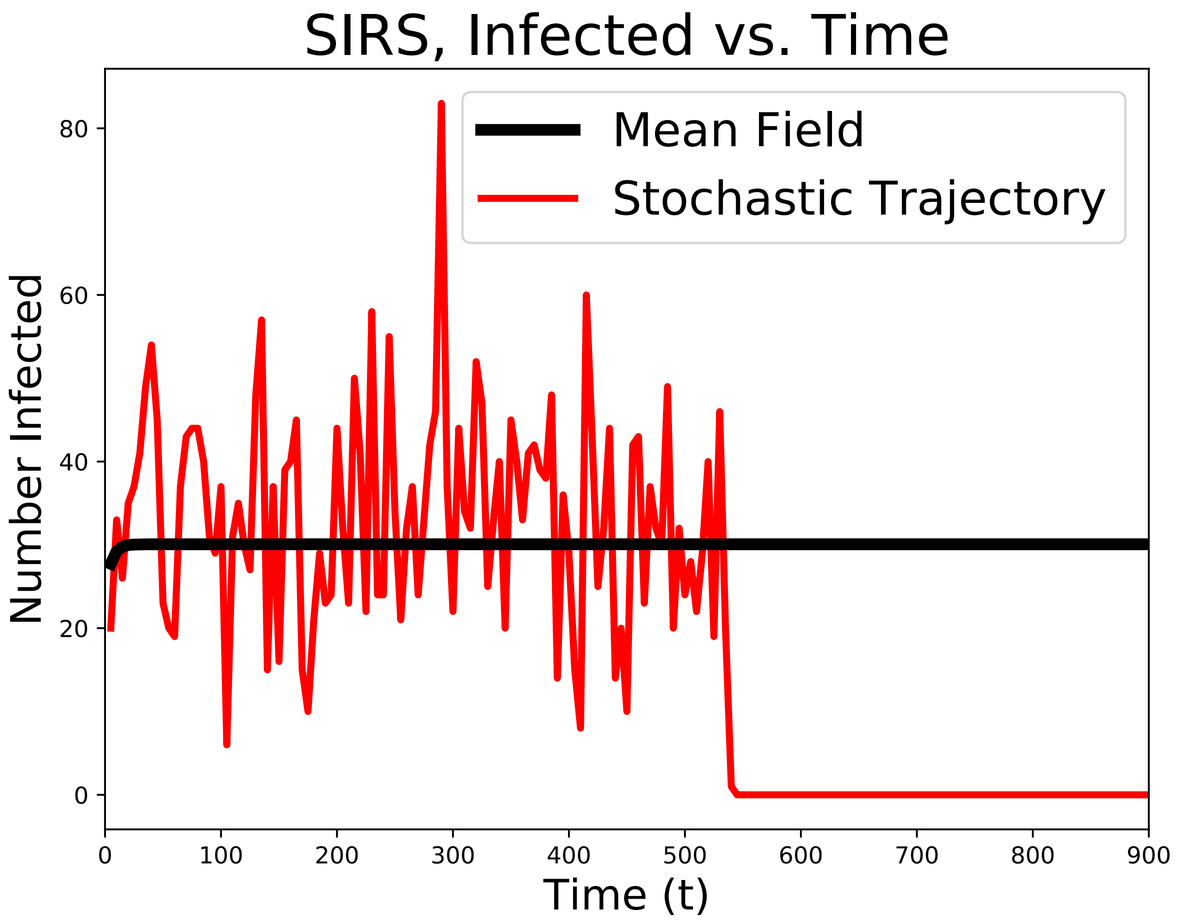


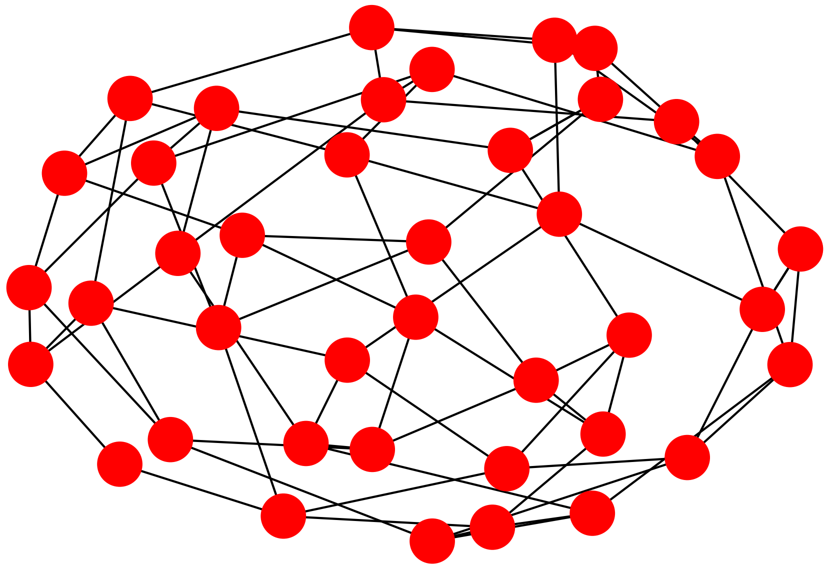
Endemic State Lifetimes

- Characteristic Lifetime
- Depends on
  - Mean Infection **μ**
  - Fluctuation Size **σ**

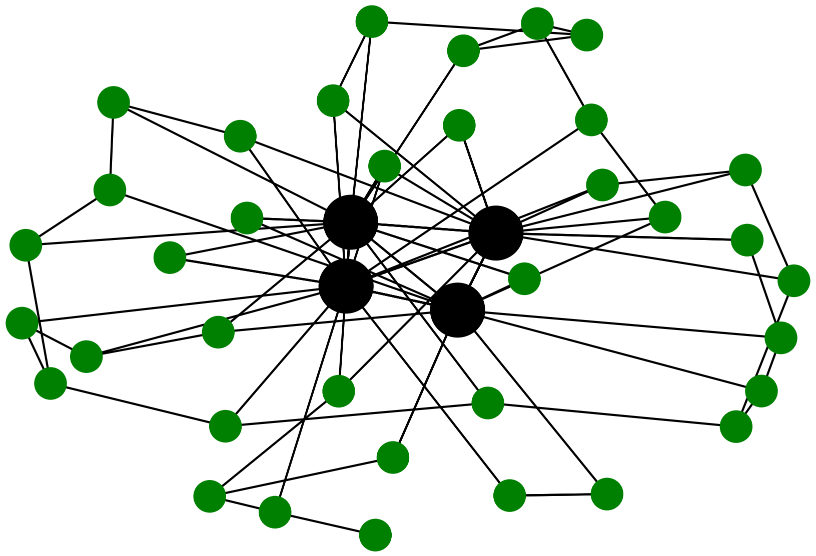


Network Effects

- Change contact network topology
- What happens to the endemic state lifetime?

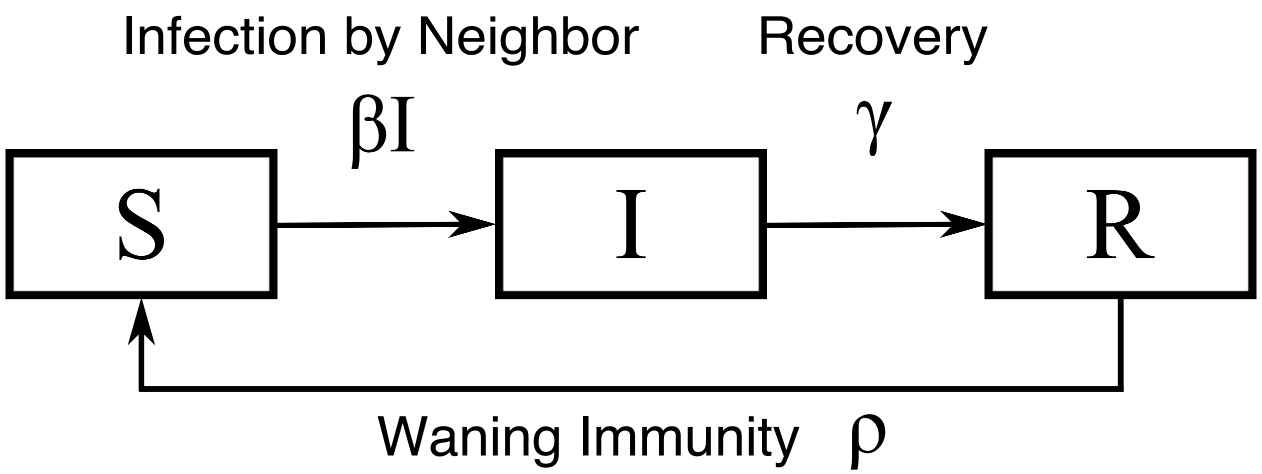


Homogeneous Graph

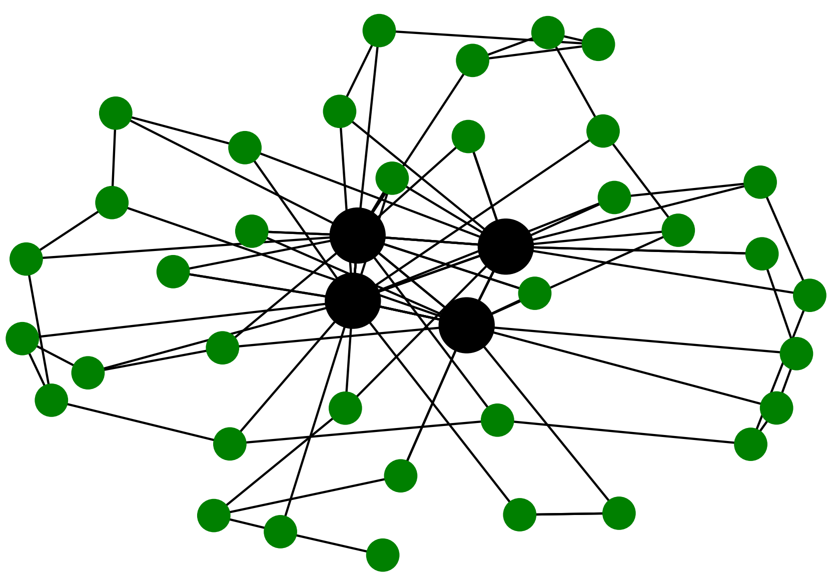


Heterogeneous Graph

Our Simulations



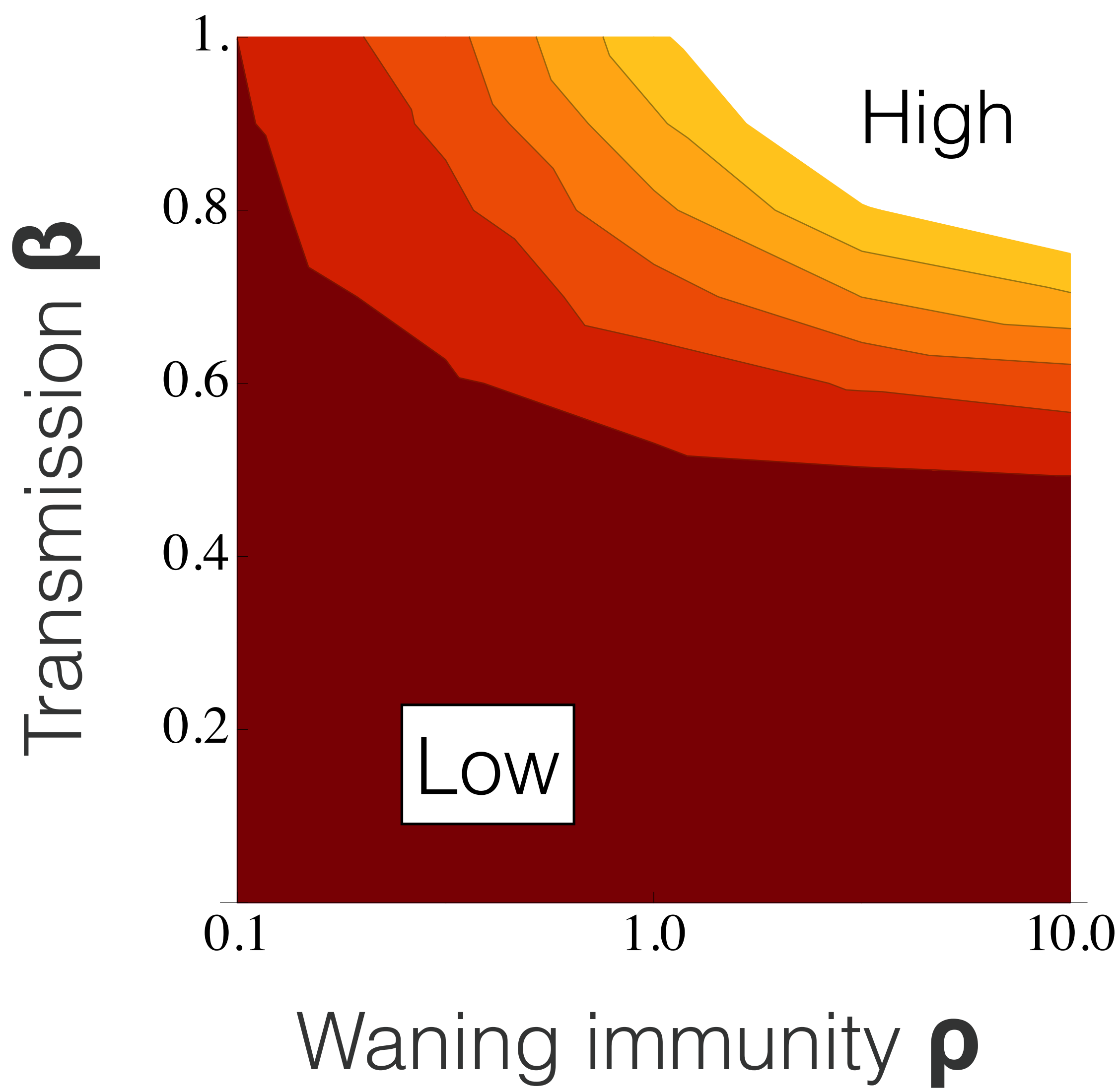
- SIRS model
- Annealed networks
- Vary degree heterogeneity **$<\sigma_k>$**
- Generate ensembles of trajectories
- Measure lifetime of endemic state



Results

500 nodes, mean degree 10, <σ_k> = 10

Mean Infection Level



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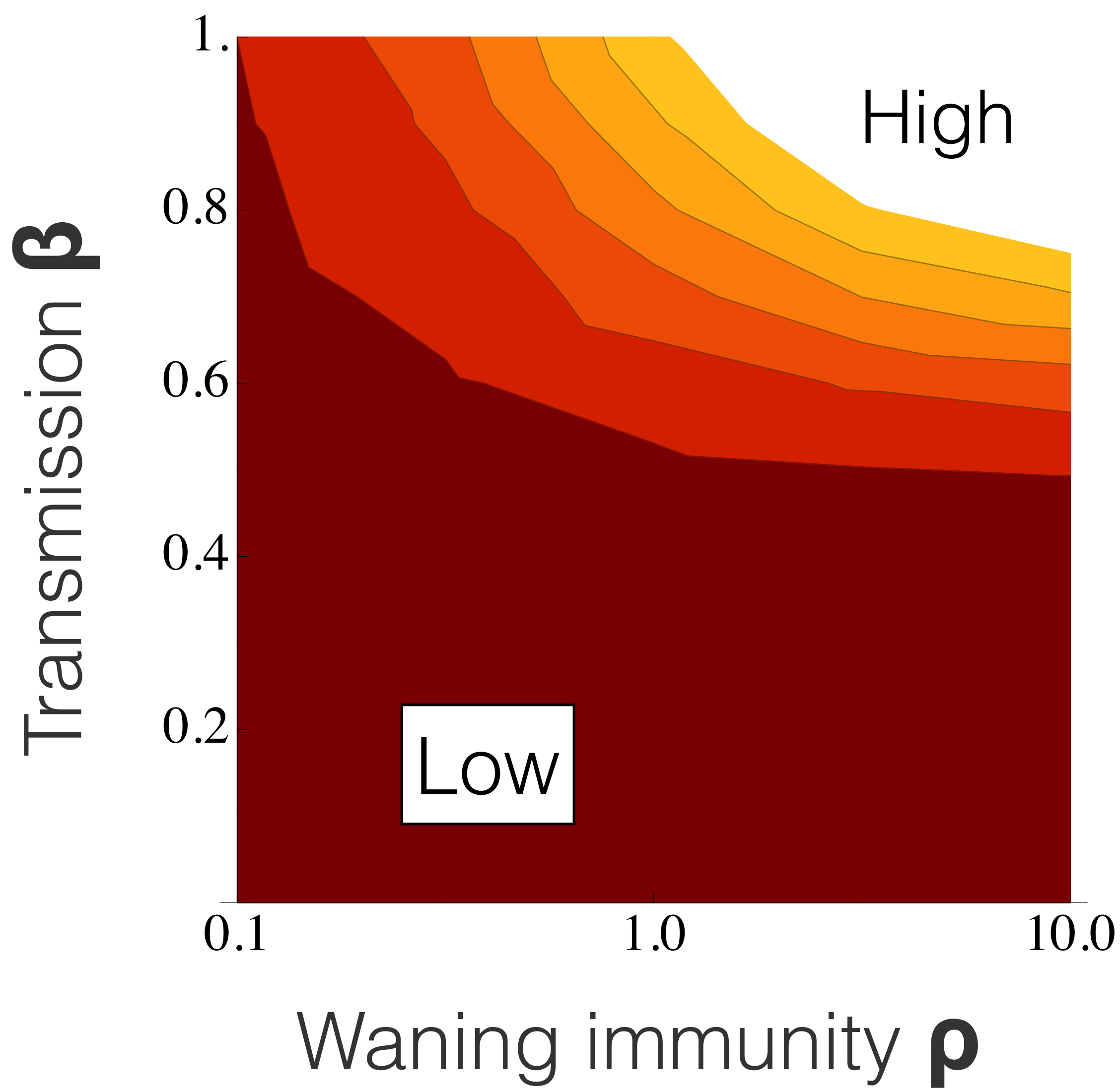
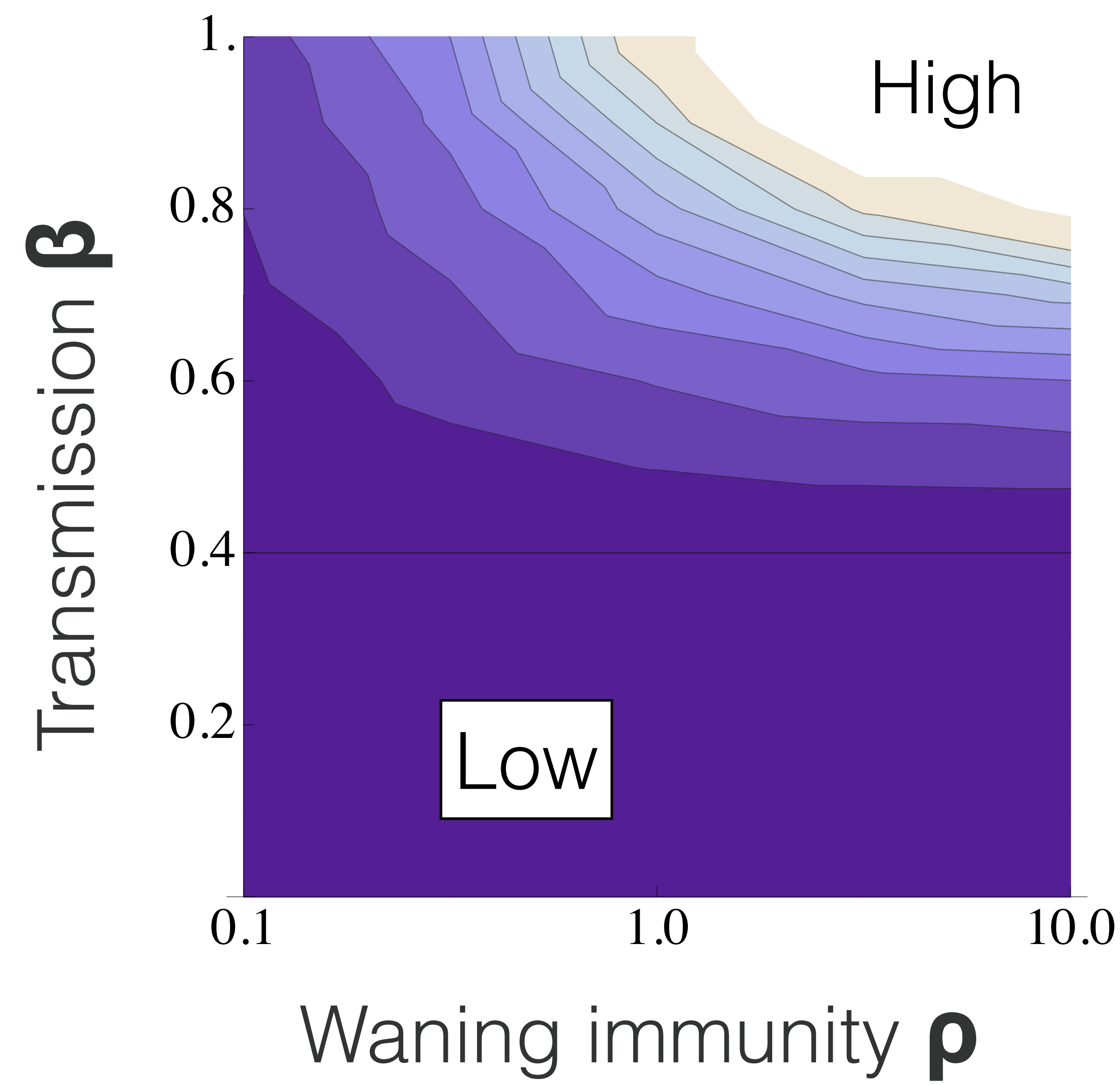


Mean Time to Extinction

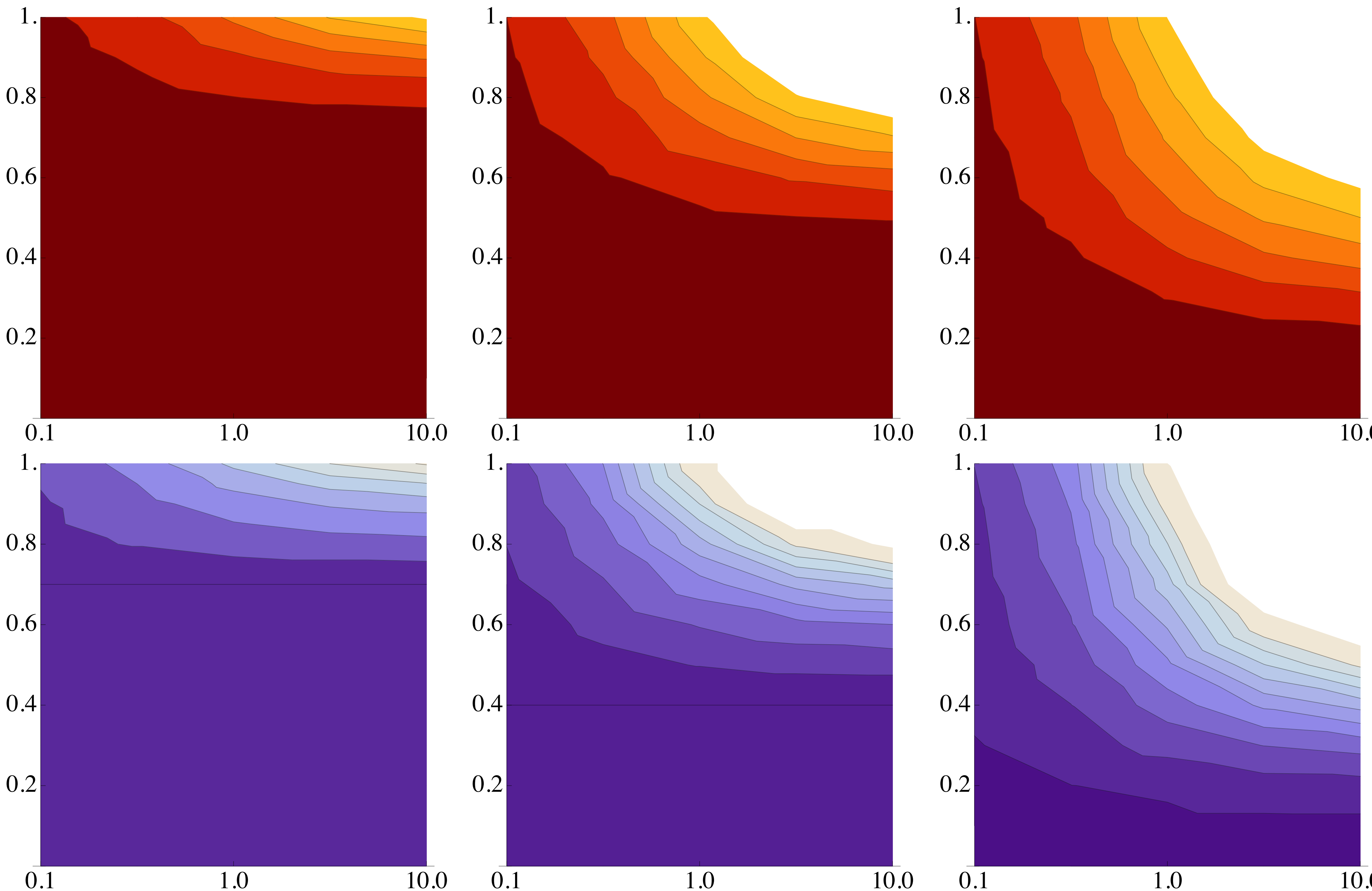


Results: Across Graphs

<σ$_k$> = 5 (Homogeneous) | **<σ$_k$> = 10** | **<σ$_k$> = 20 (Heterogeneous)**

Mean Number Infected

Mean Endemic Lifetime



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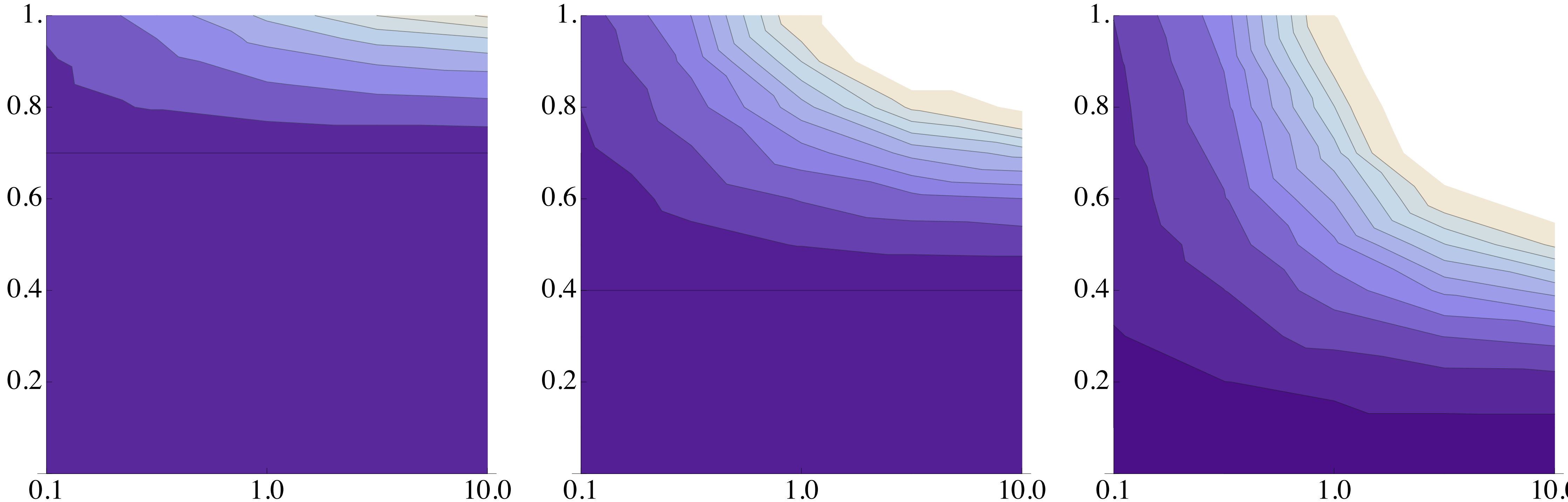

- Heterogeneous graphs have longer persistence
- Endemic lifetimes depend on topology

Predicting Lifetimes

- Can we predict endemic state lifetimes?

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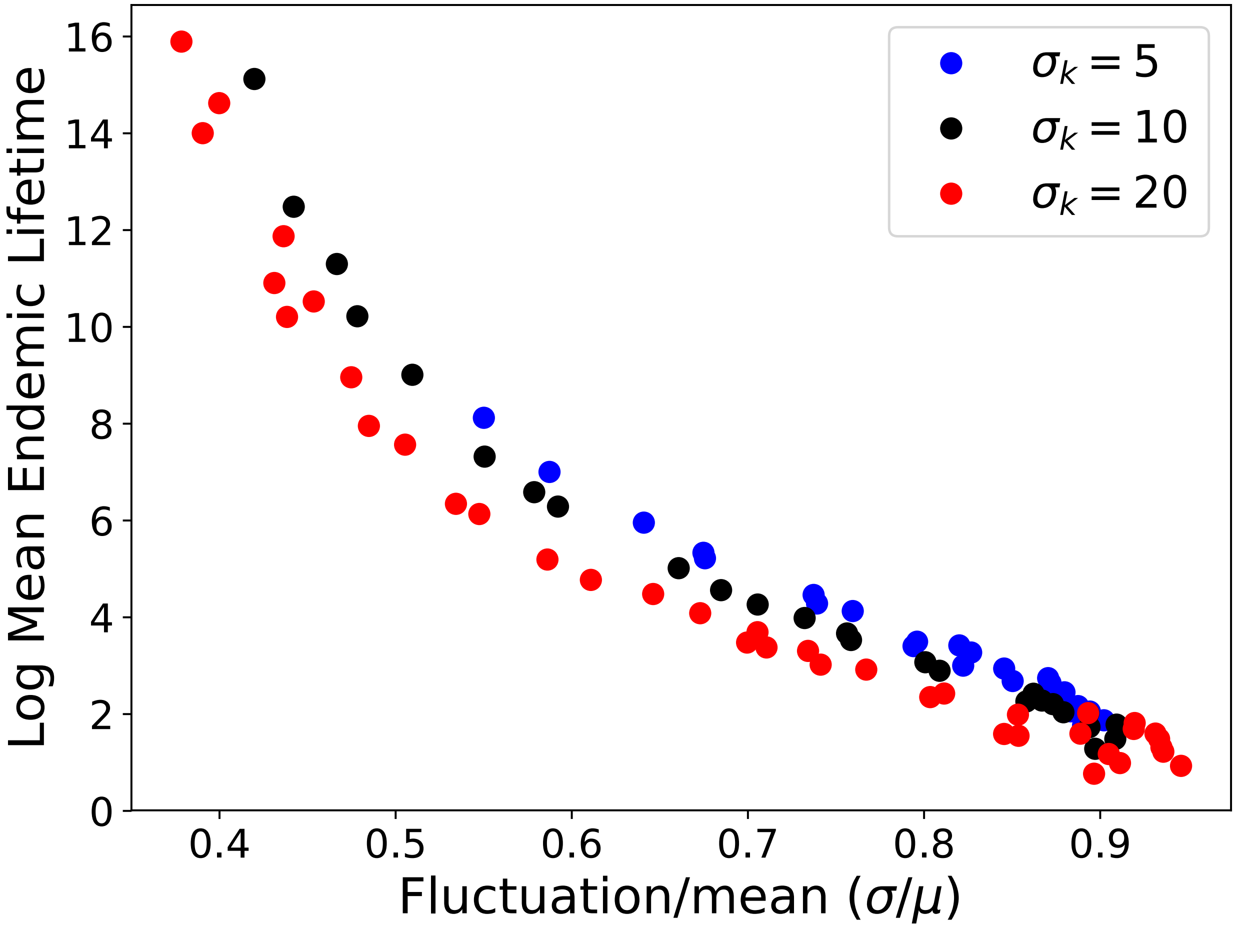

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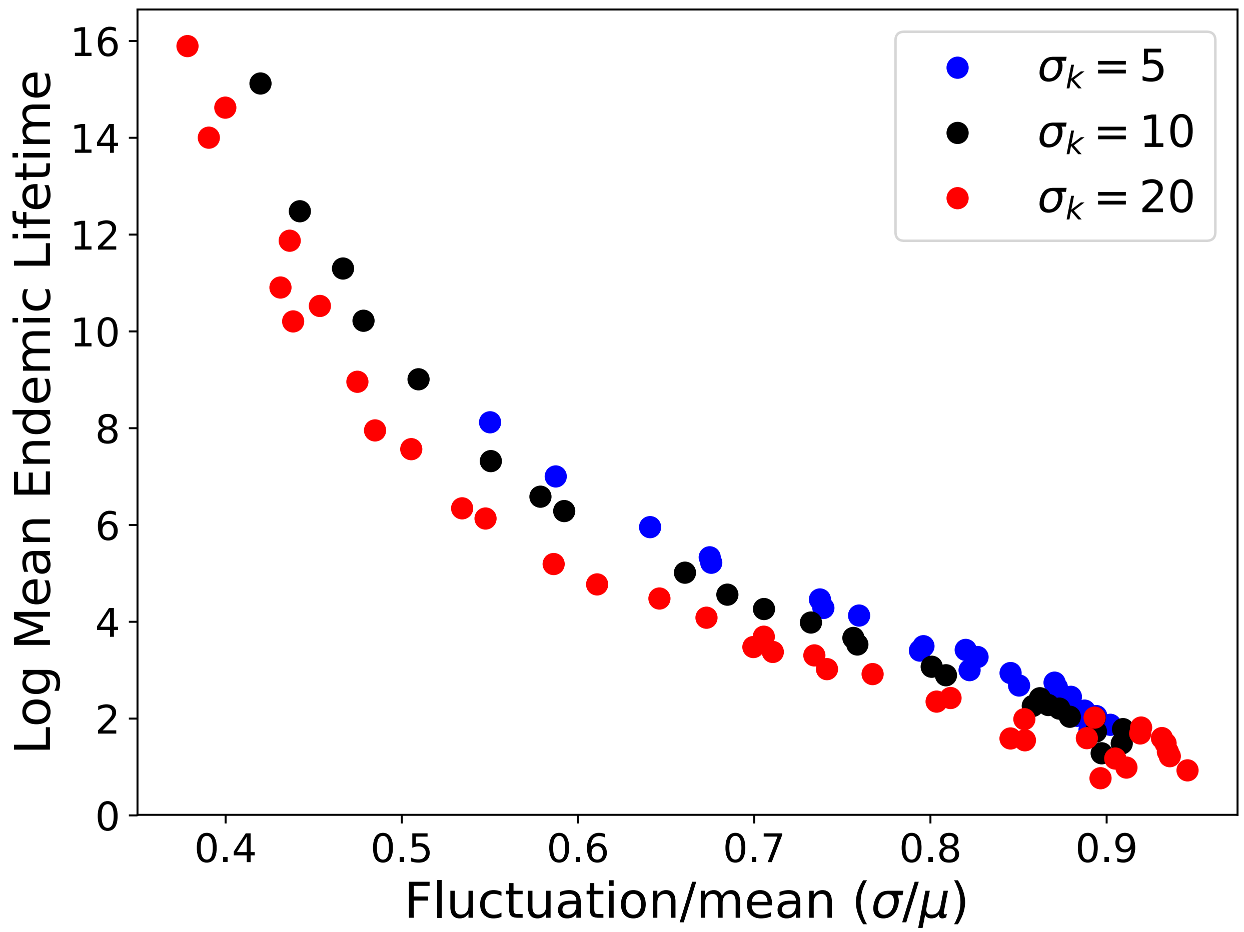

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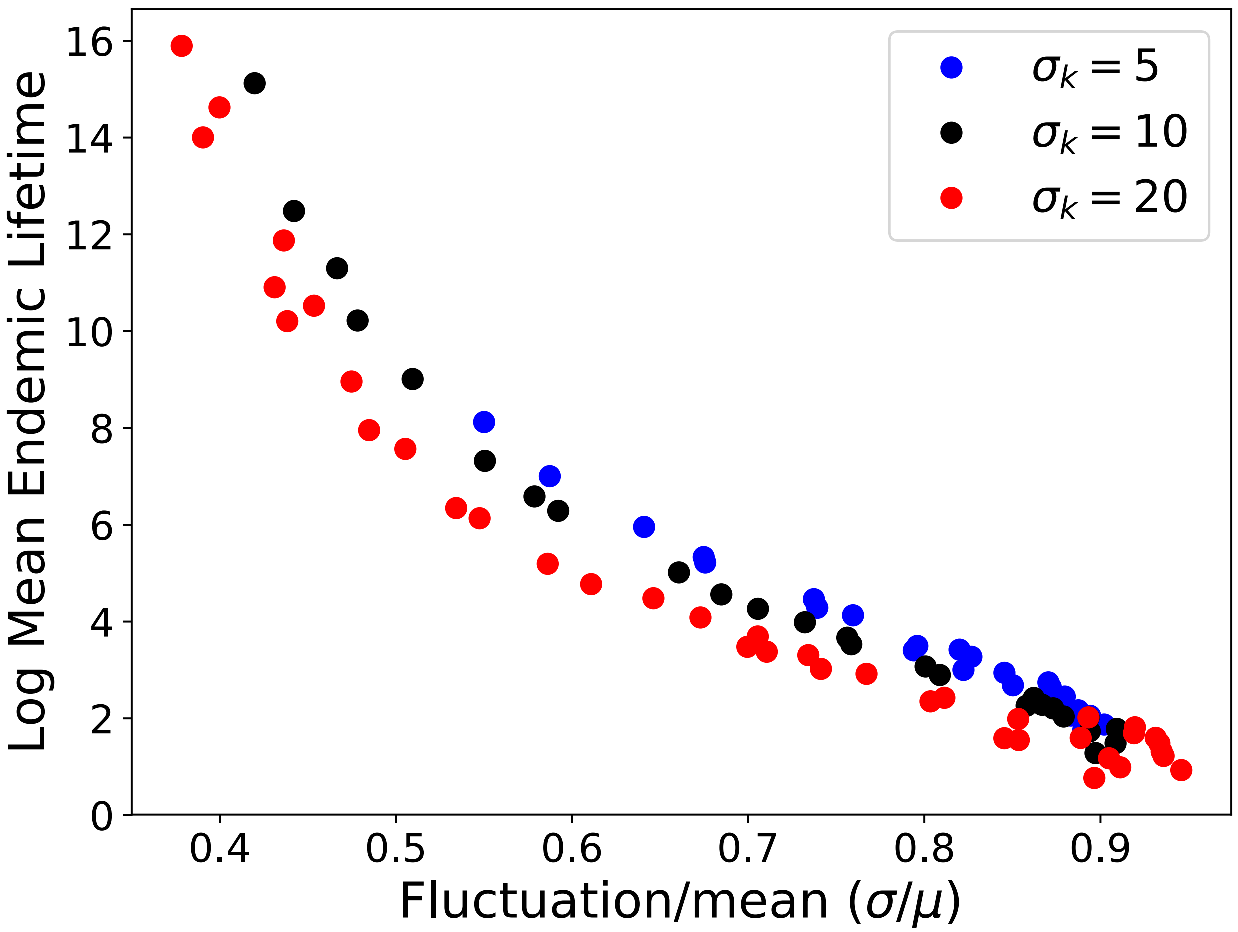
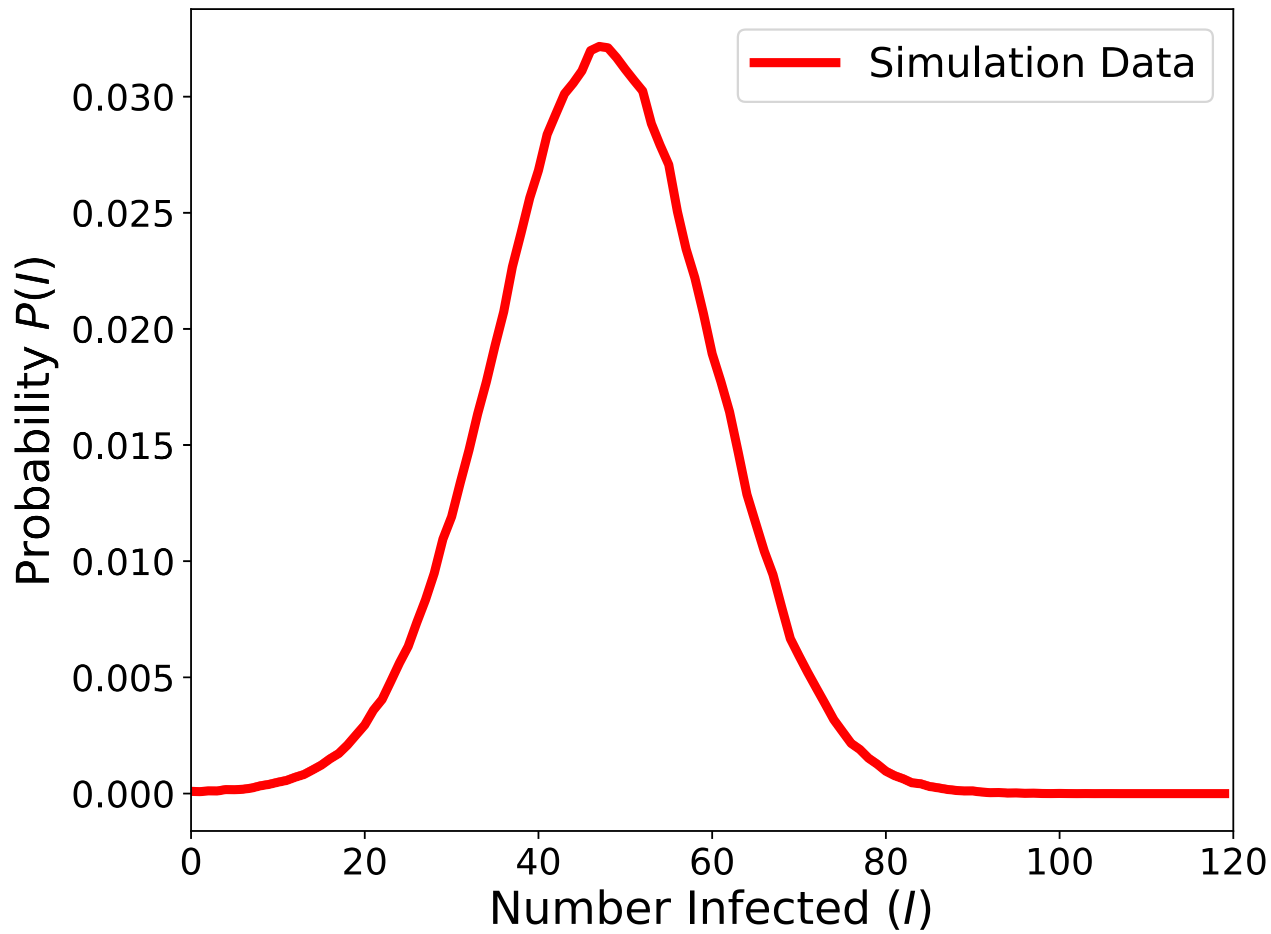


- Fluctuation/mean ratio **σ/μ** is sufficient

- Corrections from changing topology

Moment Closure

- Analytical technique that predicts *both* **means** and **fluctuation sizes**



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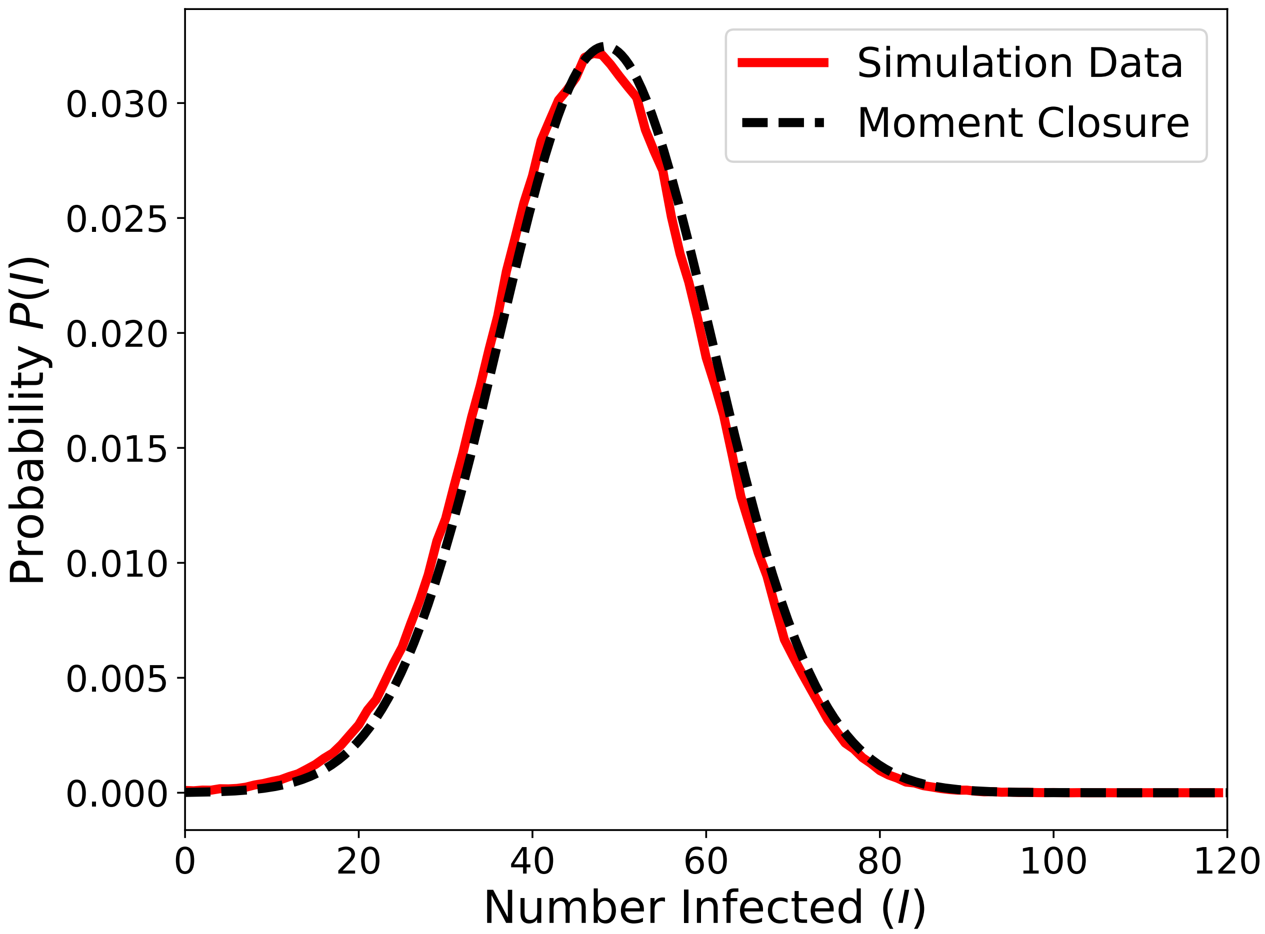

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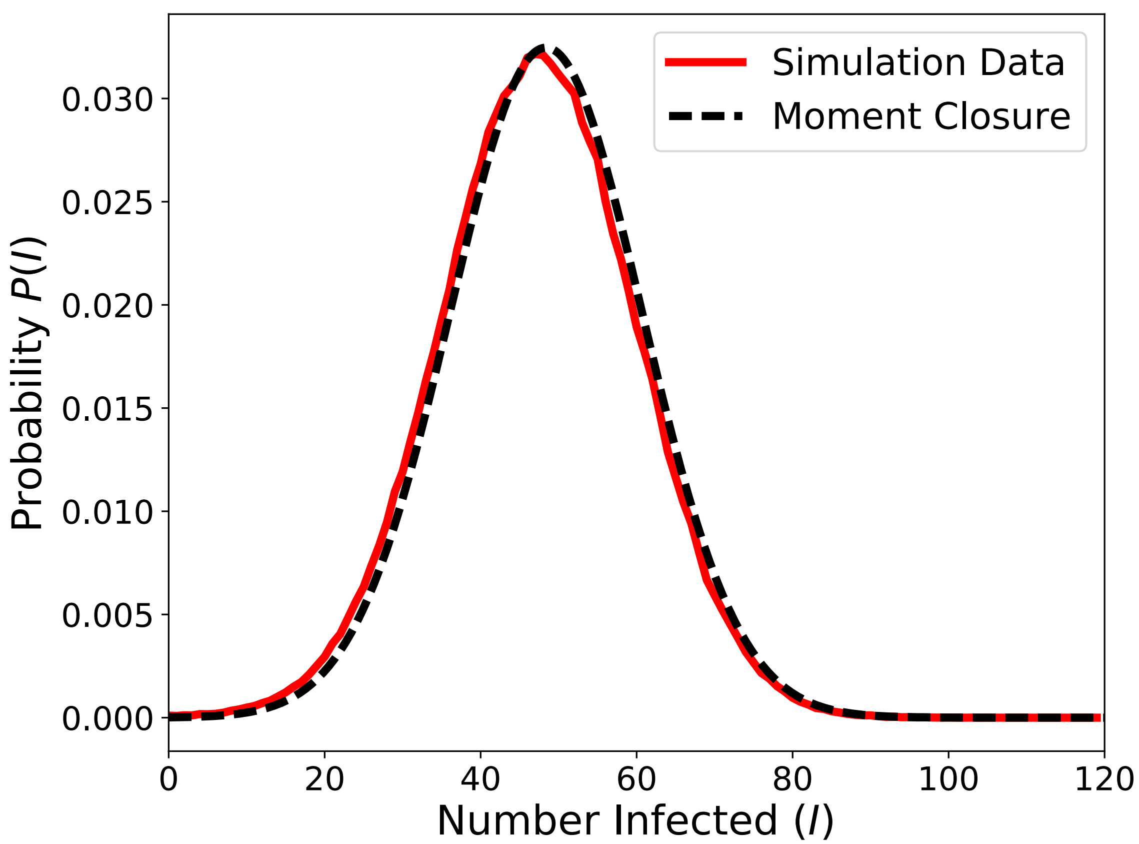

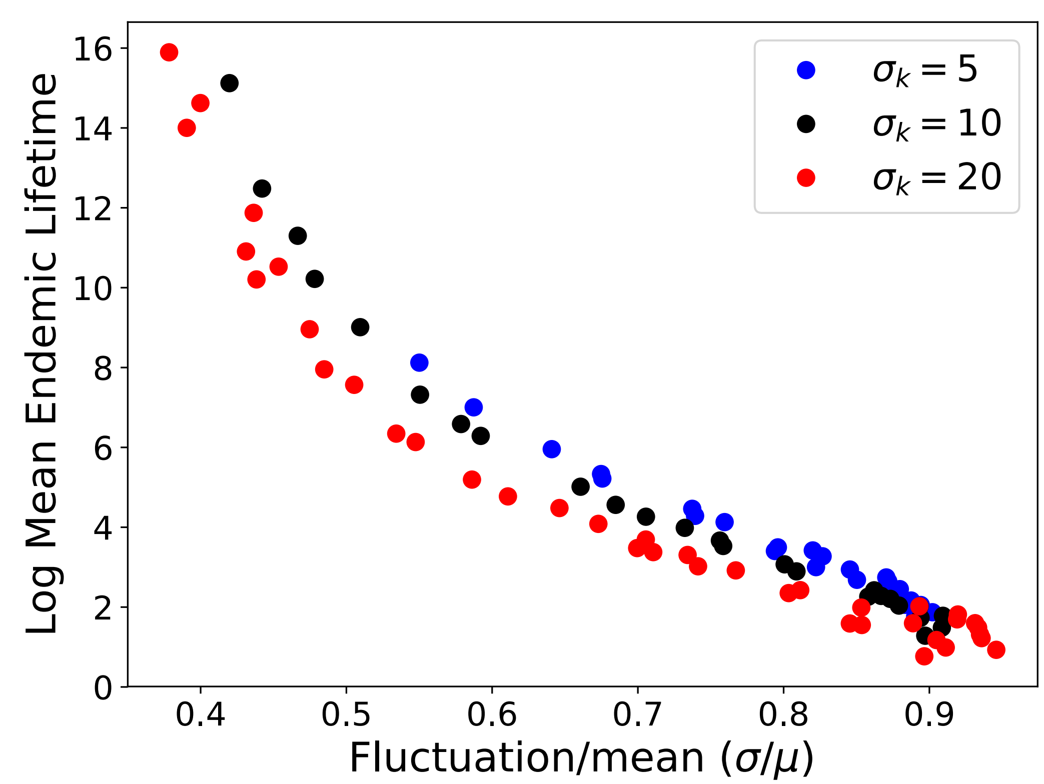

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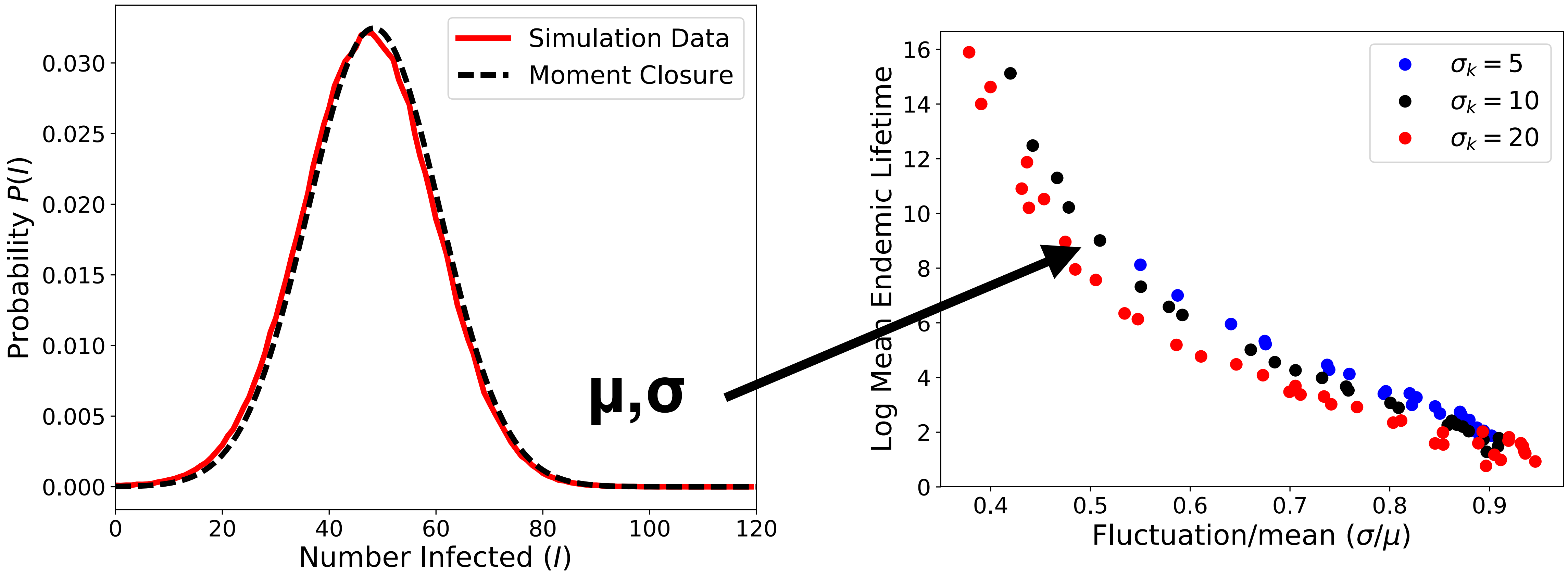

Summary

- Network topology can affect the persistence of endemic disease
- Higher degree heterogeneity leads to longer lifetimes
- Moment closure may be useful for predicting lifetimes

Acknowledgments

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Bibliography

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Constant Mean Infection Level

- Measure means, fluctuations
- Can we predict the lifetime?
- Vary graph topology

Constant Mean Infection Level

- Measure means, fluctuations
- Can we predict the lifetime?
- Vary graph topology
- Finite size effects
- High and low degree classes

- 500 Nodes
- <I> = 35 Infected