

Bundesinstitut für Risikobewertung

## Network Analysis and Food Safety Assessments

Past, Present, and Future Research @ BfR

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Part I

# Past Research



Hans Mielke, 2016-02-08, HoA Meeting

### What is Network Analysis

Provides computational methods

- to analyse contacts (arcs) between elements (nodes) in a contact network
- for the identification of relevant (central) nodes or arcs
- within a specific research question (e.g. food safety assessment)





## Node Centrality Examples

Different concepts have been developed, among others

- a. Betwenness
- b. Closeness
- c. Eigenvector
- d. Degree
- e. Harmonic
- f. Katz

Image source: Wikipedia





## **Contact Clustering**

- Identification of Communities
- Need computational power





## **Application of Network Computational Methods**

- Data availability
  - Mobile phone
  - Social media
  - Flight passengers
  - Animal Trade
- Methods availability
  - Barabáshi-Albert
  - Erdős-Rényi
  - Wasserman & Faust
  - Newman
  - Vespignani
- Software availability
  - igraph (Csárdi & Nepusz, CRAN)
  - NetworkX (Los Alamos Lab)





Part II

# Present Research



## Networks Evolve. How to Analyse?







## Networks are partially known. How to find central nodes?





#### **Real network**

**Reported network** 







## **Problems & Suggestions**



"Networks are rarely completely observed and prediction of unobserved edges is an important problem, especially in disease spread modeling where networks are used to represent the pattern of contacts."

"One important ingredient to consider is the pattern of diseasetransmission contacts among the elements, however lack of data or delays in providing updated records may hinder its use, especially for time-varying patterns."







# Future Research



## Gravity Model of Trade

- Acknowledge: We do not have all the data needed.
- Instead develop models explaining the trade data.
- Predicted trade data may be used instead of real data.
- Will this work? Under which conditions?



Validate!

 $F_{ij} = G(M_i^{\beta_1} M_j^{\beta_2} / D_{ij}^{\beta_3}) \eta_{ij}$ 



## Gravity Model of Trade

Applied to outbreak source detection





the underlying food distribution network. We show that this approach can efficiently identify most probable encenters of food-borne disease outbreaks. We assess and discuss the method in the context of the 2011



German food shipping network constructed from a gravity model



## Gravity Model of Trade

### Trade prediction may be influenced by

- Borders
- Regulatory measures
- Demographic change
- Climate change
- Projected impact of climate change on agricultural yields \* A key culprit in climate change - carbon emissions - can also help agriculture by enhancing photosynthesis in many important (... crops such as wheat, rice, and soybeans. The science, Change in agricultural productivity ever, is far from certain on the nefits of carbon fertilisation between 2003 and the 2080s This map represents the case of beneficial carbon fertilisation processes. +25 +10 +5 0 -5 -15 -25% No data Source: Cline W., 2007, Global Warming and Agriculture.



## Summary

- Powerful methods for the calculation of node importance have been developed in the past.
- Nowadays, the network community deals with the problem of under- and asynchronous reporting which result in eventually severely biased food chain safety assessments.
- In the future models predicting flow of goods in a food network will be available. These models are expected to support the preservation of safe global food chains.







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## Thank you for your attention

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