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Transmission of highly infectious animal diseases in a pig contact network

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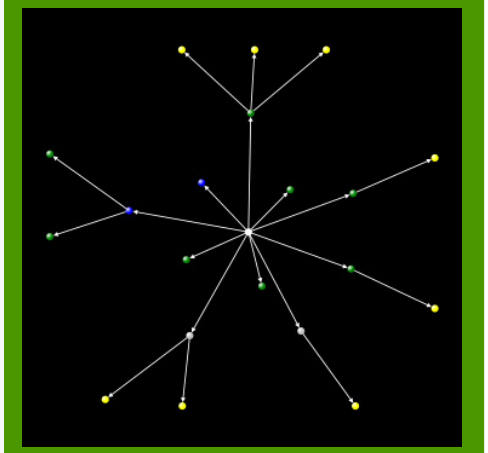
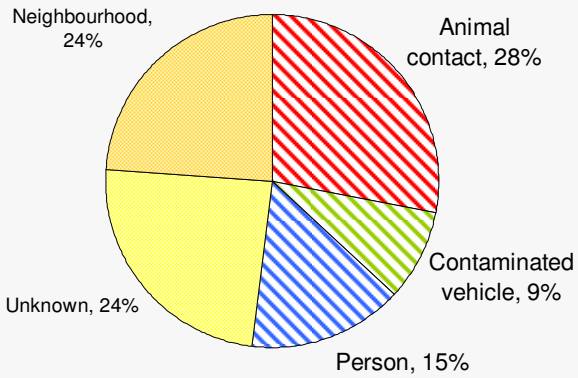


Introduction

- Animal diseases cause great economical losses
  - Foot and mouth disease
  - Classical swine fever
- Most transmission via contacts
  - Animal to animal
  - Via personal, vehicles
- Contact network between premises
  - Efficient control strategies



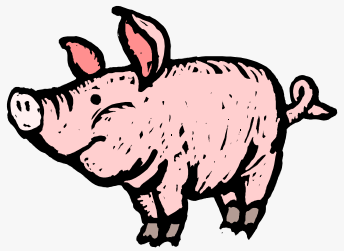
CSF Germany 1993-1997
(Fritzemeier et al., 2000)

Analyze influence of contact network between pig production related premises on disease transmission

Material - Database

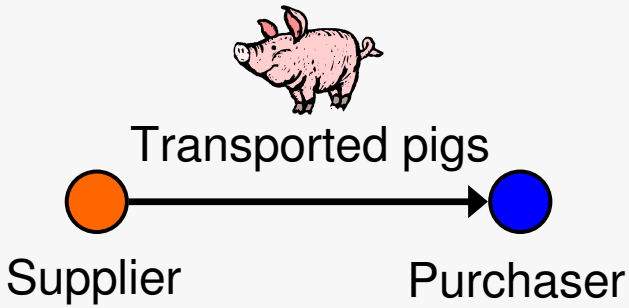
- Data recording 2006-2009 in Northern Germany
- 650 premises with 15,000 pig movements
  - Date of movement
  - Supplier (Farm)
  - Purchaser (Farm, Abattoir)
  - Number and type of animals (weaned piglets, fattening pigs, gilts, sows, boars)

- Data aggregated per week



Method – Network analysis

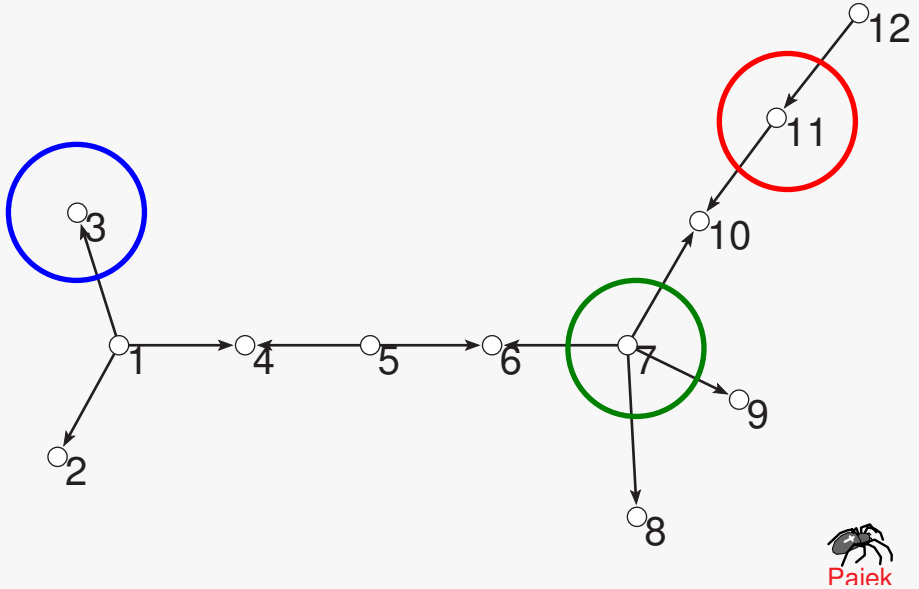
- Directed network
  - Edge: livestock movement
  - Node: premise



- Network characteristics for nodes (premises)
  - In-Degree
  - Out-Degree
  - Degree-Centrality
  - Closeness-Centrality
  - Betweenness-Centrality

In- and Out-Degree of a premise

	In-Degree	Out-Degree
1	0	3
2	1	0
3	1	0
4	2	0
5	0	2
6	2	0
7	0	4
8	1	0
9	1	0
10	2	0
11	1	1
12	0	1



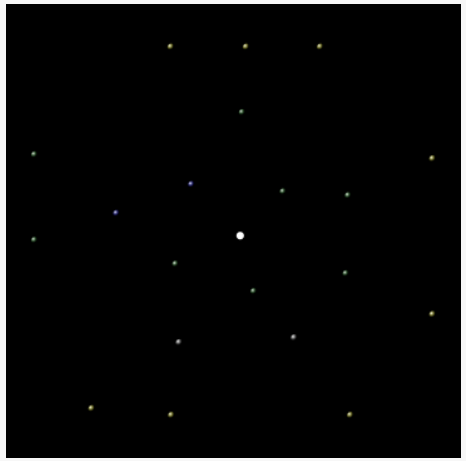
→**In-Degree**

Number of premises that can directly infect this premise

→**Out-Degree**

Number of premises that can directly be infected by this premise

Method – Disease transmission

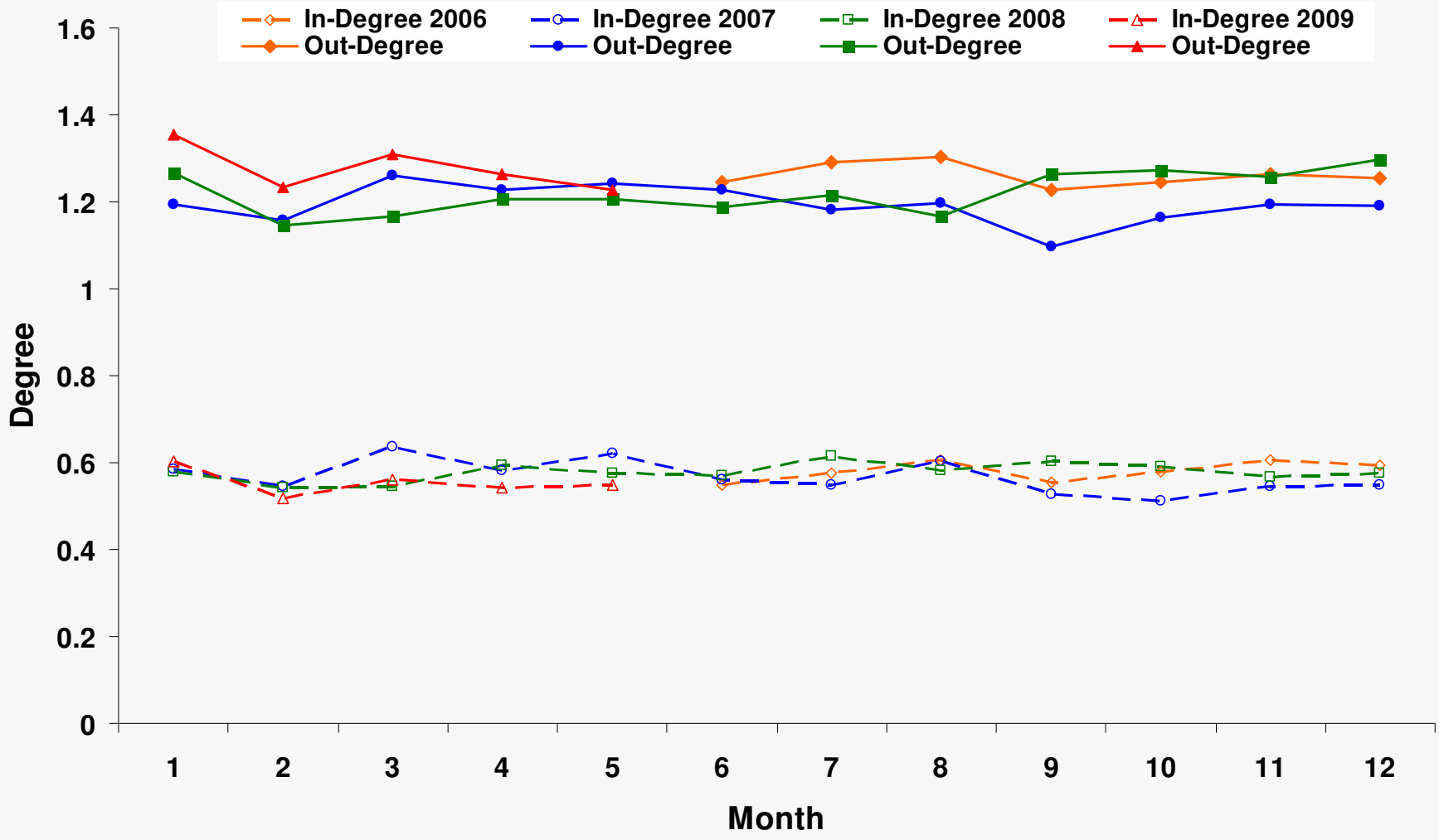


- Dynamical percolation
- Weekly basis
- Start at one initially infected premise

- Input parameter for the simulation
  - Transmission probability (0, 0.1,…,1)
  - Time until diagnosis and culling
    - Initially infected premise (3, 4, 5, 6 weeks)
    - Secondary infected premise (1, 2, 3, 4 weeks)
- 50 replications

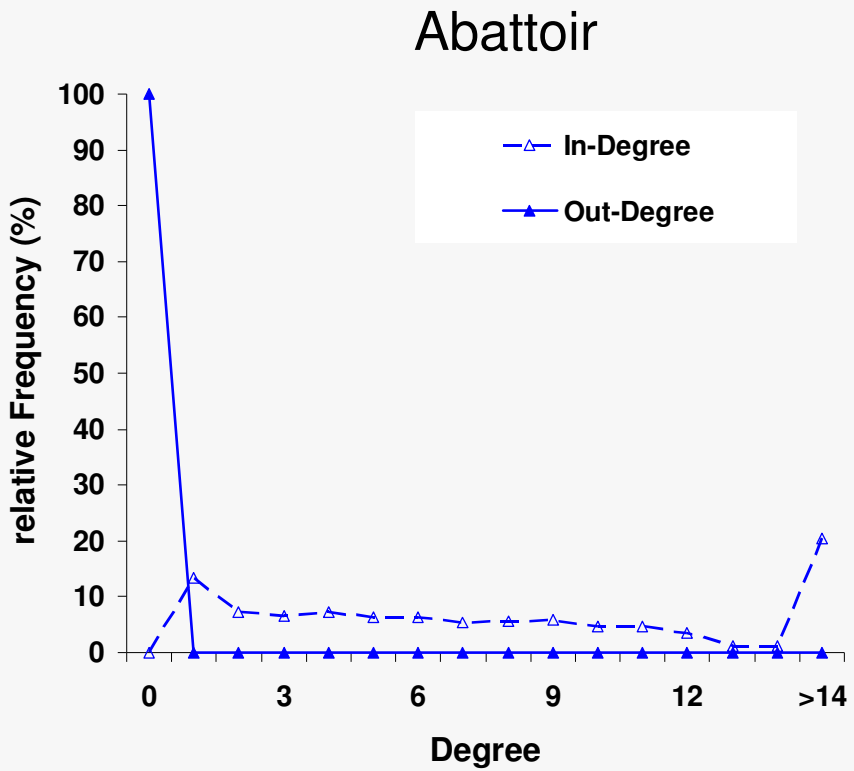
Results – Network Characteristics

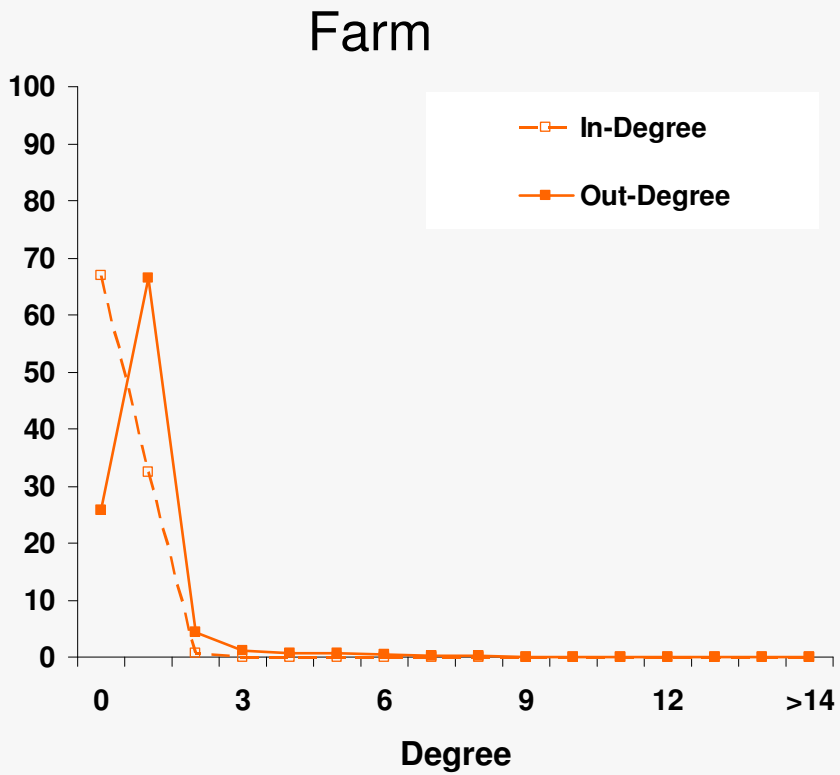
Average In- and Out-Degree per month and premise



Results – Network Characteristics

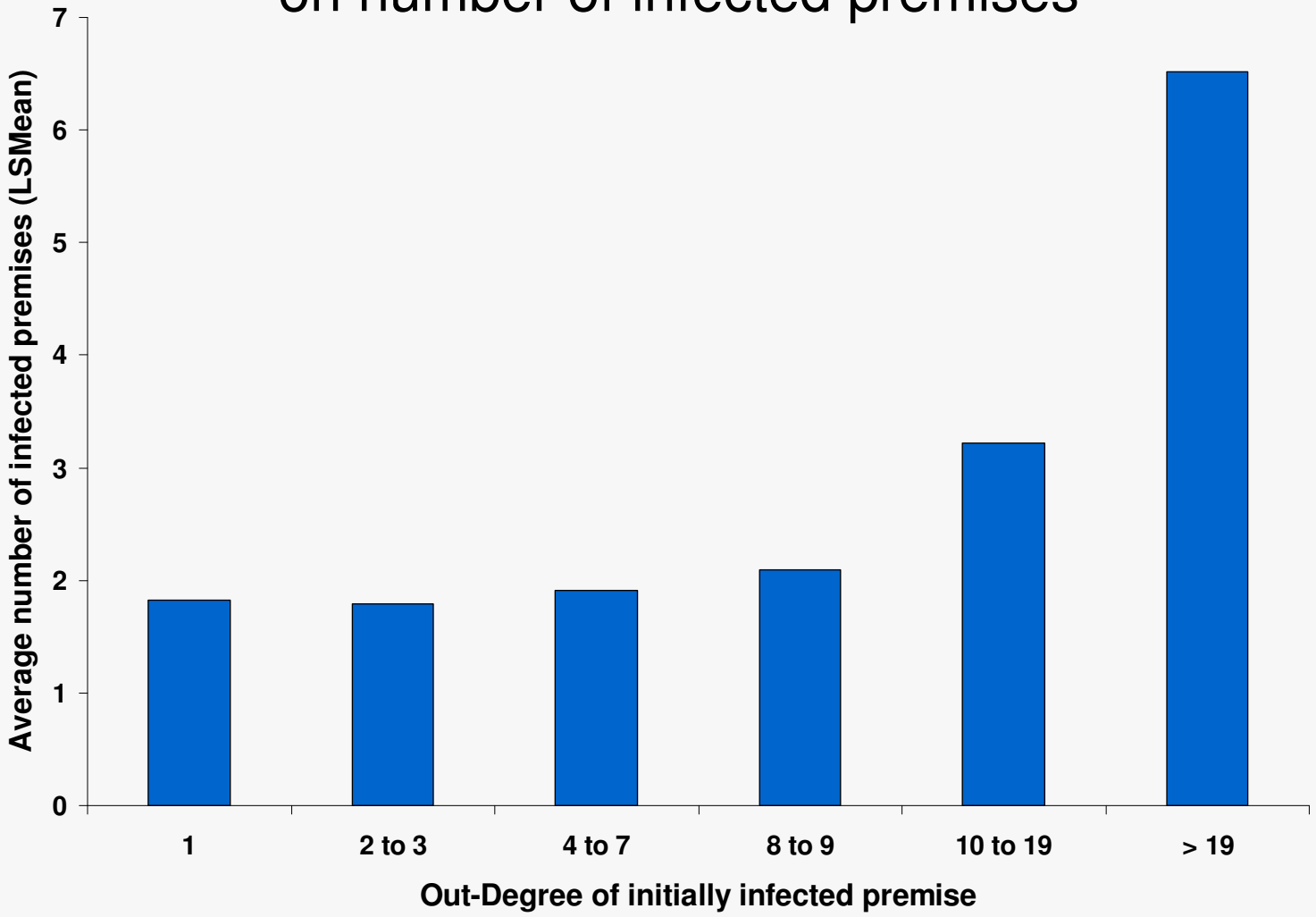
Distribution of In- and Out-Degree per week depending on type of premise





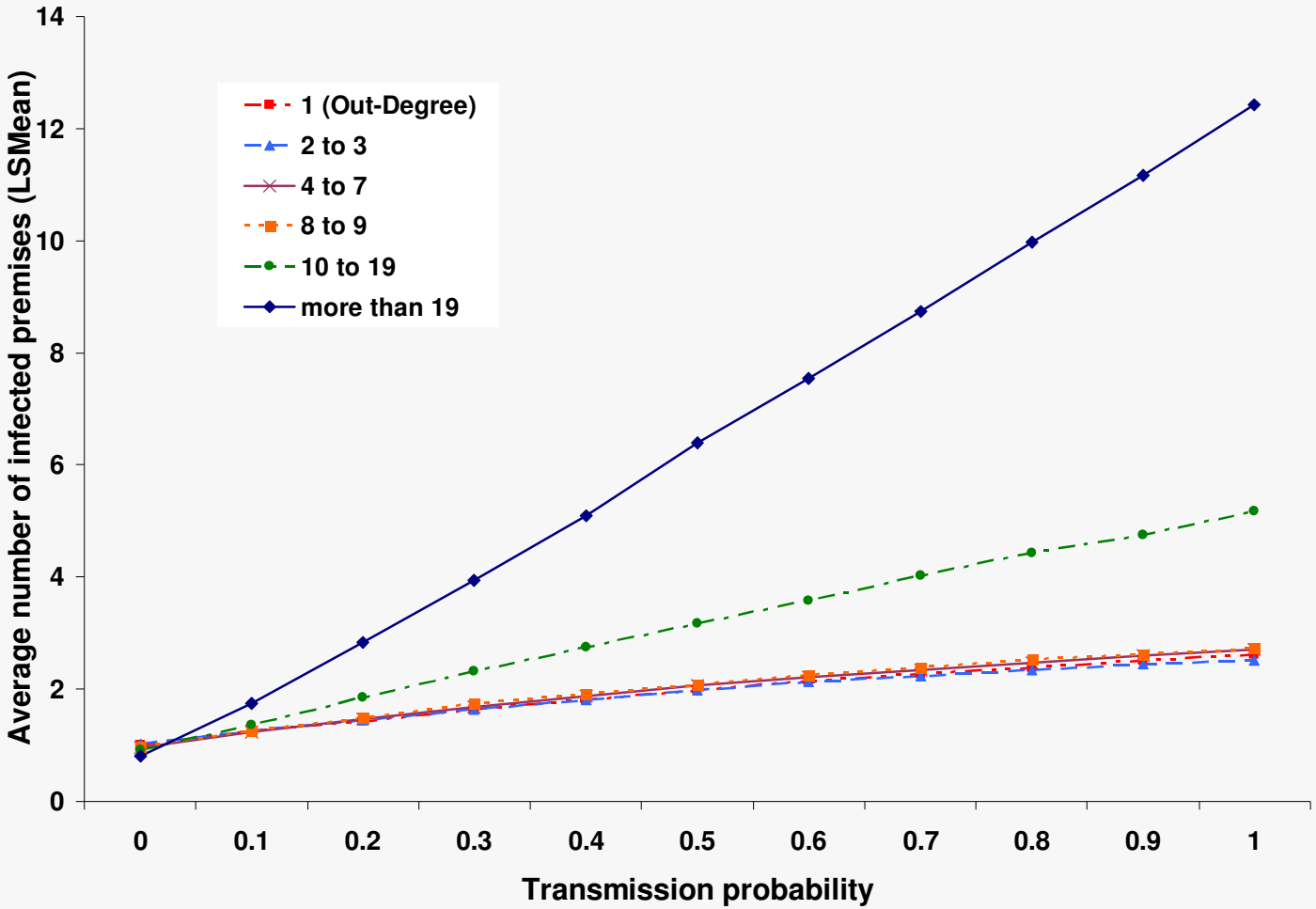
Results – Disease Transmission

Influence of Out-Degree of initially infected premise on number of infected premises



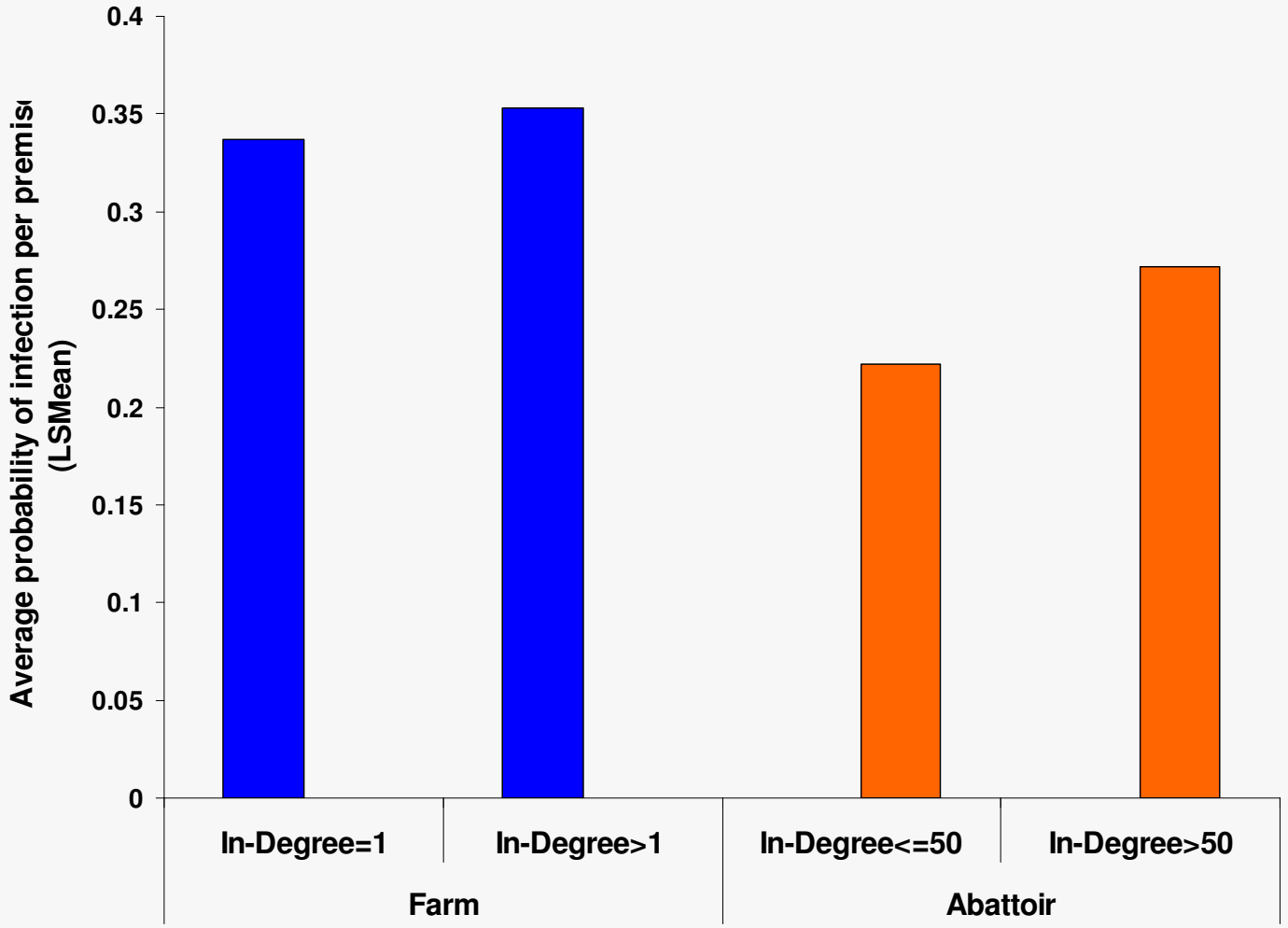
Results – Disease Transmission

Interaction between transmission probability and Out-Degree of initially infected premise



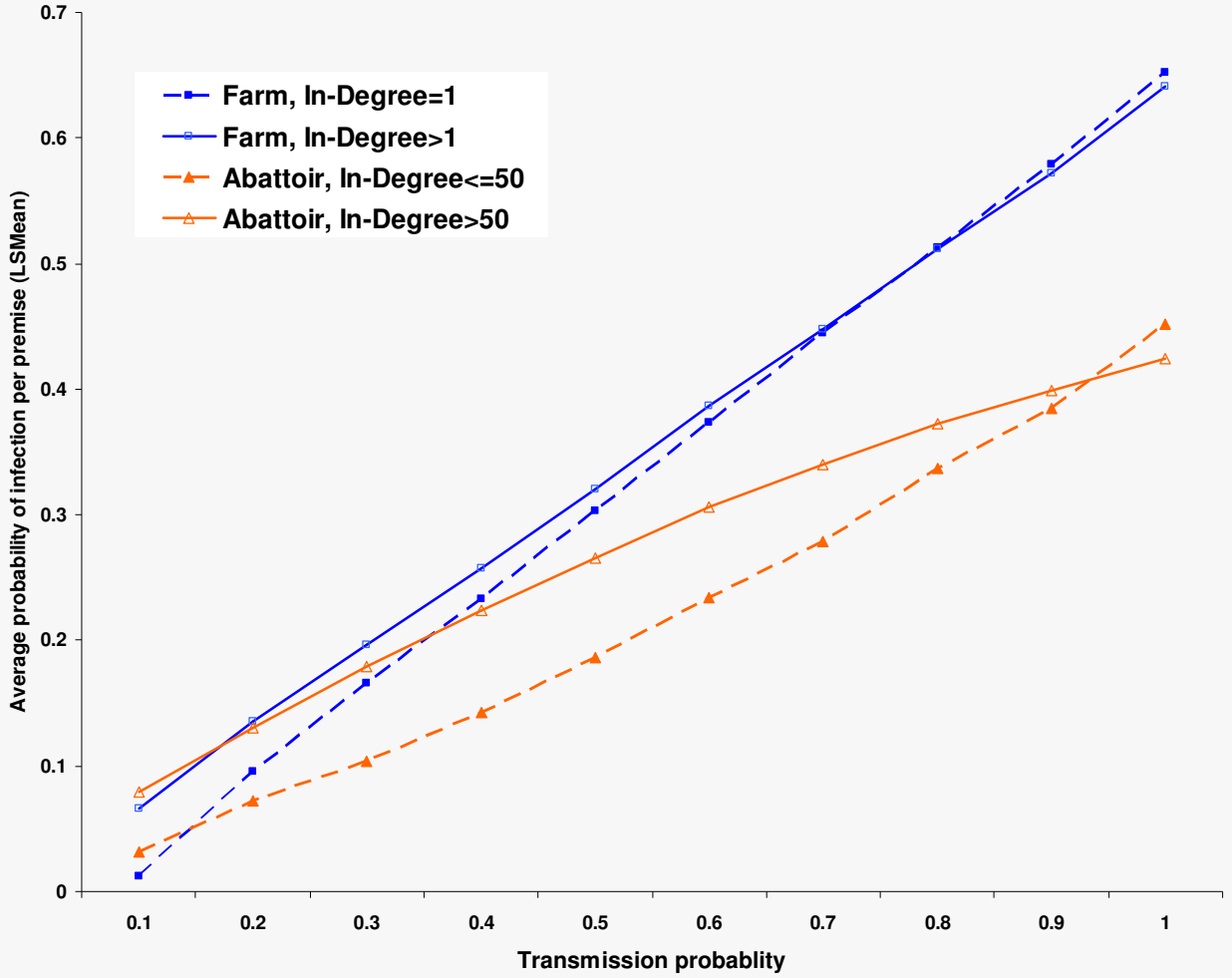
Results – Disease Transmission

Influence of In-Degree and premise type on average probability of infection per premise



Results – Disease Transmission

Interaction between In-Degree and type of premise and transmission probability



Conclusions

Network characteristics

- Homogeneous network over time
- In- and Out-Degree describes great differences between farms and abattoirs

Number of infected premises

- Start on premises with high Out-Degree (>10) result in considerably more infected premises, particularly
  - If highly contagious diseases (CSF, FMD)
  - If long time period until detection of disease

Infection probability of premises

- Only slightly affected by In-Degree of a premise especially if highly contagious disease

Thank you for your attention