Annual Conference of The Netherlands Platform of Complex Systems
19 April 2018 at Utrecht University

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A. Abstract of Lecture -- 1. Keynote Lectures

"Simplicity in complexity: fitness as compass for steering biomolecular networks"
Prof. dr. Bas Teusink, Amsterdam Institute for Molecules, Medicines and Systems, Vrije Universiteit Amsterdam

Cells have the amazing capability to adapt to ever-changing environmental conditions. They do this through overwhelmingly complex networks of metabolic reactions, singalling pathways and gene-regulatory networks. In recent years the paradigm of limited-resource allocation has matured as a conceptual framework in which coordinated changes in these component, especially proteins, can be explained. In short, it assumes a fixed (limited) proteome within which the cell needs to operate, and thus e.g. an investment in stress resistance will come at the cost of investments in growth. This framework has explained trade-offs between growth rate and stress resistance or biomass yield, and growth-rate associated behaviours such as overflow metabolism, catabolite repression and ribosome biosynthesis.
In this talk I will provide a coherent overarching picture that shows that growth-rate maximisation under protein constraints can be used to reconcile many of the observations. I will show that growth rate maximisation – as a proxy for fitness for unicellular organisms- dramatically reduces the complexity of metabolic growth strategies, and that this is backed

up by experiments. Moreover, I will discuss mechanisms by which such optimisations can be achieved by biochemical networks.

"The Price of Complexity in Financial Networks"
Prof. dr. Stefano Battiston, FINEXUS Center for Financial Networks and Sustainability, University of Zurich

Financial systems are prominent examples of multi-layer complex networks that deserve more attention in the scientific community working on Complex Systems. They play a central role in modern societies, as illustrated by the fact that our economies and societies are still recovering from the 2008 US housing sector crisis and the 2011 Euro Area sovereign debt crisis. Thus, the functioning and mis-functioning of the financial system have concrete implications for people's lives, not only in terms of economic growth, but also in terms of income inequality and environmental sustainability.
In terms of complex systems, financial systems are viewed today as multilayer networks where nodes represent financial actors and assets, and links represent financial contracts of various types (e.g. equity holdings, bonds, derivatives etc). In these networks, the value of a contract depends on the value of other contracts through cycles of direct or indirect dependencies, often in a non-linear way. However, differently from many other complex networks in the natural sciences domains, financial networks are systems that react to the attempt to measure or influence them. Indeed, financial actors try and anticipate other actors' actions, including those of regulators and policy makers, and this specific nature poses very interesting conceptual challenges to our understanding of what it means managing complexity.
More progress on the investigation of complex financial networks is needed in order to address urgent societal issues such as taming the increasing inequality (even within developed countries) and financing the transition to a low-carbon economy in order to combat climate change.

A. Abstract of Lecture -- 2. Social Sciences

"Stabilizing an unstable complex economy: on the limitations of simple rules"
Dr. Isabelle Salle, Utrecht University

This paper offers a systematic comparison of a wide range of leaning-against-the-wind interest-rate policy rules within a macroeconomic, stock-flow consistent, agent-based model. The model generates endogenous booms and busts along credit cycles. As feed- back loops on aggregate demand affect the goods and the labor markets, the real and the financial sides of the economy are closely interconnected. The baseline scenario is able to qualitatively reproduce a wide range of stylized facts. We show that a monetary policy rule that targets the movements in the net worth of firms significantly dampens the credit cycles and reduces the employment costs of financial crises, because this indicator incor- porates early signals of financial imbalances.

Performances of this three-mandate Taylor rule are also more robust to the specific parameter values and regulatory framework than the standard dual-mandate Taylor rules. Nonetheless, none of the policy rules under study completely eliminates the high employment costs of financial crises.

"Online social influence and opinion polarization"
Dr. Michael Mäs, Department of Sociology, University of Groningen

The Internet has created unprecedented potential for social influence, which sparked a heated debate about the effects of online communication on processes of opinion polarization in western societies. Some experts and scholars even argue that online communication contributed to recent political events such as Brexit and the election of Donald Trump. On the one hand, the social-scientific literature on social-influence dynamics provides a rich arsenal of theories modeling social influence and opinion polarization. On the other hand, these theories are based on markedly different micro-assumptions about how individuals influence each other's opinions and, accordingly, make competing macro-predictions about the conditions under which opinion polarization emerges from social-influence dynamics. In a lab-in-the-field experiment, we tested competing micro-models of influence. We found that individual opinions shifted linearly towards the mean of others' opinions. From this finding, we predicted the macro-level opinion dynamics resulting from social influence and tested these predictions using data from a second lab-in-the-field experiment. We found that opinion polarization decreased in the presence of social influence and corroborated this finding with large-scale field data.

"Knowledge recombination for systemic change: the integration of energy and mobility technologies in smart energy systems"
Prof. dr. Floor Alkemade, Eindhoven University of Technology

Global sustainable development critically depends on a fundamental transformation of current energy intense systems. The energy sector is responsible for 41% of the cumulative reduction of CO_2 emissions needed to keep the global warming below 2°C in 2050. This global low-carbon transition requires worldwide innovation efforts to develop and deploy renewable energy technologies. While clean technology (cleantech) and more specifically clean energy technology can be considered a new and emerging technological field, some inherent characteristics of clean energy technologies suggest that it may be more difficult to characterize as a single coherent field than traditional energy technologies. Energy technology is heterogeneous both in terms of application and technology. Understanding the specifics of patterns of knowledge production for sustainable development is pivotal for countries seeking to stimulate the development of these knowledge bases through policy.
In this paper we study these interaction patterns for smart energy systems. In visions of a future integrated energy and mobility system, smart energy systems match the supply from renewable energy sources with the demand from clean modes of transport such as electric vehicles. Smart energy systems thus integrate energy and mobility technologies. Such integration or recombination is characteristic of transition processes and radical, systemic innovation. We study the exact modes of recombination of knowledge that have created new knowledge on smart grids. More specifically we use patent data to identify the dominant

technological trajectories in smart grid technology and the extent to which these technologies recombine knowledge from either energy and mobility domains.

"Fractal Coordination Dynamics in Human Behaviour"
Dr. Ralf Cox, University of Groningen

In the past decades it has become evident that human behaviour is not only inherently noisy but temporally self-similar (i.e. fractal). In fact, fractal scaling is ubiquitous throughout motor and cognitive performances, of any kind and at any level. This can only be interpreted as an expression of the fact that behaviour emerges from the interconnections of the many physiological, cognitive and contextual processes operating at many different timescales. In other words, behaviour originates from coordination dynamics in a complex dynamical system. In addition, it has recently been shown that two people who perform a task together tend to match the fractal patterns of their behavioural time series. Loosely stated, they self-organize into task-specific dynamical systems of similar complexity. This effect called 'complexity matching' reveals global coordination at multiple timescales between individuals due to the perception-action coupling between them. In this presentation I will emphasize the fractal nature of human behaviour, showing how temporal variability constitutes a rich (but often neglected) source of information. Several research examples will be given to demonstrate that temporal patterns of variability in behaviour are indeed non-random and how fractal scaling provides valuable insights into the dynamic organization underlying individual and interpersonal behaviour.

A. Abstract of Lecture -- 3. Natural Sciences

"Gradual or catastrophic: desertification dynamics and interacting localized structures"
Prof. dr. Arjen Doelman, Leiden University

Under semi-arid conditions, uniform vegetation covers may evolve into `patterns' in which vegetated areas – or patches -- are interspersed with bare soil regions. In mathematical terms, the appearance and subsequent dynamics of these vegetation patches can be described by systems of reaction-diffusion equations that model the interactions between vegetation/biomass and water (typically ground water and surface water). In these models, the vegetation patterns are represented by `localized structures' -- isolated vegetation patches surrounded by bare soil that interact with each other through their impact on the water levels (and vice versa). As the vegetation patterns themselves, these localized structures are remarkably resilient. Nevertheless, as the `stress level' increases -- due to changing climatological circumstances or to an increasing grazing pressure – the vegetation patches may eventually destabilize, and thus disappear, so that the system moves into the final stage of the desertification process: the uniform bare soil state. This may either be a relatively slow gradual process in which individual vegetation patches disappear (roughly) one by one, or it can be a fast `catastrophic collapse' in which all vegetation patches in a large area disappear

(roughly) at the same time. In this talk we will argue that the nature -- gradual or catastrophic -- of the (final steps of the) desertification process is determined by the relative timescales of two fundamental mechanisms: the `intrinsic dynamics' of the interacting vegetation patches versus the `externally driven' rate of change of the environment. We will present a novel approach – based on mathematical insights in the far-from-equilibrium dynamics of localized structures -- and discuss how this approach enables us to predict the nature -- gradual/catastrophic -- of the final route towards the bare soil state of a vegetation pattern (in the context of a conceptual model).

"From complexity theory to novel biomarkers of brain disorders"

Dr. Klaus Linkenkaer-Hansen, Department of Integrative Neurophysiology, Center for Neurogenomics and Cognitive Research, Amsterdam Neuroscience, VU University Amsterdam, NBT Analytics BV, Amsterdam, Netherlands

Self-organized criticality is a fascinating concept introduced by Per Bak as an explanation for the ubiquity of complexity in nature (Bak et al., 1987). Over the years, the framework of criticality has inspired researchers in many fields of science to analyze and interpret complex data using analytical tools that were not previously used within these fields—often leading to novel insights. As an example, several lines of evidence have pointed to the presence of critical dynamics in neural networks at different levels of organization, where activity tends towards the balance between order and disorder (Beggs & Plenz, 2003; Linkenkaer-Hansen et al., 2001). Interestingly, having developed computational models to understand mechanisms underlying critical dynamics in neuronal networks (Poil et al., 2012), we now use these platforms to develop novel biomarker algorithms to capture aberrant brain dynamics in disease. In this talk, I will briefly introduce the concept of critical brain dynamics and how we use computational models of critical brain dynamics to develop novel biomarkers of brain disorders.

Bak, P., Tang, C., Wiesenfeld, K. (1987). Self-organized Criticality: An Explanation of l/ f Noise. Phys Rev Lett, 59(4), 381–384.
Beggs, J., Plenz, D. (2003). Neuronal avalanches in neocortical circuits. The Journal of Neuroscience, 23(35), 11167–11177.
Linkenkaer-Hansen, K., Nikouline, V. V, Palva, J. M., Ilmoniemi, R. J. (2001). Long-range temporal correlations and scaling behavior in human brain oscillations. The Journal of Neuroscience, 21(4), 1370–7.
Poil S-S, Hardstone R, Mansvelder HD, Linkenkaer-Hansen K (2012) Critical-State Dynamics of Avalanches and Oscillations Jointly Emerge from Balanced Excitation/Inhibition in Neuronal Networks. J Neurosci 32:9817–9823.

"Resilience of Ecological networks"

Dr. Ingrid van de Leemput, Wageningen University & Research

Tipping point theory is ill-equipped to deal with the complexity of ecological networks, such as food webs or mutualistic networks. It is unclear which variables should be measured to detect the much-discussed 'early warning signals'. Moreover, we are unable to foresee to which state networks might shift after a tipping point. We propose ways of extending the current theory to allow anticipating critical transitions in networks in general. Ultimately the approach may help to answer questions such as how to foresee an upcoming systemic or partial ecosystem collapse, and how to predict which species will be the winners and which the losers as ecological webs become unstable.

"Creation, maintenance and structuring of diversity - implications for disease elimination"
Dr. Yael Artzy-Randrup, University of Amsterdam

Many pathogens exhibit a high diversity of co-existing strains; these include disease-causing protozoa, helminths, bacteria, fungi, and viruses. Understanding how this diversity emerges, how it is structured, how it relates to epidemiological patterns, and how it may change after intervention, is of great value. This is especially relevant for elimination of diseases where the objective is to transition the pathogen population from a state of persistence to a system of extinction. Hence knowledge on factors that maintain diversity could be a crucial target when designing an intervention. This topic bares conceptual similarities with questions about species co-existence in community ecology. Ecologists have proposed different theories regarding the extent to which non-neutral processes structure diversity. The ecological 'neutral theory' (Hubbell 2001) stresses the importance of stochastic processes; here, at the most basic level, neutral processes can maintain diversity through a balance of diversifying processes (i.e., the gain of diversity) and drift (i.e., the stochastic loss of diversity). In contrast, 'modern co-existence theory' (Chesson 2000, as an extension of traditional 'niche theory'), emphasizes the importance of deterministic processes; where coexistence reflects a balance of between stabilizing mechanisms (i.e., selection favouring antigenic diversity, reflecting "niche" differences in host immunity space, hence promoting coexistence), and equalizing mechanisms (i.e., selection minimizing fitness differences, where competitive exclusion leads the most fit types outcompetes the others). Although these theories have historically been considered as alternatives, deterministic and stochastic processes are not mutually exclusive; they are likely to both be at play in most systems, and are likely to interact in complex and dynamic ways. Here I discuss different views on the concept of diversity, both as a measure of system functioning and as an emergent property of these systems. As a case study I focus on the human malaria parasite Plasmodium falciparum, which provides an intriguing example of an organism for which these types of complex interactions occur, where ecological and evolutionary feedbacks act on short time scales.

A. Abstract of Lecture -- 4. Applied Topics

In order to increase the awareness of the potential of complex systems research on practice this applied track will focus on two societal challenges: health and mobility. Each one hour session will start with a setting the scene session by stakeholders of these themes followed by short presentations of applied research on these areas and open discussion.

A. Abstract of Lecture -- 4.1 Health and complexity

"Health and complexity: setting the scene"
Prof. Dr. Karien Stronks, Dept of Public Health, Academic Medical Center/University of Amsterdam

Although the expertise on systems science in the field of medicine and public health is still limited, there is a growing consensus among researchers in this field that the complexities underlying health and its distribution across the population, cannot only be unravelled by traditional methods that have been largely developed in a clinical setting. In my contribution, I will explore why a shift in research paradigm to systems thinking is imperative to move this field forward. I will illustrate how systems science might provide theory and analytics necessary to examine the dynamics and complexity of health and illness, both at the individual and population level, leading to a more complete understanding of real-world problems.

"Global Value Chain Analysis for Public Health Nutrition: a New Zealand Case Study"
Dr. Wilma Waterlander, Academic Medical Centre, University of Amsterdam

Nutrition related non-communicable diseases (e.g., obesity, type 2 diabetes) place a growing burden on society. Traditionally, public health research tries to address this problem by studying questions such as "how can we encourage people to eat healthier"? This approach fails to recognize, however, how food and health are connected as part of the bigger food system. A more appropriate question would therefore be: "Why is our modern food environment so unhealthy?" To tackle this complex problem, we conducted a case study on the New Zealand potato sector aimed at understanding the broader food system. This sector was selected because potatoes are a healthy staple food, but are also processed into unhealthier products (e.g., chips, fries). Data were collected using a Global Value Chain Analysis (GVCA) approach. We collected data using stakeholder interviews with growers, processors, wholesalers and retailers. The results show that fresh potatoes, processed potatoes, potato starch and frozen potatoes have distinct value chains. Both in the fresh and processed potato sector, there are only a handful of growers who supply the largest supermarkets or processing industries. Margins are very small so only big growers can survive. There are clear tensions between the fresh and processing potato sector resulting in a situation where processed potato products can be produced for a lower price, higher convenience and better taste; while also being able to carry good (health) branding and even health claims. For fresh potatoes this is virtually impossible and growers experience tensions in meeting demands, achieving the highest yields, (low) margins, and appearance, taste and nutritional value. GVCA approach reveals how the distinct value chains for processed and fresh potato products impact on (healthy) food availability, accessibility and affordability and thereby population diets.

"Towards a better understanding of the complexities of burnout: using a combination of system dynamics modelling and retrospective scenario data "
Msc Guido Veldhuis, TNO

Burn-out is still hard to prevent as the currently used prevention and interventions struggle to grasp the full complexity of the problem. Burn-out shows complex characteristics: the condition develops over time as cognitive, mental, social and physical factors interact. In the present study, we advocate a system dynamics approach to increase personal insight in the dynamics leading to the burn-out condition. Individual learning, aided by simulation, *prior to* the condition, can help individuals understand behavioural patterns that lead to burn-outs and

changing ingrained patterns. First, a semi-quantitative biopsychosocial health model was developed that captures insights of the processes involved in burn-out trajectories based upon extensive literature studies and discussion with experts. Then, a novel approach for collecting personal retrospective story-data of participants was developed. Personal case stories were translated to quantitative scenarios and implemented in a stock and flow simulation model. The current results indicate that our first version of the system dynamic burn-out simulation model is able to simulate realistic long-term patterns of chronic stress and emergence of recovery.

A. Abstract of Lecture -- 4.2 Mobility and complexity

"**The Dutch railway transport complexity"**
Msc Pieter-Jan Fioole, NS

This setting the scene presentation will address the complexity challenges that the Dutch passenger railway transport is facing and in particular the challenge of coping with major disruptions and their cascading effects. Past, presence and future methods of handling these disruptions will be discussed.

"A complex network approach to analysing large railway disruptions"
Msc Mark Dekker, Utrecht University

The propagation of delay in railway networks is key to understanding the evolution of large-scale disruptions. Two approaches to get insight in the delay propagation are proposed. The first approach involves the calculation of the area that is affected by delays at a particular track. Calculating these areas leads to the formation of a weighted, directed network on which paths drawn show how delay propagates. The second approach involves mapping a state vector, containing the delays at all segments, forward in time. This potentially strongly increases the predictive power of large-scale disruptions, but is prone to noise and non-robustness.

"Determining and Evaluating Alternative Line Plans in (Near) Out-of-Control Situations"
Msc Rolf van Lieshout, Erasmus University Rotterdam

About once or twice a year, large disruptions cause the Dutch railway network to get in a state of (near) out-of-control, in which hardly any trains are able to run as the result of a lack of accurate and up-to-date information available to dispatchers. We investigate new disruption management strategies for dealing with these situations. First, we propose an algorithm that finds an alternative line plan that can be operated in the affected part of the railway network. This algorithm partially integrates line planning with timetabling and rolling stock scheduling, as the line plan should be feasible with respect to infrastructural and

resource restrictions. Second, to operate the railway system within the disrupted region, we propose several local train dispatching strategies requiring varying degrees of flexibility and coordination. Computational experiments based on disruptions in the Dutch railway network indicate that the algorithm performs well, finding workable and passenger oriented line plans within a couple of minutes. Moreover, we also demonstrate in a simulation study that the produced line plans can be operated smoothly without depending on central coordination.

B. Abstracts of Poster -- 1. Social Sciences

"Understanding Transnational Corporate Elite Dynamics Through Network-Based Sequence Analysis of Board Appointments" (Authors: Diliara Valeeva and Frank Takes)

Diliara Valeeva, CORPNET, AISSR, University of Amsterdam

Interlocking directorates, where individuals sit on boards of multiple corporations, are a common practice studied in corporate governance. Although previous work has shed light on the small world structure of the transnational network of interlocks, the longitudinal aspect is often ignored.
Here, we aim to find a proxy for the precise large-scale dynamics of the global network in an attempt to understand how transnational configurations of interlocking directorates are shaped.
To do so, we use data on approximately 200 thousand international appointments of individuals to board of directors of the largest corporations from 2000 to 2017. Deriving sequences of individual appointments, we apply social sequence analysis and machine learning. We extract several geopolitical centers of transnational business ties. Selected clusters are related to the distribution of the global power and caused by the transnationalization of the corporate world and elites.

"Artificial Sociality"

Dr. Gert Jan Hofstede, Wageningen University

To develop 'artificial sociality': foundational conceptual models of human sociality based on social science, for use in agent-based models of complex systems in the life sciences. The starting hypothesis is that society self-organizes as complex systems-of-systems. An applied focus rests on safety and resilience in socio-'something' systems in which human components are replaced by technical ones.

"Complexification as Governance-mode: theory and practice of leaving ineffective policy-paths"

Msc Hans Bil, Erasmus University Rotterdam

We elaborate the challenge to leave an existing, but ineffective "policy-path" and create a new and more promising one by applying the concepts of path dependency and path creation in relation to applied governance modes for dealing with social issues: simplification (reducing complexity) and complexification (enlarging complexity). When simplification comes to a dead-end alley, complexification is a promising alternative track. In the process of breaking through simplification and creating a path for complexification, we found that external pressure and increasing internal change capacity create a threshold for path creation. The actual transformation takes place on "magic events", unexpected from the onset, and afterwards identified as decisive. By learning from an in-depth case-study about the transformation of Utrecht Central Station (the Netherlands), we contribute to a more sophisticated understanding of path creation towards complexification, and highlight the crucial role of magic events.

Evidence for Practice

- Simplification is the preferred governance-mode because it promises order in and control over issues by cutting them in separable parts, working with strict procedures and involving a restricted actor constellation. It is a comfortable and well-proven approach for (public) organizations.
- Professionals tend to stick to simplification, even when this approach is ineffective for the issue at stake
- To create another path of embracing complexity, professionals can strategically use and enforce favorable conditions, such as external pressure, new kids on the block, and a chain of complexity acknowledging and daring leaders
- The real change appears to take place in events, unexpected from the onset, but considered magic afterwards. Professionals should be prepared for these moments to utilize them.
- When simplification is an ineffective path, allowing and even enlarging complexity is a promising option.

"Early warning signals in affective states predict the direction of future shifts in psychopathology" (Authors: Marieke Schreuder, Catharina Hartman, Johanna Wigman, Marieke Wichers)

Marieke Schreuder, University Medical Center Groningen

Background: Psychopathology can be conceptualized as a complex dynamic system. Recent studies showed that sudden shifts in the severity level of psychopathological symptoms are preceded by early warning signals (EWS) in affective states, such as autocorrelation. It is unknown whether EWS also signal the direction of these future shifts (*e.g.* towards depression, anxiety, *etc*.).

Aims: First, to replicate the finding that EWS in affective states are positively associated with future shifts in depression. Second, to test the novel hypothesis that EWS may inform on the direction of future shifts in psychopathological symptoms. We hypothesized that EWS would be most pronounced in affective states that were contingent with the direction of the

future shift. For instance, EWS in feeling down would precede shifts in depression and EWS in feeling anxious would precede shifts in anxiety.
Methods: Adolescent twins from the general population provided ten daily ratings of their affective state for six consecutive days (*affective states:* feeling down, listless, anxious, not relaxed, suspicious, insecure, and unwell). The resulting time series were used to compute EWS. Immediately before and one year after the collection of these data, psychopathological symptom severity was assessed (*domains:* depression, anxiety, interpersonal sensitivity, and somatic complaints). Participants were excluded if they did not report an increase in symptom severity from baseline to follow-up or if insufficient affect ratings were available.
Results: The four psychopathological domains were analyzed separately, resulting in four samples (N=166-192) that were similar in age (mean=17.9-18.0, std.=4.0-4.4) and sex distribution (34-39% male). First, we replicated the finding that shifts in depression were preceded by EWS in depression-related affective states (down, listless). Second, results partly confirmed the hypothesis that EWS signal the direction of future shifts. For all domains, we found that EWS in suspiciousness were most strongly associated with future shifts. For depression, anxiety and interpersonal sensitivity, this domain-general EWS was followed by domain-specific EWS in feeling down, listless (depression), anxious (anxiety) and insecure (interpersonal sensitivity).
Conclusion: We replicated the finding that psychopathological shifts are preceded by EWS. Second, we found that a combination of domain-general and domain-specific EWS may reveal towards which domain shifts are most likely. To evaluate the clinical utility of EWS, replication on an intra-individual level is necessary.

"Open Science: game theory and research data sharing" (Authors: Tessa E. Pronk1, Paulien H. Wiersma1, Anne van Weerden1, Feike Schieving2)

1 Utrecht University Library, Utrecht University, Utrecht, The Netherlands
2 Ecology and Biodiversity, Utrecht University, Utrecht, The Netherlands
Dr. ir. Tessa E. Pronk, Utrecht University Library

In open science, having research data available for others is one of the measures to ensure transparent, reproducible, and reusable results. While reusing research data has evident benefits for the scientific community as a whole, decisions to archive and share these data are primarily made by individual researchers. Is research data sharing also to their advantage? To tackle this question, we built a model in which there is an explicit cost associated with sharing datasets whereas reusing such sets implies a benefit. In our calculations, conflicting interests appear for researchers. Individual researchers are always better off not sharing and omitting sharing costs, whereas at the same time both sharing and not sharing researchers are better off if (almost) all researchers share. Namely, the more researchers share, the more benefit can be gained by the reuse of those datasets. Further simulation results point out that, although policy measures should be able to increase the rate of sharing researchers, and increased discoverability and dataset quality could partly compensate for costs, a better measure would be to directly lower the cost for sharing, or even turn it into a (citation-) benefit. Making data available would in that case become the most profitable, and therefore

stable, strategy. This means researchers would willingly make their datasets available, and arguably in the best possible way to enable reuse.

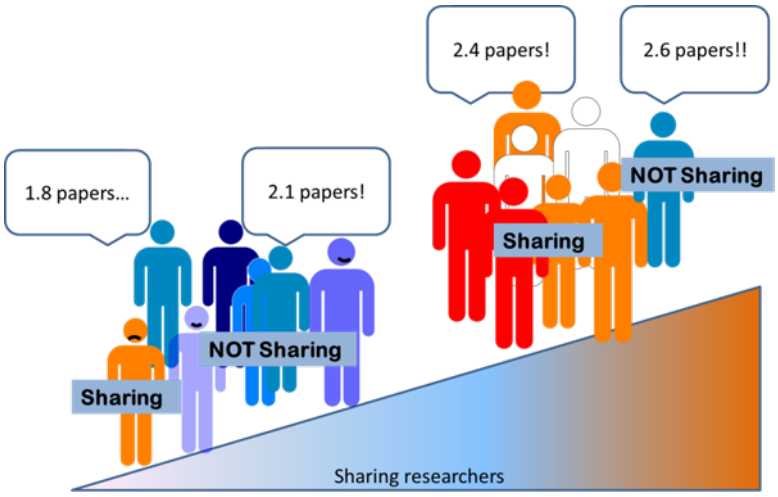

Figure. Sharing as a profitable, yet unstable strategy. Researchers in theory will tend NOT to share, to omit time costs, and have more time for producing scientific papers that generate impact (e.g. citations). Extra rewards for sharing will turn this into a stable strategy (not shown).

B. Abstract of Poster -- 2. Natural Sciences

"Spontaneous emergence of milling (vortex state) in a Vicsek-like model [1] (Authors: A. Costanzo and C. K. Hemelrijk)

Dr. Andrea Costanzo, University of Groningen

Collective motion is of interest to laymen and scientists in different fields. In groups of animals, many patterns of collective motion arise such as polarized schools and mills (i.e. circular motion). Collective motion can be generated in computational models of different degrees of complexity. In these models, moving individuals coordinate with others nearby. In the more complex models, individuals attract each other, aligning their headings, and avoiding collisions. Simpler models may include only one or two of these types of interactions. The collective pattern that interests us here is milling, which is observed in many animal species. It has been reproduced in the more complex models, but not in simpler models that are based only on alignment, such as the well-known Vicsek model. Our aim is to provide insight in the minimal conditions required for milling by making minimal modifications to the Vicsek model. Our results show that milling occurs when both the field of view and the maximal angular velocity are decreased. Remarkably, apart from milling, our minimal model also exhibits many of the other patterns of collective motion observed in animal groups.

[1] A. Costanzo and C. K. Hemelrijk, Journal of Physics D: Applied Physics, 2018

"Ecological interactions determine role of species in parasite spread amplification: the ecomultiplex network model" (Authors: M. Stella, S. Selakovic, A. Antonioni and C. S. Andreazzi)

Dr. Sanja Selakovic, Utrecht University

Multiple routes of transmission for many diseases are investigated separately despite their potential interplay. As a unifying framework for understanding parasite spread through interdependent transmission paths, we present the "ecomultiplex" model, where the multiple transmission paths among a diverse community of interacting hosts are represented as a spatially explicit multiplex network. We adopt this framework for designing and testing potential control strategies for *Trypanosoma cruzi* (Chagas disease) spread in two empirical host communities in Brasil. Our results show that the ecomultiplex network model is an efficient and low data-demanding method to identify which species enhances parasite spread and should thus be a target for control strategies. We also find that the interplay between predator-prey and host-parasite interactions leads to a phenomenon of parasite amplification, in which top predators facilitate *T. cruzi* spread, offering a mechanistic interpretation of previous empirical findings. Our approach can provide novel insights in understanding and controlling parasite spreading in real-world complex systems.

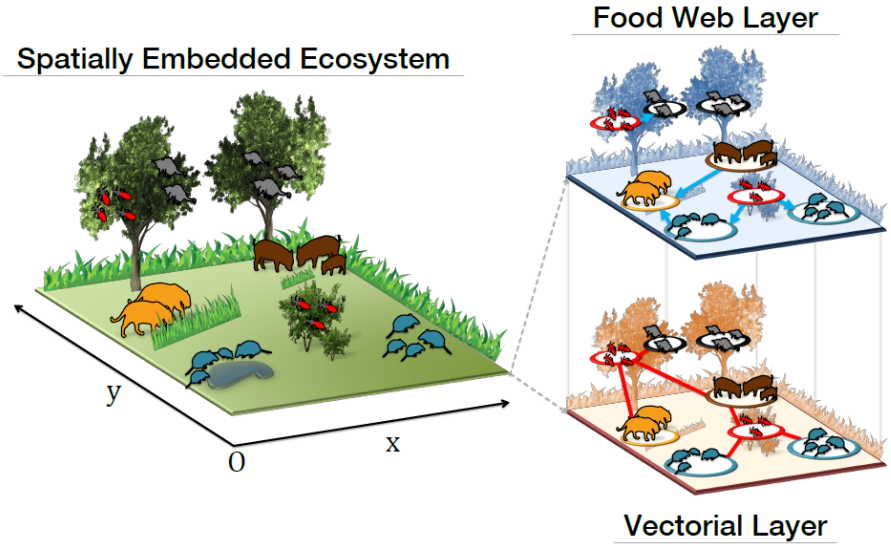

Figure 1. Visual representation of ecomultiplex network model.

B. Abstract of Poster -- 3. Applied Topics

Interactive science-practice poster session

In order to explore the potential of research in practice an interactive session focusing on two applied posters with the NPCS commission society members potential stakeholders will be hosted.

"Investigating the stress of spread on the work floor with the failure-recovery model: bistability, critical transitions and robustness"
Lisanne Hogeveen, Utrecht University, TNO

We study the stress of spread on the work floor with the failure-recovery model. Here individuals switch between the active, internally failed and externally failed state. We will use the effective degree approach to study the qualitative behavior in the system for regular networks: we will obtain stable, bistable and oscillatory behavior. Next, we will use exact stochastic simulation to investigate the robustness of different networks. Also, we study the influence of the local characteristics of the networks on their robustness.

"On-going complexity projects at Statistics Netherlands"
Drs. Gert Buiten, CBS

In its role as national statistical institute, Statistics Netherlands produces statistics and provides access to microdata for scientific and policy research. It also provides information for proper interpretation of the trends emerging from the data and develops statistical methodology and indicators.
Against this background, Statistics Netherland in 2016 started research to work out how Complexity Science can be applied in official statistics. Activities focus on three main areas. First of all, use of Complexity for a better interpretation and understanding of developments described by the statistical data. Secondly, the derivation of additional indicators from existing data – such as early warning indicators and measures for the amount of complexity. Thirdly, developing data sets describing Dutch social and economic networks for e.g. scientific and policy research.
Several approaches are used. One is empirical research, into 'complex' patterns in micro datasets as well as into emerging properties of e.g. the economy. A second approach concerns Agent Based Modeling, for better interpretation as well as for deriving Early Warning Indicators. The third one is network analysis.
Current activities in this program are the following. First of all, two master students in Econometrics from UvA and EUR started there Master thesis with empirical research into power law distributions in Dutch industry, research into the application of Agent Based Models to investigate underlying mechanisms and the (empirical) validation of Agent Based Models. Statistics Netherlands is interested to find out if Agent Based Models based on (a sample of) real micro data could result in well validated models that are suitable for policy research.
Two other ongoing projects aim at developing networks data sets. One derives a social network dataset for the Netherlands by combining various data sources. The results so far have already been used for an article on social segregation in Rotterdam. The second one aims at constructing the inter-firm network of Dutch companies, using a combination of data sources and imputation methods. By the end of this year a Proof-of-concept should be ready and hopefully also a Bèta version of the dataset for external use.
Related to this is the research being carried out to develop sampling theory for limited observations of large and fast changing network phenomena such as Facebook and the World Wide Web. A first paper was published recently.
Finally, a paper has been published with examples of applications of Complexity in official statistics.

Statistics Netherlands is very interested in co-operation with other institutes, such as universities and policy research institutes.

"A system dynamics approach to model the T2DM patient journey and the total societal costs?" (Authors: Lotte V. Lokkers, Stephan F.J.M. Raaijmakers, Heleen M. Wortelboer, Guido Veldhuis)
Heleen M. Wortelboer, TNO

Diabetes Mellitus Type 2 (T2DM) is a metabolic disorder and worldwide the number of individuals suffering from T2DM is dramatically increasing, resulting in an increasing burden on society and healthcare costs. Recent research suggests that individuals suffering from T2DM can be reversed with appropriate lifestyle changes. T2DM is a disorder that evolves over time. An urgent need to gain new insights in whether lifestyle intervention could reduce this continuous rise of burden on society and healthcare costs is needed.
Knowledge from literature, experts, and stakeholders were used to gain insights in the socio-economic processes involved along the T2DM patient journey. A system dynamics model is developed to examine the Dutch T2DM patient journey. Datasets provided by CBS, KPMG, Nederlandse Zorgautoriteit, NIVEL, RIVM, and TNO were used to quantify the model. System dynamics modelling is an appropriate method as it captures the complex, dynamics processes involved and allows to simulate the effect of possible interventions upfront of actual implementation and evaluation of intervention programs in real life, as that would be too costly.
The simulation model suggests a T2DM patient journey from being normoglycemic to becoming prediabetic to becoming T2DM patient and the possibilities to be reversed to a healthy individual again. In accordance with literature, the preliminary results suggest an increase in T2DM population and thus, an increase in societal costs. Additionally, the preliminary results suggest a significant decrease in T2DM population when a Lifestyle as Medicine program is implemented, either as intervention or prevention program. Consequently, a significant decrease in societal costs is observed. The most effective policy observed is a combination of the policy options intervention and prevention. Further scenario analysis is needed to analyze the potential reduction of total T2DM population and a potential costs reduction using a lifestyle intervention program vs a lifestyle prevention program.

"Modelling job stress contagion with an agent-based model" (Authors : Jiske D. Janssen1,2, Bob van der Vecht1, Heleen M Wortelboer1, Mike H. Lees2. 1TNO, The Netherlands, 2UvA, The Netherlands)
Bob van der Vecht, TNO

The number of people with burn-out complaints remains rather stable despite detailed knowledge of factors involved and different intervention programs. Important factors that contributes to the appearance and the continuation of a stress-related disorder are imbalances between the (perceived) responsibilities, the available resources and social support (Schaufeli et al, 2009; Aronsson, 2017). Emotional Contagion is the process where a person influences the emotions or behavior of someone else. Due to emotional contagion, an individual stress

can be contagious to others. Modelling can give a better understanding on the development and the continuation of stress contagion within groups. The main goal of this research is explaining the field of stress contagion and to examine this field in a new light, by using an agent-based model. Based on previous literature, a simple agent based model was hypothesized and tested. The model was analyzed and behaved as expected in normal and abnormal situations. Stress contagion occurs in this model and can be monitored. This model can be used to investigate and visualize interesting questions like: what are the effects of different leadership styles?

"Contagion in Credit Portfolios: A Network Based Approach"
Ioannis Anagnostou, University of Amsterdam/ING Bank

Portfolio credit risk models estimate the range of potential losses due to defaults or deteriorations in credit quality. Most of these models perceive default correlation as fully captured by the dependence on a set of common underlying risk factors. In light of empirical evidence, the ability of such a conditional independence framework to accommodate for the occasional default clustering has been questioned repeatedly. Thus, financial institutions have relied on stressed correlations or alternative copulas with more extreme tail dependence. We propose a different remedy — augmenting systematic risk factors with a contagious default mechanism which affects the entire universe of credits. We construct credit stress propagation networks and calibrate contagion parameters for infectious defaults. The resulting framework is implemented on synthetic test portfolios wherein the contagion effect is shown to have a significant impact on the tails of the loss distributions.

"Financial statement networks: an application of network theory in the audit"
Marcel Boersma, University of Amsterdam

We propose a method to construct financial statement networks from journal entry data to visualize the organizational structure of a company. The resulting network can be used to

- Assess the financial complexity of the company
- Propose plausible relationship models for audit purposes

Auditors use predictive models to estimate financial account values in the financial statement. Prior studies suggest that incorporating organizational knowledge in these models yield better predictive accuracy. We propose a novel method to construct a financial statement network to gain insight into organizational structure of a company using real financial transaction data from 8 companies. We show that real data yields financial statement networks of varying complexity. We introduce a method to aggregate the nodes and edges of the financial statement network which results in its visualization at the right level of tractability. We also show that this visualisation enables the auditor to assess the complexity of the organizational structure of a company and to use it as a risk indicator for the audit. Furthermore, the obtained network yields insights into the monetary flows between financial accounts and business processes. We show that this information can be used to add organizational knowledge to the predictive models for the purpose of obtaining audit evidence.

"Wrong-way risk in credit and funding: a network-based approach"
Dr. Sumit Sourabh, University of Amsterdam

Wrong-way risk (WWR) in the context of counterparty risk can lead to significant losses in stressed market scenarios. The principal drawback of the existing WWR models is that they do not take into account that WWR occurs due a systemic market event. Moreover, they require calibration of a correlation parameter between exposure and credit which is often unstable and unreliable due to lack of representative historical data. Turlakov proposed a model for WWR in credit and funding based on the conditional probability of default of sovereign given counterparty default. We present a novel network-based methodology to calibrate the conditional probability for WWR, thus incorporating systemic risk in the pricing of financial derivatives.
stable strategy (not shown).

"Resilience introduced to the management of the Dutch large waterbodies"
Dr, Marjolein Sterk, Aquatic Ecology and Water Quality Management Group (AEW) Wageningen University & Research

In various scientific disciplines resilience has become a key concept for theoretical frameworks and more practical goals. The growing interest resulted in multiple definitions of resilience. This paper highlights how and why resilience has become a meaningful concept guiding multiple disciplines to understand and govern social-ecological systems. Moreover, the concept of resilience can be operationalized in complex social-ecological systems that are inherent to change and unpredictable outcomes.

"Resilience in complex air transport systems"
Matt Vert, Delft University of Technology

Sociotechnical Systems (STS) may be considered as being Complex Adaptive Systems (CAS): they are composed of numerous, heterogeneous, dynamical, interconnected components while interacting within an evolving environment. Moreover, they are able to adapt and learn which are two important mechanisms for resilience. Resilience is defined as the ability for a system to adapt itself before, during or after expected or unexpected adverse events in order to maintain an acceptable level of functioning. In this poster, we present a conceptual framework for resilience of STS. There are desiderata allowing a system to be resilient. Mechanisms, present at the individual, social, and organizational levels, are identified. When they are combined all together, we can interpret resilience as an emergent phenomenon. A case study is briefly introduced. It is the use of the agent-based modelling paradigm to investigate resilience of the runways and taxiways operations at Schiphol airport.