

Evaluation Report of the ASTIN Working Party ANCRM

Magda Schiegl,
University of Applied Sciences Landshut

About the speaker



- **Magda Schiegl**
- Professor
- Diploma in Physics; TU Munich.
- Dr. rer. nat in theoretical Physics, Max-Planck-Society; TU Munich.
- 1996-2009 Actuarial and Risk Management practice, Insurance and Energy Industry.
- 2009-2012 Professor for Risk Management; TH Cologne.
- Since 2012 Professor for applied Mathematics and Physics; University of Applied Sciences Landshut.

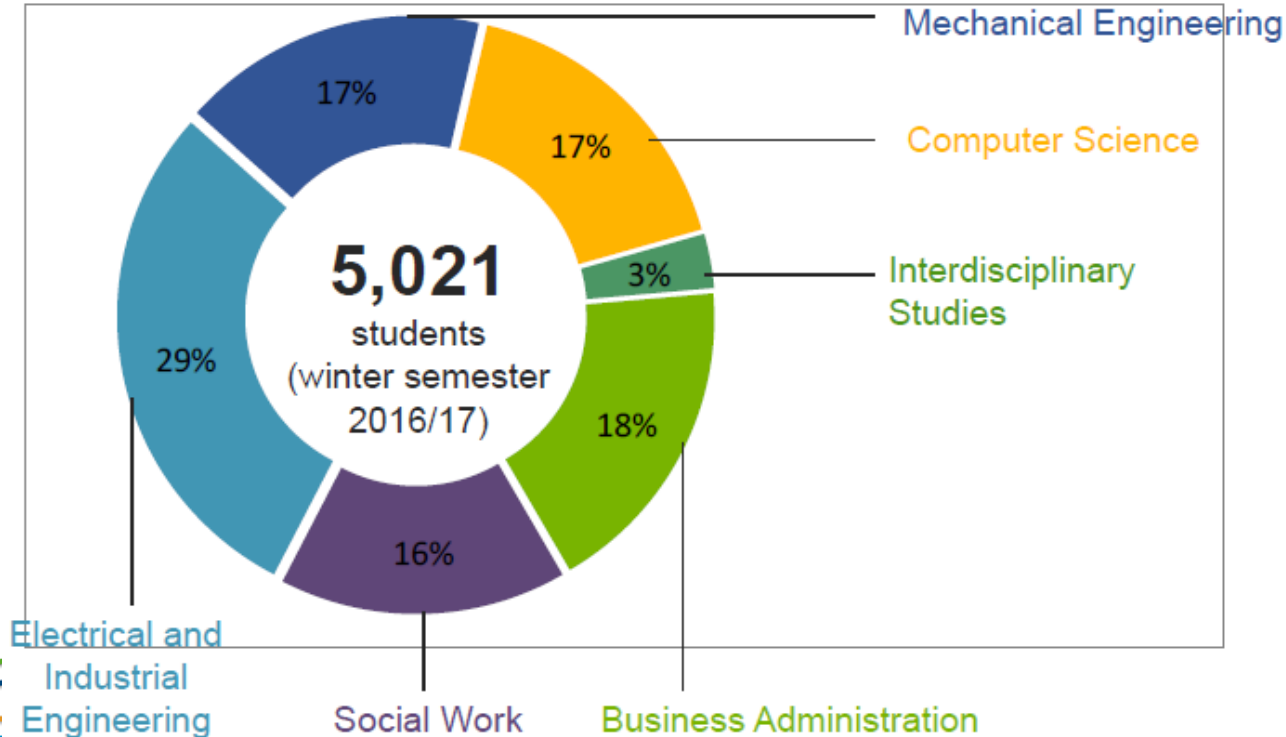
About the speaker



University of Applied Sciences Landshut



BERLIN 2018



About the speaker



Campus

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About the speaker



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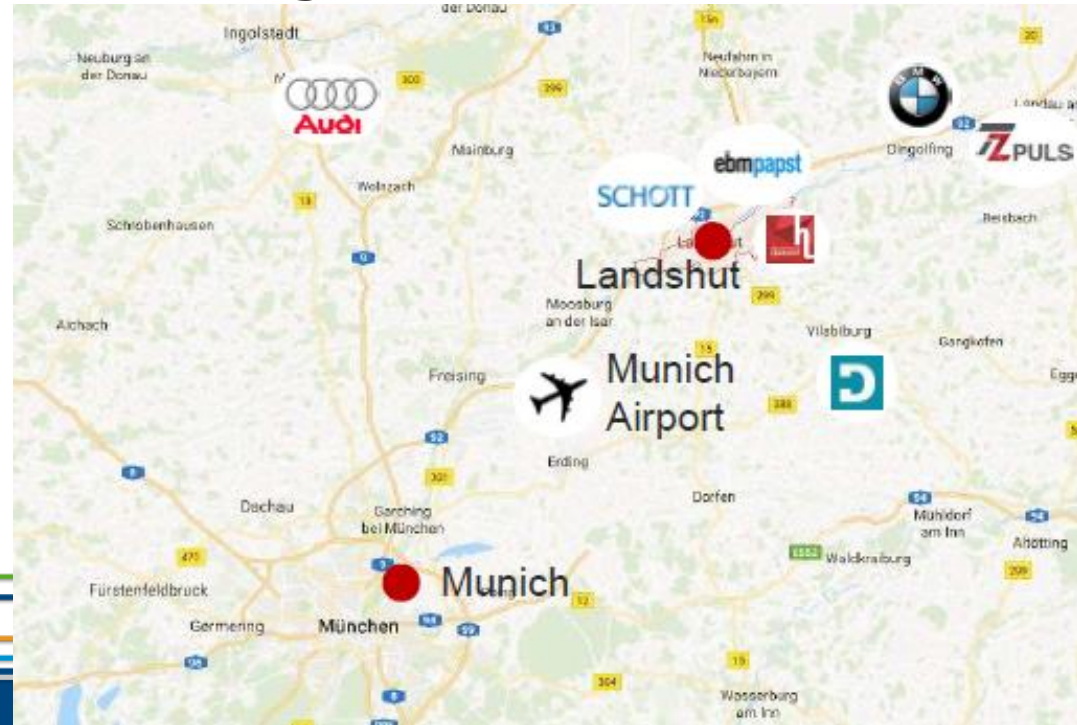


40 min by train from Munich Main Station

About the speaker



University of Applied Sciences Landshut Landshut as an economic region



Outline



- **Working party ANCRM**
- **Literature**
- **Networks**
- **Agent-based models (ABM) and cellular automata (CA)**
- **Health models**

ANCRM



IAA NON-LIFE INSURANCE SECTION
SECTIONS ASSURANCE NON-VIE DE L'AAI



ASTIN Working Party
on
Agent Based Models, Networks and Cellular Automata in
Risk Management:
Review and Perspective
ANCRM

ANCRM - Members

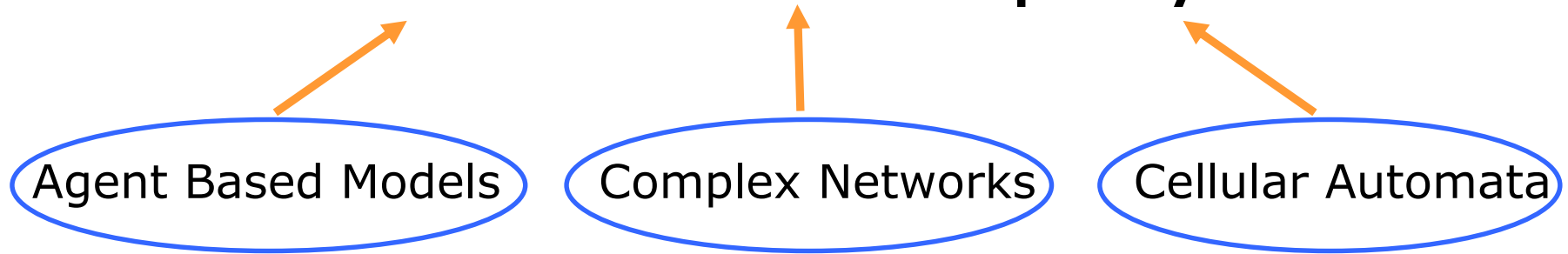


Active members

- Rocco Roberto Cerchiara
- Ali Ishaq
- Cathine Lam
- LiLi Lin
- Nita Madhav
- Ana J. Mata
- Rasa Varanka McKean
- Magda Schiegl

.... and three passive members.

Describe and understand complex systems



Application to P&C (re) insurance industry: **Risk Management**, especially the risk **evaluation** and the **aggregation** of risks.

ANCRM – Specific Aims



Develop a deeper understanding of and new ideas for application in risk evaluation and risk aggregation.

The research will include:

- Find a structured overview of recent scientific contributions in this subject with a clear focus on the P&C (re)insurance industry. (Review paper)
- Give an evaluation of applicability in insurance business.
- Generate ideas and proposals for further applied research and development in this area.

ANCRM – Literature



Search in 25 specified peer-reviewed journals (see appendix) and proposals of the members of the working party.

Years 2005 – End of 2017.

Search for:

agent based, (complex; neuronal) networks, cellular automata
In connection to insurance and/or risk (management).

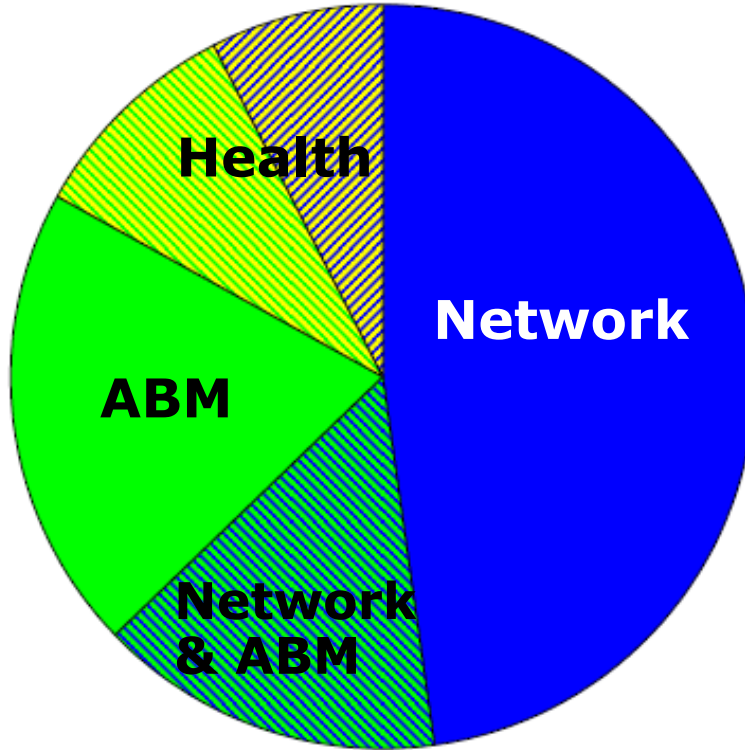
We exclude macroeconomic market models

→ Some 100 Articles to be analysed. → Results.

ANCRM – Literature

Papers found about...

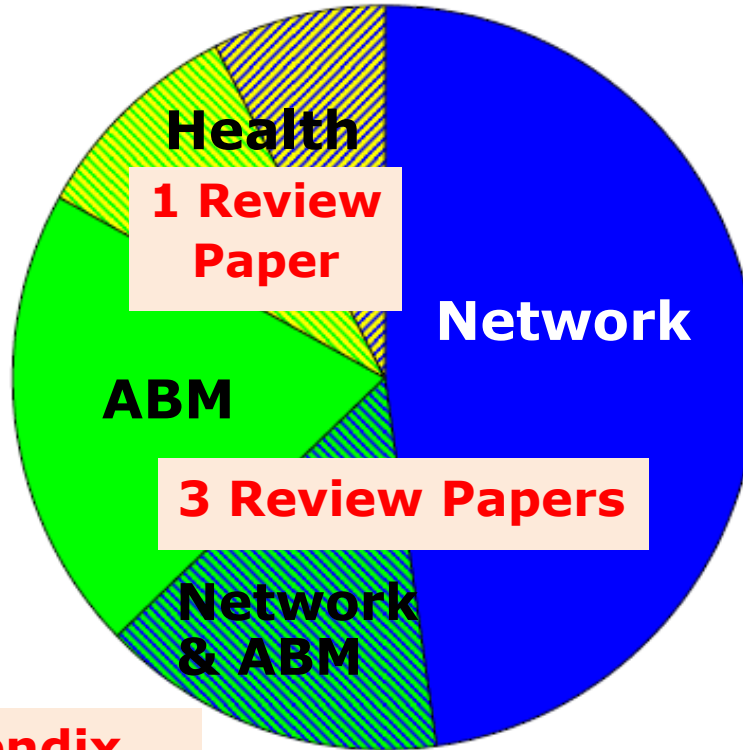
ABM: Agent-based models
(incl. CA)



ANCRM – Literature

Papers found about...

ABM: Agent-based models
(incl. CA)



Review papers → see appendix

ANCRM vs. AI – Networks

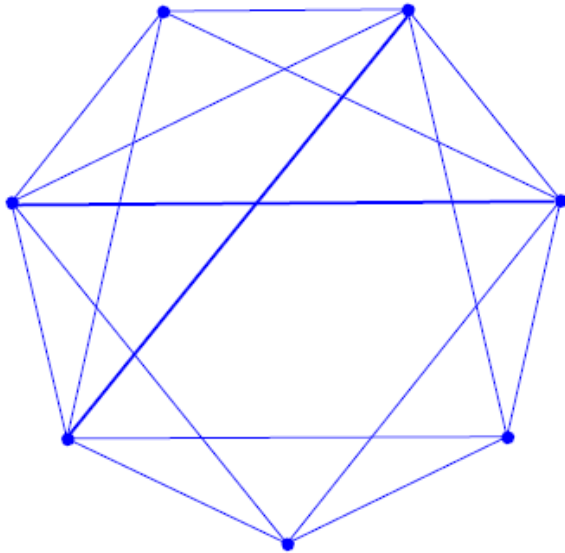


ANCRM Focus (Network types found in papers)

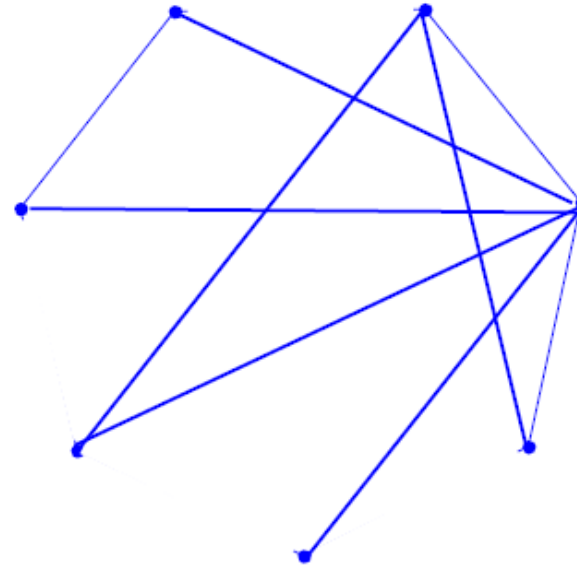
- Real networks (banks in a country, reinsurance companies)
- Model-networks (small world, scale-free, multiplex)
- Bayesian networks
- Simulated random graphs
- Agents on networks

ANCRM vs. AI – Networks

ANCRM Focus (Network types - examples)



Small world



Scale-free

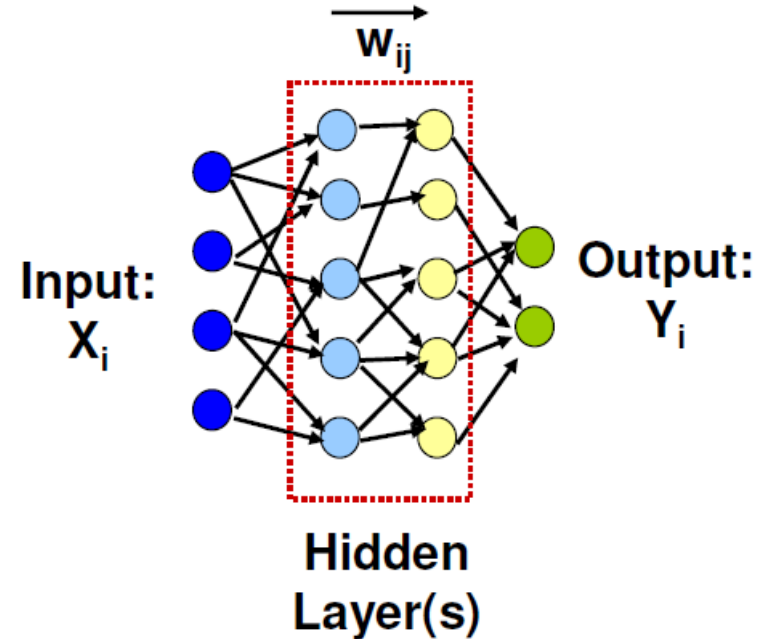


ANCRM vs. AI – Networks

Artificial Intelligence (AI) → Neural Network

Learning:

Dataset → updating the weights w_{ij}



ANCRM – Networks



Topics I

- Contagion banking systems
- Stability / fragility of the system given stress / market shocks
- Bubbles and crashes in financial markets
- Supply chain networks
- Systemic risk
- managing systemic risk → optimal architecture for financial network
- Operational risk
- Counterparty risk
- Moral hazard

ANCRM – Networks



Topics II

- Liquidity / Capitalisation
- Enterprise risk management (ERM)
- Regulatory requirements
- Overlapping portfolios
- Copulas vs. networks: dependence pattern
- propagation mechanism of idiosyncratic shocks → aggregate fluctuations

ANCRM – Networks



Nodes / Links

- Financial institutions / exposures (max. loss, expected loss, conditional on default, liabilities, claims)
- Traders (strategy) / deals
- Stock prices / cross correlation
- Credit: agents / claims
- Manufacturer / product supply
- Directors / service on common company boards

ANCRM – Networks



Methods I

- Dynamic / static
- Stochastic simulation
- Analytic studies (limiting cases: large networks)
- Statistics on networks
(degree distribution, connectivity of nodes)

ANCRM – Networks



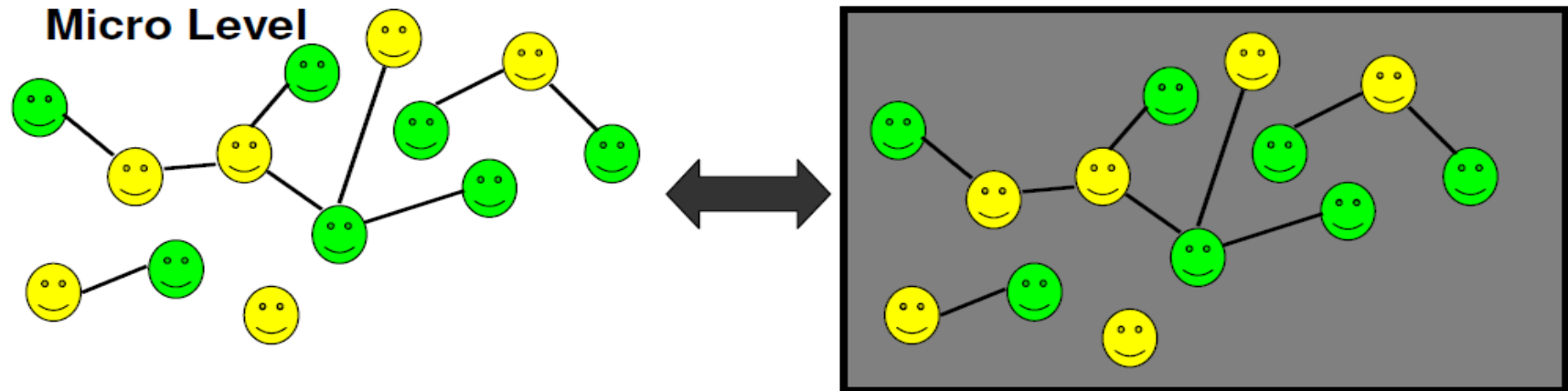
Methods II

Defining and comparing measures of risk:

- Resilience to contagion
- Systemic importance of financial institution (node)
- Concentration of risk
- VaR-like measures
- Analysis of default cascades

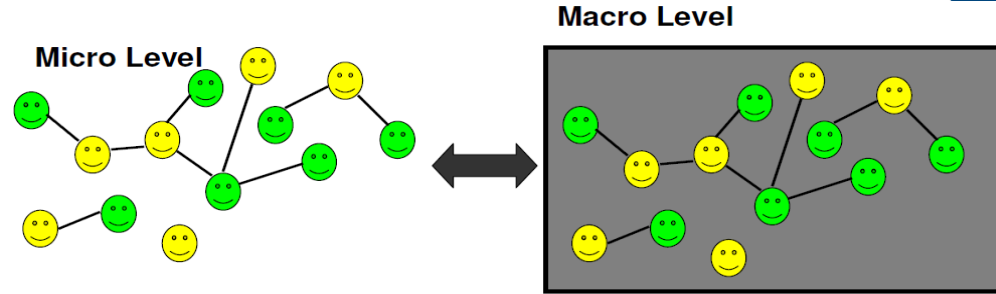
ANCRM vs. AI – Agent Based Models

ANCRM Focus



ANCRM vs. AI – Agent Based Models

ANCRM Focus

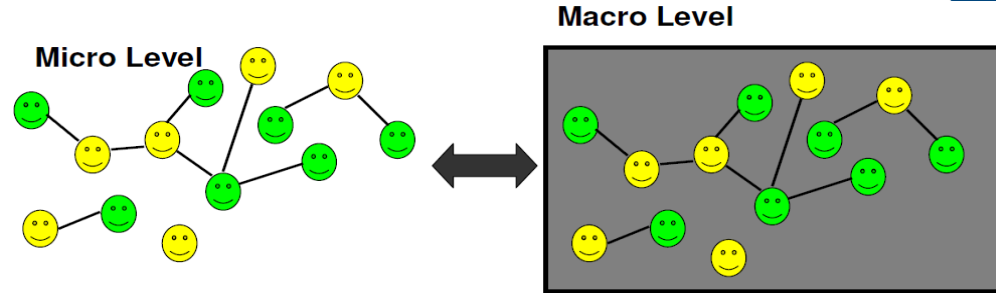


Agents

- Own internal degrees of freedom (internal parameters): Properties characterising each individual agent. Possible not static (change with time).
- Autonomy: Agent's actions depend on:
 - Its properties (internal parameters)
 - „Environment“ (for instance mean value of the collective or the nearest neighbours).

ANCRM vs. AI – Agent Based Models

ANCRM Focus



Agents' activities:

- mobility.
- reactivity: react on other agents and the environment.
- proactivity: can actively influence other agents and the environment. (for instance change internal parameters or influence mean values)
- locality: agents and their influence radius is small compared with the whole system.

Generalisation of physical models that describe phase transitions (for instance Ising-model for ferromagnetism).

ANCRM vs. AI – Agent Based Models



Artificial Intelligence (AI)

Agent = Object (for instance software code, hardware)
that exhibits intelligent behaviour.

→ Very complex agents.

→ Intelligence has to be defined.

ANCRM – Agent Based and CA



Most topics (by far) in finance, banking, market.

- Testing strategies in volatile environment / endogenous shocks
- Collective market dynamics (herding / bubbles / crashes)
- Stylised facts of markets (asymmetric distribution of returns / fat tails / volatility clustering / autocorrelation of time series)

→ Only two papers with clear relation to insurance →

ANCRM – Agent Based and CA



Ingram, D., Tayler, P., Thompson, M. (2012). Invited Discussion Paper: Surprise, Surprise From Neoclassical Economics To E-Life. *ASTIN Bulletin*, **42**(2), 389-411.

- 30 insurance companies (= agents) compete with each other; build the market.
- Each company has to decide for one of four strategies (theory of plural rationality).
- Strategies can / have to be changed dependent on agent's financial results / environment.
- Aim of agent: Prosperity (cash balance / amount of investments / return).

ANCRM – Agent Based and CA



Haer, T., Botzen, W.J., Moel, H., Aerts, H. (2017) Integrating Household Risk Mitigation Behavior in Flood Risk Analysis: An Agent-Based Model Approach. *Risk Analysis*, **37**(10), 1977–1992.

- Strategic game: Adaptive human decision making in flood risk analysis.
- Agents (Strategies):
 - Households (take insurance, cancel insurance, implement loss reduction / technical risk management)
 - Insurance (set premium, set discount, collect / pay-out)
- Environment: Climate change and flood risk increase.

What could / should be done – some ideas:

- Industrial insurance / supply chain risks / ERM.
- Testing typical insurance strategies: within company; company interaction with market.
- Phase transition / Regime-Switch (Origin: Ising model)
- Supervisory / regulatory strategies for insurance (interplay of micro and macro level)
- Solvency-tree (risk aggregation): Tree structure is a network!

Infectious Disease

- One of the greatest threat to the human population
- Can lead to tremendous impacts on public health, local and global economy, and society

Mathematical modelling is a powerful and ethical method to understand infectious disease dynamics, transmission mechanisms and intervention strategies.

- Incorporates essential characteristics of disease transmission
- Produces realistic simulation of the intricate interactions between the modeled pathogen, susceptible agents, and the environment

Agent Based Models

- heterogeneity in disease transmission within a population
 - Socio-demographic structure of population
 - Attributes and behavioural differences of each individual
 - Transmission pathway
- Infections transmission and frequency criteria of the modeled disease

Complex Networks

- contact structure within a population to model the transmission (blood-borne, sexually transmitted)
 - Socio-demographic and behavioural structure of high and low risk individuals/groups
 - Close contact transmission
 - Transportation structure (Airline and local commuting)
- different network types and structure can be used to simulate realistic disease spread and intervention dynamics

Thank you very much for your attention!



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Appendix: Journals I

- Annals of Actuarial Science
- Astin Bulletin
- British Actuarial Journal
- CAS Monograph Series
- Econometrica
- European Actuarial Journal
- Finance and Stochastics
- IEEE Transactions on Evolutionary computation
- Insurance: Mathematics and Economics
- International Journal of Theoretical and Applied Finance

Appendix: Journals II

- Journal of Banking and Finance
- Journal of Economic Theory
- Journal of Risk
- Journal of Risk and Insurance
- Journal of the American Statistical Association
- Journal of the Royal Statistical Society: Series C
- Mathematical Finance
- North American Actuarial Journal
- Phys. Rev. E
- Physica A

Appendix: Journals III

- Quantitative Finance
- Risk
- Risk Analysis
- Scandinavian actuarial journal
- Variance

Appendix: Review Papers I



Allan, N., Cattle, N., Godfrey, P., Yin, Y. (2013) A Review Of The Use Of Complex Systems Applied To Risk Appetite And Emerging Risks In ERM Practice: Recommendations For Practical Tools To Help Risk Professionals Tackle The Problems Of Risk Appetite And Emerging Risk. *British Actuarial Journal*, **18**(1), 163-234.

Parodi, P. (2012) Computational Intelligence With Applications To General Insurance: A Review: I – The Role Of Statistical Learning. *Annals of Actuarial Science*, **6**(2), 307-343.

Parodi, P. (2012) Computational Intelligence With Applications To General Insurance: A Review: II. Dealing With Uncertain Knowledge. *Annals of Actuarial Science*, **6**(2), 344-380.

Appendix: Review Papers II



Willem, L., Verelst, F., Bilcke, J., Hens, N., Beutels, P. (2017)
Lessons From A Decade Of Individual-Based Models For
Infectious Disease Transmission: A Systematic Review (2006-
2015). *BMC Infectious Diseases*, **11**(17), 612.