

A horizontal banner with a dark blue background. It features a network of white dots connected by thin white lines, creating a web-like pattern. The text "Social Simulation Conference 2022" is centered in a white, bold, sans-serif font.

Social Simulation Conference 2022

12-16 September 2022

University of Milan
Department of Social and Political Sciences

Via Conservatorio 7, 20122 Milan
<https://ssc2022.behavelab.org/>

Programme

Monday 12 September 2022

14.00-15.30 - Tutorials

An introduction to agent-based simulations in the Julia language

(Room 11)

Bogumił Kamiński (SGH Warsaw School of Economics, Poland), Przemysław Szufel (Warsaw School of Economics, Poland) & Rajith Vidanaarachchi (University of Melbourne, Australia)

This tutorial aims to show how Julia language can be used to create agent-based simulations in the social sciences. More detail on the tutorial programme [here](#).

Using interdisciplinary co-simulation for modeling socio-technical energy systems

(Room 12)

Fabian Adelt, Sebastian Hoffmann (TU Dortmund University, Germany), Jan Sören Schwarz (Carl von Ossietzky University of Oldenburg, Germany) & Matteo Barsanti (École Polytechnique Fédérale de Lausanne, Switzerland)

This tutorial addresses the use of co-simulation approaches to couple simulation models from different domains, programming languages and programming approaches, aimed at designing integrated simulation scenarios for examining socio-technical energy systems. (1) First, it will introduce the Python-based co-simulation framework *mosaik*, its theoretical background and basic functions. (2) Then, two exemplary model couplings with *mosaik* are showcased: *demod* as library for bottom-up domestic energy demand, and *SimCo-Energy* for the analysis of residential technology adoption. Additionally, brief previews for other components of an integrated simulation scenario will be provided, like innovation processes and networks (*SKIQ*), power distribution grids (*SIMONA*), and a model for industrial energy supply and demand. Interested participants can check out the *mosaik* documentation and tutorials in JupyterLab in advance, but this is not mandatory. For the workshop, basic programming skills and basic knowledge of Python is helpful, but not required.

Overcoming barriers in computational social science education

(Room 13)

Katarzyna Abramczuk (University of Warsaw, Poland) & Wander Jager (University of Groningen, The Netherlands)

In this workshop, we intend to exchange ideas and discuss problems related to teaching computational methods to social science students. We would then like to share educational materials prepared within the ACTISS project that help overcome the barriers in computational social science education at an introductory level (CSS for absolute beginners) and gather ideas for further applications of the materials and for the best ways to make them most useful for academic teachers. Programme details [here](#).

15.30-16.00 - Coffee break

16.00-17.15 - Workshops

ESSA@work, by the ESSA@work team

(Room 11)

Chair: Silvia Leoni, University of Leicester

ESSA@work is a workshop where participants can present their model (at any stage of development as long as at least partially implemented and explored) in a constructive atmosphere to get feedback and suggestions for improvements and developments from two expert modellers and the whole audience.

Presentations:

Ryu Koide (National Institute for Environmental Studies, Japan), *Consumer behavior and product circulation simulation of emerging circular economy strategies: An agent-based model for sustainability and circularity assessment*

Dehua Gao (Shandong Technology and Business University, China), *Identifying the impact of artifacts-based exploration and exploitation on routine's formation dynamics: An agent-based model*

Peter Steiglechner (Jacobs University, Germany), *Social identity shapes consensus formation in opinion dynamics models*

Marie Lisa Kogler (University of Graz, Austria), *Threat messaging in the climate debate and diffusion of climate scepticism and anxiety: An ABM approach*

Experts: Geeske Scholz & Gary Polhill (The James Hutton Institute, Aberdeen, Scotland, UK)

The ethics of agent-based social simulations

(Room 12)

Chairs: David Anzola (Universidad del Rosario, Colombia), Peter Barbrook-Johnson (Oxford University, United Kingdom) & Nigel Gilbert (University of Surrey, United Kingdom)

This workshop aims to promote a collective critical discussion of: (i) the ethical challenges faced during the modelling process, (ii) the connection these challenges have with other scientific domains and areas of research, and (iii) the possible means of ethics regulation in the field. It aims to identify sources of ethical concern in agent-based social simulation, consider advantages and disadvantages of different alternatives of ethical regulation and advance in the formulation of code of ethics.

Artificial utopias (Agent-based models of utopian societies)

(Room 13)

Chair: Bruce Edmonds (Manchester Metropolitan University Business School, United Kingdom)

This workshop addresses the use of agent-based models to articulate utopias in a formal, reproducible and transparent way in any area and at any level of abstraction, including, for instance, post-capitalist economies, post-nation state worlds, algorithmic money and post-money societies and any new utopias never previously presented. Critical discussion and opinion pieces are welcome. It follows a previous workshop entitled "Envisioning Post-Capitalist Societies via Simulation – Critique, Utopias and Agent Based Modelling".

17.15-18.00 - Invited talk

(Room 11)

"Inverse Generative Social Science: From Intelligent Agent Design to the Blind Model Maker"

Joshua M. Epstein (NYU School of Global Public Health, USA)

Chair: Flaminio Squazzoni (University of Milan, Italy)

Typically, we design completed agents—fully endowed with rules and parameters—to grow macroscopic target patterns from the bottom up. Inverse generative science (iGSS) stands this approach on its head: Rather than handcrafting completed agents to grow a target—the forward problem—we start with the macro-target and evolve micro-agents that generate it, stipulating only primitive agent-rule

constituents and permissible combinators. Rather than specific agents as designed inputs, we are interested in agents—indeed, families of agents—as evolved outputs. This is the backward problem and tools from Evolutionary Computing can help us solve it, extending the reach of agent-based modeling, while addressing several common criticisms of it. Concrete examples of iGSS and outstanding foundational issues surrounding it are discussed. A theme throughout is the need to evolve explicit formal alternatives to the rational actor, with Agent_Zero as one possible point of evolutionary departure.

Tuesday 13 September 2022

9.00-9.15 - Welcome

(Room 11)

Petra Ahrweiler (ESSA President) & Flaminio Squazzoni (SSC2022 chair)

9.15-10.45 - Parallel Tracks

– Track: “Management” - Section I –

(Room 11)

Chair: Friederike Wall (University of Klagenfurt)

Collaborative search and autonomous task allocation in organizations of learning agents

Stephan Leitner (University of Klagenfurt, Austria)

This paper introduces a model of multi-unit organizations with either static structures, i.e., they are designed top-down following classical approaches to organizational design, or dynamic structures, i.e., the structures emerge over time from micro-level decisions. In the latter case, the units are capable of learning about the technical interdependencies of the task they face, and they use their knowledge by adapting the task allocation from time to time. In both static and dynamic organizations, searching for actions to increase the performance can either be carried out individually or collaboratively. The results indicate that (i) collaborative search processes can help overcome the adverse effects of inefficient task allocations as long as there is an internal fit with other organizational design elements, and (ii) for dynamic organizations, the emergent task allocation does not necessarily mirror the technical interdependencies of the task the organizations face, even though the same (or even higher) performances are achieved.

Controlling replication via the belief system in multi-unit organizations

Ravshanbek Khodzhimatov, Stephan Leitner and Friederike Wall (University of Klagenfurt, Austria)

Multi-unit organizations such as retail chains are interested in the diffusion of best practices throughout all divisions. However, the strict guidelines or incentive schemes may not always be effective in promoting the replication of a practice. In this paper we analyze how the individual belief systems, namely the desire of individuals to conform, may be used to spread knowledge between departments. We develop an agent-based simulation of an organization with different network structures between divisions through which the knowledge is shared, and observe the resulting synchrony. We find that the effect of network structures on the diffusion of knowledge depends on the interdependencies between divisions, and that peer-to-peer exchange of information is more effective in reaching synchrony than unilateral sharing of knowledge from one division. Moreover, we find that centralized network structures lead to lower performance in organizations.

How does behavioral interdependence influence performance? An experimental study on human teams

Giovanni Francesco Massari & Ilaria Giannoccaro (Politecnico di Bari, Italy)

Behavioral interdependence is the extent to which team members actually work together in solving a task. It is considered an important feature of high-performing teams, even though empirical confirmations are still scarce. Here we conduct a behavioral experiment to investigate how behavioral interdependence, by fostering the team members in utilizing other’s task-related information, impacts on individual and team performance. Results show that behavioral interdependence influences individual and team performance. Performance peaks at medium levels of behavioral interdependence. We also find that environmental complexity moderates the relation between behavioral interdependence

and performance. In particular, high levels of behavioral interdependence are particularly detrimental for highly complex tasks. We discuss theoretical and practical implications of these results for team design.

Is management overrated? An exploration of the satisfaction and performance on group dynamics and task components

Shaoni Wang, Kees Zoethout and Wander Jager (University of Groningen, The Netherlands)

This article is aiming at studying the impact of team formation and task dynamics on group performance, aligning with the comparison between the bottom-up and top-down task allocation strategies. The complex interactions between individuals, task components and group performance are difficult to explore with traditional methods for organisational behaviour research. In this paper, we adopt an agent-based model with implementations of theories on motivation to explore the dynamic interaction of tasks, team and performance. The simulation results show that: 1) higher task variety leads to lower team performance; 2) the socially-oriented team has higher satisfaction; 3) teams have preferential ranges for task complexity.

– **Track: “Using qualitative data to inform behavioral rules in agent-based models”** –

(Room 12)

Chair: Melania Borit (UiT The Arctic University of Norway, Norway)

Trustworthiness of simulation: A qualitative account

Martin Neumann (JGU Mainz, Germany)

The extended abstract attempts to continue the discussion on validation of agent-based simulation models. Two contributions are provided. The first objective is to draw attention to qualitative accounts to validation. It is shown that indeed participatory modelling account do make use of some of these validation procedures even though the naming is different. Second, a novel method for assessing the trustworthiness of counterfactual scenarios is proposed. Using hermeneutical methods for interpreting simulation results enables to assess whether counterfactual scenarios are meaningful. It is argued that meaningfulness of scenarios enhances the trustworthiness of counterfactual scenarios.

The innovation network in the Rhenish Lignite area – A participatory ABM approach to partner selection and knowledge diffusion

Christian Stehr & Miriam Athmer (Ruhr-University Bochum, Germany)

This paper presents on the one hand an agent-based model of an innovation network, i.e. a set of interconnected actors that engage in the exchange and recombination of knowledge, with a focus on partner selection and knowledge exchange in a selected case region. On the other hand it also presents the process of integrating qualitative data into the model, obtained from a series of workshops and short semi-structured interviews with selected regional stakeholders with a background related to innovation or networking. We find that the obtained qualitative data enhances the ontology of our model significantly, especially regarding the partner selection modes of the agents where it led to the implementation of new processes. Furthermore the involvement of stakeholders built trust in the modelling process.

Integrating agent-based modelling and behavioural data analytics: A case study of climate change farmers’ perception in Italy

Sandra Ricart, Paolo Gazzotti, Claudio Gandolfi & Andrea Castelletti (Politecnico di Milano, Italy)

Climate change is arguably the most severe and complex challenge facing today’s society, a cross-cutting issue affecting many sectors and connected to other global challenges, such as ensuring sustainable water management and food security. Agricultural systems are adversely influenced by climate change through increased water stress, change in run-off patterns, seasonality fluctuation, and temperature variations. Farmers are, hence, a valuable source of first-hand observations of climate change as they may provide a deeper understanding of their manifestation, relevance, and effects. Social and be-

havioural sciences have investigated the influence of farmers' experiences in increasing climate change adaptation capability and improving decision-making processes at the system level. The conclusion is that local perceptions provide sufficient baseline information for understanding individual and collective exposure to climate risks, an essential element for effective policy formulation and implementation. Traditional management approaches based on simple, linear growth optimization strategies, overseen by command-and-control policies, have proven inadequate for effective adaptation to climate change. Conversely, accurate bottom-up approaches focused on social learning can complement the system transformation by building collaborative problem solving among individuals, stakeholders, and decision-makers. In this context, deepening social perception becomes fundamental for two main reasons: i) it is a key component of the socio-political context, and ii) it is an essential step for behaviour transformation and attitude change. In this line, associative processing methods, such as interviews and surveys, have been discussed for their ability to monitor the nature, extent, significance, and influence of personal experience on climate change adaptation. Also, modelling techniques have been recognized in social sciences as effective mechanisms to simulate the social influence in decision-making processes. System dynamics (e.g., causal loop diagrams, CLD) and Agent-Based Models (ABM) can include feedback between social and physical environments, define individuals' and stakeholders' narratives, and map the social network with agents' interactions. This proposal aims at testing how qualitative data can enable policy-makers and managers to understand and re-think water management and climate change policies at the local level, which is essential to address agricultural risks. From a system dynamics approach, we examine how ABMs can most effectively integrate behavioural data collected from semi-structured interviews and surveys to increase robustness in decision-making processes while attending to farmers' behaviour on climate change adaptation. We surveyed 460 farmers and semi-structured interviews with 13 irrigation consortiums from northern Italy to deepen a triple loop analysis on climate change awareness, perceived impacts, and adaptive capacity. Computer-assisted qualitative data analysis and statistics have been applied to gain insights from interviews and identify farmers' profiles from surveys. We included the profiles in an ABM coupled, in turn, with a distributed irrigation-soil-vegetation model that covers the irrigation district of the Adda river. Profiles influence agents' risk perception and their ultimate decision on the adopted crop type and irrigation method. Tentative results can enrich the discussion about the gaps and benefits of including qualitative data in agent-based modelling.

Challenging the establishment: A computational grounded theory of the emergence of sustainable food companies in Colombia

Cesar Garcia-Diaz, Mónica Ramos-Mejía, Sebastian Duenas-Ocampo & Isabella Gomati de la Vega (Universidad Javeriana, Colombia)

Understanding the underlying mechanisms that drive institutional change is a necessary step to develop paths toward sustainability. One possible instance is studying the emergence of new market logics in food systems. In this context, a new market logic favors alternative (i.e., organic) food systems over industrialized food production chains, and focuses on social rather than on monetary profitability. We study how these alternative, health-focused food systems strive for its establishment in a market dominated by industrialized food producers. We use a mixed-method approach that combines data from semi-structured interviews carried out to 30 small and incipient organic food companies in Colombia, a subsequent computational text analysis, and an agentbased model. Backing up the agent-based model construction with the key market dimensions, actors, and firm strategies identified by the text mining techniques, the model serves as a vehicle to theoretically explore actionable strategies that may lead to the emergence and establishment of social enterprises.

– **Track: “Multiscale ABSS method for social policy making” - Section I –**

(Room 13)

Chair: Takao Terano (Chiba University of Commerce, Japan)

Societal Prototyping Design (SPD), an integrative platform for policy design to realize a sustainable and healthy society

Toshiya Kaihara, Takao Terano, Hajime Kita & Shingo Takahashi (Kobe University, Japan) et al.

This paper describes basic concepts and strategies for Societal Prototype Design (SPD), which we are proposing to realize a sustainable and healthy society. To design a sustainable and healthy urban area with evidence-based policy making principles, it has been difficult to evaluate the pros and/or cons beforehand about various services such as education, lifeline, and health environments, because their results would appear after long time delay, e.g., several decades. Furthermore, such political decisions must be smoothly connected the current situation to future ideal city planning. However, the state-of-the-art data-driven methods are not enough for the purpose, because such analyses with social big data and/or AI technologies are able to only uncover the causes of the past events. They are very hard to apply to future political predictions without clear decision scenarios nor new evaluation measures. In the JST MIRAI Project, we are working on research and development to resolve these difficulties. As a part of our research results, in this paper, we discuss a new concept of SPD, the development of an integrative platform with real-scale agent-based simulation.

The economic and epidemiological effects of contact tracing in the face of an evolving virus

Patrick Mellacher (University of Graz, Austria)

I extend a viral evolution model to investigate the economic and epidemiological effects of contact tracing policies. My preliminary findings suggest that contact tracing increase output and reduce the number of deaths, both in a mutation and a no mutation scenario.

Workplace assignment to individual workers in each household using synthetic population in Japan

Tadahiko Murata, Daiki Iwase & Takuya Harada (Kansai University, Japan and Shibaura Institute of Technology, Japan)

In this paper, we assign workplace attributes to each worker in each household in a synthetic population using multiple censuses conducted in Japan. The synthetic population is a set of artificial individual attributes for each resident that is synthesized according to census data. We have synthesized a set of the synthetic populations of Japan. We assign a workplace attribute to each worker to estimate daytime population distribution and develop activity-based models in agent-based or micro-simulations. Although statistical information in a residential area or a workplace is released, no individual relations between a residential area and a workplace are not released in Japan nor in many countries to protect the privacies of residents. We employ origin-destination-industry (ODI) statistics to estimate workplaces for workers. Since some attributes in ODI statistics are not available for privacy reasons, we propose a workplace assignment method for all autonomous bodies in Japan. We show that 88.2% of workers in a city in Japan are assigned to correct cities as workplaces by our proposed method. We also show several maps of daytime population distributions by our proposed method. Synthetic populations with workplace attributes enable real-scale social simulations to design transport or business systems in times of peace or to estimate victims and plan recoveries in times of emergency such as disasters or pandemics.

Identifying socio-economic characteristics of influential spreaders using agent-based modeling

Marius Kaffai (University of Stuttgart, Germany)

Identifying the social groups causing high numbers of infections in a pandemic is necessary to implement targeted interventions. We use an empirically calibrated agent-based model to simulate the spread of a contagious disease and investigate whether life stage and household composition affect the number of infections directly or indirectly caused by an individual. We find that life stage, household composition and their interaction are key factors in identifying influential spreaders. While employed adults seem to cause the highest number of infections in general, the pandemic relevance of unemployed adults highly depends on household composition.

A study on multi-scale modeling in social simulation focusing on relationships among

decision-makers

Gaku Shimizu, Toshiya Kaihara, Daisuke Kokuryo & Nobutada Fujii (Graduate School of System Informatics, Kobe University, Japan)

The concept of System of Systems (SoS) is important to realize a society that creates sustainable value and services through the coordination and cooperation of systems. On the other hand, for SoS consisting of subsystems with different spatio-temporal levels, it is difficult to achieve both a macro-level evaluation of the entire system and a micro-level evaluation of the details simultaneously, because conventional modeling methods are applied independently at each level. In this paper, we propose multi-scale modeling of each system component at the spatio-temporal level for social simulation. The proposed method is applied to a local city where COVID-19 is prevalent, and comprehensive analysis of the target system is conducted by modeling and integrating decision-makers at different levels, such as citizens, organizations, and a municipality.

10.45-11.15 - Coffee break

11.15-12.45 - Parallel Tracks

– Track: “Management” - Section II –

(Room 11)

Chair: Stephan Leitner (University of Klagenfurt, Austria)

The benefits of coordination in (over)adaptive virtual teams

Dario Blanco Fernandez, Stephan Leitner & Alexandra Rausch (University of Klagenfurt, Austria)

The emergence of new organizational forms—such as virtual teams—has brought forward some challenges for teams. One of the most relevant challenges is coordinating the decisions of team members who work from different places. Intuition suggests that task performance should improve if the team members’ decisions are coordinated. However, previous research suggests that the effect of coordination on task performance is ambiguous. Specifically, the effect of coordination on task performance depends on aspects such as the team members’ learning and the changes in team composition over time. This paper aims to understand how these two factors moderate the relationship between coordination and task performance. We implement an agent-based modeling approach based on the NK framework to fulfill our research objective. Our results suggest that both factors have moderating effects. Specifically, we find that excessive individual learning harms the task performance of fully autonomous teams but is less detrimental for teams that coordinate their decisions. In addition, we find that teams that coordinate their decisions benefit from changing their composition in the short term, but fully autonomous teams do not. In conclusion, teams that coordinate their decisions benefit more from individual learning and dynamic composition than teams that do not coordinate. Nevertheless, we should note that the existence of moderating effects does not imply that coordination improves task performance. Whether coordination improves task performance depends on the interdependencies between the team members’ decisions.

The effects of variety and redundancy driven inertia on collaborative problem-solving

Claudia Estevez-Mujica and César García-Díaz (Universidad de los Andes & Universidad Javeriana, Colombia)

In this paper we build a computational simulation to measure the effects of inertia related decision-making phenomena in collective processes of problem solving. In particular, we include basic status quo inertia and two kinds of inertia driven by the characteristics of the information problem-solvers receive from their alters: variety and redundancy of information.

Exploring the coping strategies of bullying targets in organisations through abductive reasoning: An agent-based simulation approach

Marco Campenni, Chia-Hao Ho, Costantine Manolchev & Navonil Mustafee (University of Exeter, UK)

Workplace bullying can socially exclude a person in the workplace through repeated acts of harassment and offence. Over the past few decades, work-place bullying and other forms of ‘negative acts’ have become a phenomenon of global interest. Existing studies have shown this to be also true for the UK health sector. The analysis of primary data from two UK National Health Service (NHS) trusts identified that, among employees reporting bullying incidences and seeking redressal to such acts, there is a deviation from the expected pattern of behaviour. This deviation is referred to as an observed anomaly. Following the four stages of abductive reasoning process, namely, observing anomalies, confirming anomalies, generating hunches, and evaluating hunches, we hypothesise (generate a hunch) that social networks among the workforce determine employees’ coping mechanisms. We use agent-based social simulation (ABSS) with the NHS survey data to experiment with various social network topologies to empirically evaluate the hunch. Finally, to explore the coping strategies of employees who have experienced bullying, we identify four types of coping mechanisms, which draw on internal and external organisational channels, and the formal or informal support mechanisms offered within them.

Superiority bias and communication noise can enhance collective problem solving

Amin Boroomand & Paul Smaldino (University of California, Merced, USA)

Error affects most human judgments and communications. Here we consider two types of error: unbiased noise and directional biases, and consider how their effects may be different at the individual level and the group level in the context of collective problem-solving. We studied an agent-based model of networked agents collectively searching for solutions to simple and complex problems on an NK landscape. We compared the team’s performance in solving problems collectively when agents exhibit a superiority bias, preferring their own solution to those offered by others. We additionally considered the effect of communication noise on the team’s outcome. Our results show that when a team faces complex problems, both communication noise and superiority bias are time and resource-consuming traits that nevertheless have a positive effect on the overall quality of the team’s outcome. It was demonstrated that when a team faces simple problems, a moderate level of communication noise leads to a decrease in the required time and resources for a team. A trade-off of the team’s required time and resources with the connectedness of a communication network, superiority bias, and communication noise was found. This study contributes to the greater body of knowledge regarding collective problem-solving in teams.

Process evidence in experimental accounting research: The benefits of integrating agent-based modeling with laboratory-based experimental research

Jannick Plähn & Matthias Meyer (Hamburg University of Technology, Germany)

Laboratory experiments are among the most frequently used methods in management accounting research because experiments provide high internal validity, which allows for studying causality. Besides problems of external validity, experiments often face the problem of providing support for their proposed causal mechanism through which the independent variables affect the dependent variables due to the abundance of psychological and behavioral theories which predict similar outcomes. In this paper, we argue that agent-based modeling is well suited to complement laboratory experiments in the sense that agent-based modeling is a powerful tool to increase confidence in how the proposed causal relationship occurs. Therefore, we conduct an experiment in a participative budgeting setting where we claim that a social norm of honesty is the underlying mechanism. Next, we adapt an agent-based model that explicitly incorporates a norm-based decision process to our budgeting setting and show the first results from the agent-based model in contrast to the results from the laboratory experiment.

(Room 12)

Chair: David Anzola (Universidad del Rosario, Colombia)

A Simple model of citation cartels: When self-interest strikes science

Davide Secchi (University of Southern Denmark, Denmark)

This paper is an attempt to study a well known (probably little studied) phenomenon in academia: ‘citation cartels.’ This is the tacit or explicit agreement among authors to cite each other more often than they would do in a more “sincere” approach to science. This is collusion and a distortion of scientific progress in that it affects scholar’s attention. The phenomenon has been around for decades and it does not seem to spare any discipline. By starting from outlining the characteristics of a “cartel” using NK Modeling in management, this study then builds an agent-based model in an attempt to define the extent to which colluding behavior affects progress in a given discipline by distorting citation counts. Data is still preliminary although enough to conclude that cartels promote lax scientific practices.

Disagreement on the diagnostic value of evidence in scientific communities: an opinion dynamics model

Matteo Michellini, Javier Osorio, Wybo Houkes, Dunja Šešelja & Christian Straßer (Technical University of Eindhoven, The Netherlands)

Scientific disagreements may persist even if evidence is shared in a community, as shown for instance by the limited success of so-called consensus conferences (Stegenga, 2016). One possible explanation is that scientists attribute different degrees of significance to the same experimental result due to different background assumptions, methodologies or theoretical commitments. In this paper, we study the opinion dynamics in a community of scientists who disagree on the diagnostic value of evidence. We examine the conditions for scientists to converge on the right hypothesis despite initial disagreement on the significance of experimental results. Moreover, we explain how polarization can emerge in a community of Bayesian agents who are exposed to the same evidence (and treat evidence as certain). We develop an agent-based model (ABM) based on bandit models, common in formal studies of scientific communities (Zollman, 2007), in which agents may assign different diagnostic values to the same piece of evidence. Consequently, although agents share their evidence with each other, they may draw different conclusions from it. While agents share evidence within their social network, they exchange information about their diagnostic values only with those who have a similar opinion to theirs, following the rules of a bounded confidence model (Hegselmann and Krause, 2002). In this way, our ABM naturally extends network epistemology models, such as (O’Connor and Weatherall, 2018) and (Zollman, 2010). Our results show that an initial disagreement on the diagnostic value of evidence can, but does not necessarily, lead to polarization in a scientific community, depending on both the network structure and the confidence interval within which scientists share their opinions. These findings shed light on how different ways of interpreting evidence affect polarization in scenarios in which no detrimental epistemic factors are present, such as biases, deceptive information, uneven access to evidence, uncertainty about evidence etc. Moreover, our analysis suggests additional conditions and interventions for convergence, for example, at consensus conferences.

Comparing peer review regimes in an epistemic landscape: An agent-based model

Carlo De Bernardi & Francesco Renzini (University of Milan, Italy)

Peer-review is one of the most omnipresent selection processes in modern science. However, due to data unavailability and difficulties in implementing experimental studies, the effect of the different regimes on the selection of manuscripts for journal publication is still largely not understood. These empirical limits have spurred a stream of literature on computational models of science that allow to simulate counterfactual scenarios. However, many of the proposed models operationalize the quality of publications as a simple function of available resources. Our contribution aims to incorporate a more complex representation of the ideal space in which researchers move by making theoretical and

methodological choices, which determine the quality of their work. Furthermore, we test how this new mechanism interacts with different peer-review regimes.

Fairness in funding research by lottery

Thomas Feliciani & Kalpana Shankar (University College Dublin, Ireland)

In this paper, we contribute to the ongoing discussion on the allocation of research funding by granting bodies: traditional peer review or lotteries. We focus here on two prominent definitions of fairness: whether funding decisions are meritocratic and whether they are unbiased. We synthesize the existing literature to propose a taxonomy of available funding lottery types. Then we run a simulation experiment to estimate how traditional peer review and the various lottery types compare in terms of fairness. Results show that, counterintuitively, under the conditions examined here traditional peer review is not necessarily more meritocratic than most lottery types and most lottery types are not necessarily less biased than traditional peer review.

– Track: “Multiscale ABSS method for social policy making” Section II –

(Room 13)

Chair: Toshiya Kaihara (Kobe University, Japan)

Simulation-based classification in multi-objective optimization problems with social simulation

Yusuke Goto, Hiroyuki Morita, Yasuyuki Shirai & Hisashi Ichikawa (Shibaura Institute of Technology, Japan)

This study proposes a classification method of situations based on the forecasts of intervention effects in a multi-objective optimization problem with social simulation. Two types of similarity calculation methods that take into account the characteristics of each solution set type are introduced. We show the results of applying the proposed method to the problem of designing temporary benefit programs in response to economic shocks caused by the spread of COVID-19 infection. Furthermore, we describe future extensions to interactive analysis.

Validity assessment of uncertain infection indicators using virtual artificial society model

Yuki Misu & Shingo Takahashi (Waseda University, Japan)

Effective reproduction number is one of the indicators used to monitor the epidemic of an infectious disease. To calculate the effective reproduction number, it is necessary to know the time and route of infection of all infected people. However, since these cannot be observed in the real world, the number of new positives is used for estimation. In this paper, we focus on the uncertainty in estimating the effective reproduction number and propose a method to evaluate the impact of uncertainty in the real world using a virtual artificial society model. First, a model representing the infection situation is constructed, and the values of the effective reproduction number by definition are calculated in the model. It is possible to evaluate the validity of the estimated effective reproduction number by comparing the two calculated values of the effective reproduction number in the real world and the model. This method could replace unobservable uncertainty in estimation in the real world with “observable uncertainty in the model.” Experiments are conducted to analyze the uncertainty of the rate of asymptotically infected people and human flow. Finally, we discuss the results of experiments and their adaptability of this method to other fields.

Estimating the risk of household contact transmission of COVID-19

Setsuya Kurahashi, Taisei Mukai, Keiko Otake, Yukari Sekine, Keisuke Nakajima, Junichi Sugiyama, Takeshi Takizawa & Yasushi Kakizawa (University of Tsukuba, Japan)

This paper proposes a model that visualizes the risk of contact infection to family members when going outspreads to various items at home. Behaviour data after returning home are extracted from the behaviour survey, such as location and contact objects. Then data tables are created, including a behaviour history table, behaviour probability table, contact probability table, number of visits table,

contact circulation table, etc. The material transmission rate table is created by measuring the virus transmission rate after contact with droplets in a virus experiment laboratory. In the experiment, the synthetic agent created from the acquired data probabilistically performs movement and contact behaviour after returning home and reproduces the state in which the virus attached to the hand or belongings when going out propagates to objects at home. As a result, virus-attached contacts within around 30 minutes after returning home were widely confirmed around the entrance and kitchen, suggesting the effectiveness of early handwashing behaviour.

Evacuation simulation for large-scale urban population

Etzion Harari, Naphtali Abudarham & Tomer Rokita (Advanced Defense Systems Ltd, Gazit Institute, Tel-Aviv, Israel)

Large-scale population evacuation from urban areas may occur during disasters such as earth quakes, volcano eruptions, militarized conflicts, environmental disasters and more. Efficient and safe population evacuation is of great importance as it can save lives and reduce human suffering. The current study demonstrates an Agent-Based Simulation tool which may be used to support operational planning for population evacuation from threatened urban areas. The simulation models households as agents, each acting in accordance to a designated decision function, which renders the probability of evacuation as a function of the socioeconomic and demographic characteristics of the agents and the behavior of neighboring ones. Upon evacuation decision, agents embark on their way to their preassigned destinations, while optimal route is calculated and updated periodically, based on road information (taken from Open-Street Map), accumulative traffic congestion, and simulated road conditions. The simulation calculates and records the location of all agents and enables the user to identify and analyze different evacuation scenarios, compare evacuation sequences, map and identify road bottlenecks, etc. Integrating such simulation within the planning process - both at the municipal and the national levels - can significantly enhance authorities' processes of preparing evacuation plans, including investing resources for developing safe evacuation destinations and educating the population for the unfolding of future emergencies. The method is applied and demonstrated on Kyiv (Ukraine) test-case, where a large number of its 3 million citizens have fled the city while Russia's invasion on February 2022.

Assessing the cost of population dynamics design options in a microsimulation

Rachel Bacon, George Hodulik & Wesley Wildman (Center for Mind and Culture, Boston, USA)

We explore microsimulation design options as a source of divergence when using demographic statistics from the United Nations to model population dynamics in the United States from the years 1950 to 2100. Our analyses of 100 unique model designs toggle options such as the time step, the initial sample size of agents, variance reduction, ordering of demographic events, and adjustments to risk assignment as appropriate to each statistic. Results indicate that samples of 1,000 or fewer agents will produce very high divergence, even when other options known to improve accuracy are used. These findings are important for balancing efficiency, accuracy, and fidelity in demographic microsimulation design.

12.45-14.00 - Lunch

14.00-15.45 - Parallel Tracks

– Track: “Philosophy” –

(Room 11)

Chair: Riccardo Boero (Norwegian Institute for Air Research, Norway)

A philosophy of intelligent agent-based models

Thomas Chesney (University of Nottingham, UK)

The implications of giving agent-based modelling agents the ability to learn using artificial intelligence are explored. The contribution is to philosophy of science, specifically the philosophy of simulation. An illustrative model is created where each agent is given their own artificial neural network ‘brain’. This is compared to a traditional agent-based model. The exploration suggests that learning agents will open up new and exciting research directions for artificial societies but that there will be challenges in accessing them.

Computer simulations as iterated analogies: A viable framework for the epistemology of simulation in the social sciences

Massimo Rusconi, Davide Secchi & Raffaello Seri (University of Insubria, Italy)

The epistemology of computer simulation has gained momentum in recent years thanks to a number of concurrent yet intertwined research programmes. However, most of the everyday research activities still rely on researchers’ consensus and practical choices, especially in the field of social sciences. This paper aims at providing theoretical support to the state-of-the art of the field, by reviewing and deepening an analogical account of computer simulation. This theoretical perspective proves to be extremely valuable in explaining practitioners’ epistemological choices, by bridging together pragmatic and structural positions.

Engaging with stakeholders: An expertise-centred approach

David Anzola (Universidad del Rosario, Colombia)

With the increasing popularisation of empirically calibrated models and alternative modelling goals, particularly decision-making, engaging with diverse stakeholders has progressively become a key alternative during the modelling process. Current knowledge on stakeholder engagement, however, is disproportionately influenced by research on environmental resource management, and it is not entirely clear whether it can be seamlessly transferred to other domains of social simulation. This article, then, takes an expertise-centred approach to identify knowledge gaps that are relevant when considering involving stakeholders in other contexts and for other purposes. It argues that further research is needed to clarify the multiple sources of expertise, their potential impact, and the best way to manage them from a methodological and organisational point of view.

Is agent-based modelling of utopias a good idea?

Nicholas Gotts (Independent researcher, UK)

This extended abstract explores some objections to the idea of agent-based modelling of utopias, and responses to those objections. The urge to believe in and describe possibilities for peaceful, prosperous and happy communal life is found across many cultures, and long stretches of history, and persists today; but spending limited research resources on agent-based models of utopias can be criticised as wasteful, and as impractical. It is argued here that while there are indeed considerable difficulties in designing such models and in validating them, many of these apply also to models closer to existing social formations; and that there are good reasons to build and experiment with such models.

On social simulation in 4D relativistic spacetime

Kwun Hang Lai (Leiden University, The Netherlands)

Agent-based modeling (ABM) and simulation allow us to study social phenomena in hypothetical scenarios. If we stretch our imagination, one of the interesting scenarios would be our interstellar future. To model an interstellar society, we need to consider relativistic physics, which is not straightforward to implement in existing ABM frameworks. In this paper, we present the mathematics and algorithmic details needed for simulating ABM in 4D relativistic spacetime. These algorithms form the basis of our open-source computational framework, "Relativitization".

– **Track: “Energy transitions”** –

(Room 12)

Chair: Emile Chappin (TU Delft, The Netherlands)

Policy Making in Energy Transition with Agent-based Modelling

Salih Çevikarslan (University of Twente, The Netherlands)

This paper discusses the increasing trend of the use of ABM in energy transition research. I specifically focus on how and within what limitations ABM studies inform policy makers about planning and policy development in energy transition processes. Two recurring discussion points in the literature of policy making with ABM are generalizability of results and the participation of stakeholders in model development. The lack of a consensus on theoretical foundations and empirical validity of ABM models prevent further adoption of this methodology in policy realms, which is counter balanced by increasing computing power and the use of big data in calibration and validation of models as exemplified in Covid-19 crisis. How does the inclusion of social and behavioral factors in models help with more productive policy making? Is there a trade-off between the scale and robustness of a model for policy recommendation? What is the role of interdisciplinary collaboration within ABM in effective policy design? These are the questions to be tackled in this paper.

Prerequisites for modeling the multi-domain consumer engagement in the energy transition: A comprehensive segmentation approach

Matteo Barsanti, Sebastian Hoffmann, Fabian Adelt, Claudia R. Binder & Johannes Weyer (EPFL, Lausanne, Switzerland)

Given the critical role the end consumer is expected to play in the energy transition, new assessment and optimization methods should better address the human dimension to inform policymakers and practitioners with a broader mandate to promote consumer engagement on multiple levels. Although agent-based models (ABMs) allow to simulate the behavior and interactions of individual consumers based on sound socio-psychological theories, agents are often individually parameterized or use standard and simplistic behavioral profiles. This leads to increased complexity in data management, significant discrepancy between actual behavior and predictions, and inconsistency in co-simulation scenarios. Here, based on a new empirical dataset (N=1,099), we present a consumer segmentation framework using a set of socio-psychological variables belonging to (i) adoption of low-carbon technologies, (ii) participation in demand-side management (DSM) programs, and (iii) daily energy demand and response to DSM incentives. The results show that from a set of a-theoretical factors, that is, not belonging to a unique theory, it is possible to identify five distinct consumer segments: optimistic innovators, green deviant idealists, indifferent mainstream, pragmatic energy-conscious, and striving energy-concerned. These segments share common features with the various single-domain segmentation studies available in the literature, while broadening their applicability. Insights from this study are intended to aid the parameterization of ABM-based co-simulation designs for studying co-evolutionary phenomena across multiple energy-related behavioral domains.

From CONsumers to PROsumers: Spatially explicit agent-based model on achieving positive energy districts

Erkinai Derkenbaeva, Gert Jan Hofstede, Eveline van Leeuwen & Solmaria Halleck Vega (Wageningen University and Research, The Netherlands)

This abstract outlines ongoing research that employs spatially-explicit agent-based simulation to explore homeowners' decision-making on the adoption of different energy transition measures in Amsterdam. These measures include insulation of walls, roof, and floor, and adoption of solar panels and energy-efficient heating system. This study is conceptually developed based on a comprehensive meta-model Consumat that offers a theoretical framework with macro and micro-level factors affecting individuals' behavior and a set of behavioral rules for an artificial agent. The methodology focuses on model initialization to calibrate the behavioral rules of homeowners with the empirical data based on the WoON Dutch survey 2021, and the BAG data. Expected results of the model include the empirically observed temporal and spatial patterns of the decision-making processes of the homeowners across the districts in Amsterdam. Additionally, examining different scenarios of possible policy interventions can inform policymakers on observed energy-related behavioral patterns of homeowners and examined factors affecting these patterns, and contribute to achieving Positive Energy Districts goals in the city.

A model of district regeneration in Stockholm

Gary Polhill, Andrea Scalco, David Hales, Giuseppe Pellegrino-Masini, Erica Löfström & Christian Klöckner (The James Hutton Institute, UK)

This paper describes a model of district regeneration intervention design in a district of Stockholm (Järva), which is particularly ethnically diverse.

Dynamics of Individual Investments in Heat Technology

Sascha Holzhauer, Friedrich Krebs & Lukas Jansen (University Kassel, Germany)

The transition of heat provision in the urban building stock towards climate neutral sources poses a major challenge to German cities. The underlying actor structure is complex and interlinked. Municipalities set regulatory boundary conditions and decide on infrastructure investments like district heating networks. Necessary investments on the premises of house owners are not only inhibited by unavailability of capital but also by a lack of technical knowledge and ultimately by capacity shortages of installation companies. In the paper, we outline the agent-based model being developed in the course of a new research project aiming to support local heat transitions by socio-technical modelling and simulation. We aim to represent the investment dynamics evolving from interactions of building owners with a broader set of stakeholders, namely energy consultants whose knowledge and thus recommendations shape the set of investment options, and craftspeople such as plumbers whose experience has an impact of building owners' decisions. Furthermore, we discuss how to integrate the agent-based model with a model of the local energy system to account for feedbacks between the heating infrastructure and investment decisions of building owners.

– Track: “Crowd management & evacuation modelling” –

(Room 13)

Chair: Marcin Czupryna (Cracow University of Economics, Poland)

Computational decision support for crowd management applications: A case study on operational in-event pedestrian crowd management

Floris Boendermaker, Natalie van der Wal, Willem Auping, Dorine Duives & Corentin Kuster (Delft University of Technology, The Netherlands)

While crowd management is a crucial element in keeping many situations safe, operational support assisting practical crowd management applications are sparse. Two main reasons are hypothesized to be the cause of this: (1) inherent uncertainty regarding crowd modelling; and (2) computational requirements. This study presents three methodological steps—exploration, selection, and evaluation—to utilize crowd models for operational crowd management. This work applies these steps specifically on the shopping street ‘Grote Markt’, in the city of Breda, The Netherlands. The research question is: what are the potential effects of three proposed crowd management measures—traffic regulators, directional guidance, and object placement—on the pedestrian speed and densities? Main findings highlight the potential of the proposed traffic regulator measure, and its effectiveness compared to object placement and directional guidance. With the proposal of the methodological steps, this work provides the needed stepping stone for operational support on crowd management. One that utilizes crowd models to understand in-event crowd management systems, and thereby enables the comparison between different in-event measures before they have to be implemented in real life.

Strategies to mitigate disasters at the Hajj religious festival using GIS and agent-based modelling

Muteb Alotaibi, Graham Clarke & Nick Malleson (University of Leeds, UK)

Crowd management techniques have become a major concern of decision makers at major events. In this research, the integration of a Location-Allocation Model and an Agent Based Model is used to locate services in an optimal fashion at the religious festival in Mina and to explore whether or not these service locations has any implications for pilgrims' movement across the Mina road network. In this paper, we will focus specifically on the use of the ABM to look at the dynamics of crowd movements

along a key route and to explore how much congestion is ‘acceptable’. To define the ‘acceptable’ term here, we will use Fruin’s LOS category breakdown which has become a standard tool for interpreting crowd congestion. The 4 scenarios include: one way without health centre, one route with a health centre, two routes with the current health centre locations and two routes with a new location for a health centre. The first scenario is applied on ‘Souq Alarab’ road, one of the main routes pedestrians use to get to the location of the ritual stoning exercise - Jamarat Bridge. The other road in the third scenario is a planned new road. The findings confirm that the addition of a new road would mitigate the congestion in Mina in general and along ‘Souq Alarab’ road specifically. However, there is no significant evidence that the change of health centre locations will mitigate or alleviate the traffic congestion in both roads ‘Souq Alarab’ and ‘the new planned road’. The most congested case is where there is only one route (‘Souq Alarab’) with additional queueing whilst waiting to be served from the current health service. These findings confirm that the potential new route is a promising option for decision makers to mitigate the predictable congestion in ‘Souq Alarab’, in this scenario or in any route in Mina towards Jamarat.

Impact of leader-follower behavior on evacuation performance: An exploratory modeling approach

Jakob Irnich, Natalie van der Wal, Dorine Duives & Willem Auping (Delft University of Technology, The Netherlands)

Different leader-follower behavior may be observed in models, such as group gathering, backtracking, and flexibility of the group. However, a comparison of these behaviors resulting in possible substantially different estimates of optimal evacuation procedures is lacking. Hence, we developed an Agent based model in combination with exploratory modeling to compare backtracking, group gathering, and the possibility to change to another leader and investigate their influence on the evacuation and response time to receive a robust result. The results showed that backtracking and flexibility of the group increased the evacuation time. Whereby group gathering impacts the response time. In addition, the combination of behaviors increases the influence on evacuation and response time. Further research needs to test these results with empirical studies. Furthermore, the impact of other leader-follower behavior needs to be investigated.

An agent-based simulation model for crowd evacuation based on Bayesian Nash equilibrium

Yiyu Wang, Jiaqi Ge & Alexis Comber University of Leeds, UK)

The lack of experimental data for individual behaviors has hindered the systematic studies of crowd management as well as the refined development of regular laws of individual movement in evacuation simulation models. This research developed a simulation model for crowd evacuation on the basis of Bayesian Nash Equilibrium (BNE) and Multi-Agent System (MAS). BNE was introduced in this paper to augment the rationality of individual decision-making process in evacuation simulation and to assist pedestrians in discovering an optimal evacuation route to avoid congestion. A series of simulation experiments were conducted to evaluate the performance of the initial model, and the current experimental results indicate a noticeable positive influence of BNE on reducing evacuation time. A de-tailed introduction of the establishment and implementation process of the model as well as the discussion based on experimental results have been provided in this paper. Limitations and a few optional research directions in the future are also discussed.

Dynamic of pedestrians’ flows during daytime

Marcin Wozniak (Adam Mickiewicz University, Poland)

The movement of people in the city varies significantly during the day. However, the availability of open localization data that could be useful in calibration of pedestrian ABM is negligible. The investigation of pedestrian traffic fluctuations could be an important element of city management (e.g. planning public transport, identification of bottlenecks). For that reason, the paper develops the agent-based model of pedestrians’ flows dynamics in the center of one of the largest Polish cities (Poznan). The Google Places traffic data as well as census data and Geo-graphical Information System were used

to calibrate the model to generate reliable fluctuations of pedestrian movements. The developed ABM provides several valuable information that stand behind aggregate Google Places popular times rank. Mainly, we estimated the speed and size of pedestrians' flows together with the inflow and outflow of pedestrians to the city center. We were also able to identify bottlenecks, pedestrians' waves and areas of high/low density. The model captures and confirms several facts associated with fundamental diagrams of pedestrian flow and it could be used for further experiments regarding urban planning.

15.45-16.15 - Coffee break

16.15-17.15 - Invited Talk

(Room 11)

“Complex centrality: Predicting influence in social networks”

Damon Centola (University of Pennsylvania, USA)

Chair: Flaminio Squazzoni (University of Milan)

Who are the “influencers” for behavior change? Network strategies for predicting influence in social networks are based on techniques for locating the most central individuals. Based on my new book, *Change: How to Make Big Things Happen* (Little Brown/Spark, 2021), I present a new method for identifying the network locations that are most effective for spreading behavior change. I show how the novel measure of complex centrality, can significantly improve the scientific capacity to identify both the network structures and node locations best suited for spreading innovations. We validate our computational theory of influencers on 70 empirical networks taken from the AddHealth database, and then confirm our theoretical predictions with an experimental study on the spread of a microfinance program in 43 rural Indian villages. The findings show that complex centrality significantly outperforms all existing approaches to identifying “influencers” within social networks.

17.15-18.00 - Selected paper

(Room 11)

Chair: Flaminio Squazzoni (University of Milan)

Can social norms explain long-term trends in alcohol use? Insights from inverse generative social science

Tuong Manh Vu, Charlotte Buckley, Joao A. Duro, Alan Brennan, Joshua M. Epstein & Robin Purshouse (University of Sheffield, UK)

Social psychological theory posits entities and mechanisms that attempt to explain observable differences in behavior. For example, dual process theory of alcohol use suggests that an agent's behavior (i.e. drinking alcohol) is influenced by intentions (arising from reasoning involving attitudes and perceived norms) and habits. In order to pass the generative sufficiency test, we argue that the theory should be able to explain notable patterns in alcohol use that exist in the population, e.g. the distinct differences in drinking prevalence and average quantities consumed by males and females. In this study, we further develop and apply inverse generative social science (iGSS) methods to an existing agent-based model of dual process theory of alcohol use. Using iGSS, implemented within a grammar-based genetic program, we search through the space of model structures to identify whether a single parsimonious model can best explain both male and female drinking, or whether separate and more complex models are needed. We identify that a highly complex model structure is needed in order to achieve a high goodness-of-fit on both male and female drinking patterns simultaneously—whilst this

structure is difficult to interpret due to its complexity, it is notable in its involvement of all the core concepts from dual process theory.

18.00-18.30 - Virtual gathering event

18.30-20.00 Poster session + drinks & finger food

Interpreting agent behaviour that has emerged through artificial intelligence learning

Thomas Chesney & Robert Pasley (Adam Mickiewicz University, Poland)

This poster will consider the implications of the ‘wonky die’ problem (Chesney, 2021) for agents with artificial intelligence that have learned their behaviour rather than being gifted it through rulesets created by modellers. A philosophical problem, ‘wonky die’ comments on the difficulty of validating a model from test cases if the model is being used to explore novel scenarios: Imagine you are holding a loaded die. If it is thrown on the ground, six comes up most frequently, followed by five, then four, and so on down to one. If however it is thrown against a certain slope, the frequency of getting a six is reduced. In fact if you throw the die now, each side comes up about 16 times in 100, exactly as expected from a normal die. These adjustments have made the die’s use uniform, without actually changing what would be considered as the ‘correct’ part of the system to fix. It is the same with an agent model. To have a model perform as expected in a test case validation, any number of different parts of it could be adjusted. This is akin to changing the slope on which the die is rolled, or adjusting the die itself, or adjusting the strength of the wrist that throws it, or perhaps all three. The only way to make these adjustments is to be guided by theory; however theory is not always available. With a traditional model, researchers have rules that lead to emergent behaviour; with a model where behaviour is learned through some form of AI, we only have the emergent behaviour. Within this behaviour will lie social norms, institutions, values and social practices that the agents have arrived at on their own. Interpreting these is an exciting challenge. However if an intelligent model is tuned to perform as expected in test cases, there is little to give us confidence that it will capture the target behaviour when it faces a fresh scenario. How then should we consider AI agent behaviour? Can it ever be validated? This poster presentation will consider three possibilities: running a human lab experiment alongside an intelligent model, using a traditional agent model alongside an intelligent model, and interpreting a model qualitatively.

Search theory, conventionality and the “emergence of money”: an agent-based model in the context of economic sociology

Eduardo C. Ferracioli (Lisbon School of Economics and Management, Lisbon, Portugal)

This work-in-progress investigation proposes an agent-based framework for the study of fundamental issues on the theory of money, mobilizing central reflections on the issue drawn from different traditions in economics and in economic sociology. Many aspects of the theory of money remain puzzling to or disputed by economists and sociologists, and we submit that agent-based methodologies can shed light on important open questions related to the nature of money as an institution, including the extent to which “money-ness” is arbitrary or conventional and money’s role as a particular form of interaction that provides a unique (and unstable) type of coherence to the economic system. Considering that most attempts to formalize intuitions on the nature of money in economics (usually through fairly abstract approaches relying on search-theory and general equilibrium) and in sociology (often qualitative investigations that drive at foundational institutional features but are difficult to translate into theoretically tractable models) can be said to be at odds with each other, agent-based models could strike a new balance between these different perspectives, enabling researchers across disciplinary divides to address long-standing questions in a new, useful and realistic way.

Relativitization: a turn-based strategy game in 4D relativistic spacetime

Kwun Hang Lai (Leiden University, The Netherlands)

We have created a turn-based strategy game based on our framework "Relativitization". The relativistic aspect of the game creates many challenges that do not exist in typical strategy games. The game already has a graphical interface and many gameplay mechanics, but we are still polishing the game to make it more enjoyable. We hope the game can encourage people to appreciate the physics of special relativity and explore how special relativity may shape the social mechanisms in an interstellar society.

Social influence modeling in Python using defSim

Marijn Keijzer (Institute for Advanced Study in Toulouse, France)

Understanding opinion dynamics and the mechanisms behind opinion formation has been a major challenge in a multitude of scientific domains such as political science, sociology, psychology, network science, mathematics and computer science for many years (for reviews, see e.g. Flache et al. 2017; Castellano et al. 2009; Iyengar et al. 2019). In fear of increasingly polarized political climates within socially segregated societies, attention for the opinion dynamics literature is growing. Studying opinions in social systems is, however, notoriously difficult due to interdependencies between individuals, as well as their embeddedness in society at large where politicians, pundits and collective events all factor into the observed opinion distributions (Macy and Willer 2002). We may study individual reasoning, ponder argument-topic graphs or even examine large-scale longitudinal survey data, but rarely do we fully grasp the causal mechanisms that bring about polarization, ideological fragmentation or consensus (Keijzer and M"as 2022). Agent-based models (ABMs) are a tool well suited to do exactly this. They allow the researcher to examine the internal validity of a theoretical argument, when the proposed process is embedded in a system that exhibits properties of a complex system (Edmonds et al. 2019). In other words, we can use ABMs as a means to understand macro-outcomes that result from many, stochastic micro-level interactions constrained by and possibly interacting with a meso-level interaction structure (Macy and Flache 2009). In this presentation, I introduce defSim—the discrete event framework for social-influence models (Laukemper et al. 2019). defSim is a fully open source Python package that allows researchers, teachers and students to efficiently code and run social-influence models. defSim is mainly a simulation framework, but also contains a repository of pre-programmed, classic social-influence models. The software package can be useful to anyone who wants to model collective dynamics of social influence processes on opinions, attitudes or beliefs and wishes to (1) sketch a quick idea in a few lines of code, (2) scale-up their code to run quickly in parallel on their own computer or a High Performance Computing (HPC) cluster, (3) seek a simulation tool with easy to read syntax to introduce others (e.g. students) to simulation based research.

Agent-based modeling of highly-crowded event

Antonio Kruse & Corinna Köpke (Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut, EMI, Germany)

The newly founded Fraunhofer Center for the Security of Socio-Technical Systems (Fraunhofer SIRIOS, <https://www.sirios.fraunhofer.de/>) in Berlin, Germany investigates complex safety and security scenarios in order to increase safety, security and resilience in modern societies. It consists of members of the Fraunhofer Institute for Open Communication Systems (FOKUS), the Fraunhofer Institute for Transportation and Infrastructure Systems (IVI), the Fraunhofer Institute of Optronics, System Technologies and Image Exploitation (IOSB) and the Fraunhofer Institute for High-Speed Dynamics, Ernst-Mach-Institut (EMI). The aim is to develop a system for mission planning and decision support for preparation, prevention and protection of certain infrastructure considering events such as industrial accidents, terrorist attacks, riots or climate-related extreme events. One key aspect is to address the socio-technical risks and social dynamics of highly-crowded and realistic environments. Here, we employ an Agent-Based Modeling (ABM) approach to simulate pedestrian flows, their interaction with the infrastructure and respective information systems as well as their reaction to certain arising critical situations. To depict the latter, we mimic collective phenomena such as escape and panic behavior among the agents. We study the consequences of these mechanisms on different event types and event layouts. Analysis of the spatial and temporal distribution of agents will help to derive appropriate safety and security measures. In addition to behavioral parameters, our ABM also includes a model

for the perceptibility of simulated acoustic and visual warning systems. We study the effects of information spread through various warning systems and among agents on their behavior to further optimize communication strategies and crowd-control mechanisms in a variety of critical situations. Initially, a small example simulation environment is established. It includes the generation of a simple layout, the agents pathing, and collision detection between agents and obstacles. The environment is based on RiMEA (<https://rimea.de/>) test cases for microscopic evacuation analysis and we choose an example that is relevant for the scenario described above. The specific layout, the number of agents, the agent’s walking speed and the needed duration of escape to succeed the test case given by RiMEA, enable us to validate the basic functions of our ABM. The escape duration depends on the optimal choice of the agents pathing while also considering arising congestions at narrow points. Finally, as we aim for simulations including several thousands of agents, we also test the numerical performance of our code by using different numbers of agents.

An agent-based model of prosocial equilibrium: Simulating the role of religiously motivated behaviour in the formation and maintenance of large-scale societies

Ivan Puga-Gonzalez, Leron Shults, Ross Gore & Konrad Talmont-Kaminski (NORCE Center for Modelling Social Systems, Kristiansand, Norway)

This paper outlines a new agent-based model that represents the dynamics by which a society achieves and maintains prosocial equilibrium. The latter is understood as a social balance involving the interplay of prosocial behavior, anxiety, environmental threats, and religiosity in the population. Experiments showed that the model was able to simulate the emergence of relatively large societies under the sorts of conditions that would be expected based on the theoretical literature and other empirical findings in the relevant fields. We conclude by describing the main insights of the simulation experiments and pointing toward future work currently being planned by the research team.

An evolutionary analysis of network formation in asymmetric coordination games

Francesco Renzini (University of Milan, Italy)

Communication network topologies play a determinant role for reaching unanimity of decisions in asymmetric coordination games. However, research so far has mostly experimented with fixed and exogenously provided topologies, while in reality individuals decide both which strategy to pursue and their network neighbors. For these reasons, Kearns et al. (2012) have experimentally endogeneized network formation in such coordination dilemmas and found that individuals tend to free-ride on network formation, thus generating very centralized topologies leading to coordination failures. In this work, we provide an evolutionary formulation for the Kearns et al. game to show that free-riding in network formation in asymmetric coordination dilemmas is an evolutionary stable strategy and that the presence of punishers should be a sufficient condition to avoid free-riding. We further propose an experimental modification to the Kearns et al. game to test our findings.

Wednesday 14 September 2022

09.00-10.00 - Invited Talk

“Simulating social systems with individual-based models: are they worth it?”

Alison Heppenstall (University of Glasgow, UK)

Chair: Petra Ahrweiler (Johannes Gutenberg University, Mainz, Germany)

Over the past 15 years, the popularity of individual-based modelling approaches (i.e. agent-based modelling and microsimulation) has rapidly grown. This can be attributed to a number of factors including increased computational power, the availability of rich individual-level data and the appearance of development tools. The appeal of these models lies in their ready ability to simulate heterogeneous individuals and their behaviour. However, handling behaviour and calibrating/validating these models remain evergreen challenges. Is the effort that is required to create and evaluate these models worth it? This talk will introduce individual-based models and using a number of examples to walk through the pros and cons of this approach.

10.00-10.45 - Selected papers

Chair: Petra Ahrweiler (Johannes Gutenberg University, Mainz, Germany)

The importance of dynamic networks within a model of politics

Ruth Meyer & Bruce Edmonds (Manchester Metropolitan University, Manchester, UK)

Many simulation models of social influence are for the theoretical exploration of the outcomes resulting from certain mechanisms. They therefore tend to be relatively focussed on one mechanism at a time – the KISS approach. Here we take a more KIDS approach, looking at the interaction of two mechanisms within an evidence-led simulation of political behaviour in Austria 2013-2017. In this simulation there is not only the mutual social influence of attitudes (within a 7D space), but this social influence is constrained by a social network. However, one can also allow this social network to adapt based on the interactions between agents, so the social attitudes and social networks co-evolve. In this model, we find that (a) whether the social network is allowed to adapt is more important to the outcomes than the particular kind of social network it is initialized with, but also that (b) (given all the other mechanisms, parameters and structures in this model) a changing social network seems essential to getting outcomes that are qualitatively similar to the patterns in the observed polling data.

Simulating social innovation processes and policy experiments: The case of a referendum on closing a road in a public park for car traffic

Loes Bouman, Wander Jager & Patrycja Antosz (University of Groningen)

In an agent-based simulation we investigate social innovation processes and how complex network dynamics emerging from social interactions can shape the diffusion and acceptance of an innovation. We use the real-life empirical case of Groningen, The Netherlands, where an important park at the heart of the city was closed for through car traffic as a result of a referendum. Thereby, we mimic the complex social dynamics of the process of attitude formation, information exchange and casting the vote among 1994 Groningen residents. We use the HUMAT architecture that integrates key drivers and processes of behaviour and social interaction. Our simulations replicated empirical reality and show that the referendum resulted in a victory for the close voter, but addresses a tipping point due to the almost equal number of votes in favour or against. Moreover, we demonstrate the volatility of tipping points with simulating policy experiments (presence of informational campaigns and townhall meetings) and show their impact on innovation diffusion processes. We conclude that deliberative persuasive acts by local authorities have a strong influence on the acceptance of the innovation.

10.45-11.15 - Coffee break

11.15-12.45 - Parallel Tracks

– Track: “Socio-ecological systems and social behaviour” - Section I –

(Room 11)

Chair: Geeske Scholz (The James Hutton Institute, UK)

Navigating the space between empirics and theory: empirical-stylized modelling of social-ecological systems

Maja Schlüter, Nanda Wijermans, Laura Elsler, Blanca Gonzalez-Mon, Emilie Lindkvist, Romina Martin, Rodrigo Martinez-Pena, Kirill Orach, Kara Pellowe & Udit Sanga (Stockholm University, Sweden)

The use of agent-based models and modelling to study social-ecological systems is becoming increasingly common. There is a diversity of model types, model purposes and uses of models, in part because of the complexity of sustainability problems and the multidisciplinary nature of the field. Given the field’s problem and solution-oriented aims, many models focus on policy assessment or decision support to provide knowledge for policy making and action. The potential of modelling for theorising in the context of complexity, i.e. building generalised, complexity-aware knowledge of the dynamics of social-ecological systems, is still underdeveloped. Agent-based modelling, as a method that takes a complexity perspective when simulating the interactions that generate emerging system-level outcomes, has a great potential to support explanation and theory building (refs), particularly when combined with in-depth empirical research. In this contribution, we present an approach of linking (qualitative) empirical research with agent-based modelling to develop generalised understanding of SES that accounts for their complex and social-ecological nature. We elaborate key dimensions of the approach, which we call BIM (Being In the Middle), present several examples and reflect on our experience with its application to develop insights about social-ecological phenomena in the context of natural resource use. Finally, we discuss ways forward and challenges associated with it.

A data driven approach to model fishery responses to socio-ecological change in the southern North Sea

Jonas Letschert, Birgit Müller, Gunnar Dreßler, Christian Möllmann & Vanessa Stelzenmüller (Thünen Institute of Sea Fisheries, Bremerhaven, Germany)

In the past two decades many computer models were developed to simulate the temporal and spatial behavior of fishers. Many of these models assume human behavior purely based on profit maximization, despite a growing body of evidences for more complex behavioral strategies of fishers. We developed an agent-based model (ABM) to simulate temporal and spatial fishing dynamics of individual German fishing vessels in the southern North Sea, while integrating behavioral strategies, such as pursuing social norms and habitual behavior. Our approach integrates various types of empirical fishery, environmental, and economic information, such as sea bottom temperatures, oxygen concentration, primary productivity, salinity, as well as fish and oil prices. The strong reliance on empirical data of our model ensures a high degree of realism and enables the applicability to analyze future scenarios. Especially in the North Sea, gaining information about future scenarios is of relevance, as vast offshore windfarm (OWF) extensions will limit available space for free-ranging activities, such as fishing. We tested and parameterized the model by applying a pattern-oriented modelling approach and carried out a sensitivity analysis. Results reveal the heterogeneity of fishing fleets and highlight the relevance of behavioral theories other than profit maximization. Our model outputs offer guidance for effective area-based management and foster the inclusion of fisher behavior into marine spatial planning.

Attracted to fish: a gravity-based model of purse-seine vessel behaviour

Nicolas Payette, Ernesto Carella, Katyana A. Vert-Pre, Brian Powers, Steven Saul, Michael Drexler, Aarthi Ananthanarayanan & Richard Bailey (University of Oxford, UK)

The tropical tuna fishery in the Eastern Pacific Ocean is characterized by the use of fish aggregation devices (FADs). The increasing use of FADs and improvements in GPS and echo-sounder technology are rapidly changing the face of that fishery, making it challenging to anticipate the effect of potential policy interventions to protect vulnerable species like Bigeye tuna. In this paper, we describe how we use the POSEIDON platform to build an agent-based model of tuna fishing in that region. The model has many layers, ranging from fish biology and ocean currents to ports and markets, but we focus on the middle layer of the model in which we use a "gravity-based" strategy to drive the behaviour of fisher agents. While the model is still a work in progress and concrete policy evaluations have yet to be performed, we believe our new behaviour algorithm to be original enough to warrant the interest of the social simulation community in its own right.

Multiscale agent-based modelling with a hierarchical nested approach

Zhanli Sun (Leibniz-Institut für Agrarentwicklung in Transformationsökonomien, Germany)

Social-ecological systems (SESs), like many other complex adaptive systems, are inherently multi-scale and hierarchical. The dynamics of SESs are driven by the behaviors and at-scale and cross-scale interactions among the agents located at different scales, such as organizational levels and spatial scales. Agent-based models (ABMs), with the capability in modelling the emergence phenomena, proved to be highly powerful tools in modelling SESs. However, most existing ABMs, including some large-scale models on national or global level, merely consider two scales, namely the individual/micro and system/macro level, and rarely describe and catch the multi-scale nature of SESs. Thus, they cannot simulate many interesting cross-scale dynamics such as feedbacks and system dynamics across multi-scales, teleconnections, tipping points and cascading effects across scale in SESs. Here we advocate for the multi-scale ABMs, explain the necessity, benefits, and the challenges of multi-scale ABM of SESs. Furthermore, we present conceptual frameworks of multi-scale SESs, and modelling strategies and approaches in realizing multi-scale ABM. Finally, as an illustrative example, we present an stylized nested hierarchical ABM in common pool nature re-source management. We hope this research will further stimulate impending endeavors in modelling multiscale SESs using ABMs—which have profound policy implications, for example, in identifying the leverage point at a certain scale in shaping the pathways of SESs development and supporting multi-scale nature resource management.

– Track: “ABM in Economics” - Section I –

(Room 12)

Chair: Paolo Pellizzari (Ca' Foscari University of Venice, Italy)

Assessing the performance of collective and individual pay for performance systems

Silvia Leoni (University of Leicester, UK)

This paper aims to assess the performance of collective and individual performance-related pay, and hybrids of them using an agent-based model. The increasing use of variable pay in recent years has highlighted longstanding concerns about their potential downsides, including the possibility that this approach undermines intrinsic motivation. This paper addresses two research questions: 1) which pay system results in better firm performance in terms of productivity and profitability in the short and long run? 2) how do different pay systems affect workforce composition and workers' retention? We use agent-based modelling to answer these questions. The model simulates a closed economy populated by firms and employees. Firms adopt fixed pay in combination with variable pay in the form of either individual, collective or a combination of both. Employees can switch companies based on the expected job satisfaction, intrinsic and extrinsic, associated with an alternative job.

Elephants in the negative space: Simulating regional innovation systems in low income countries

Ozge Dilaver, Joshua Omoju & Roseline Wanjiru (Northumbria University, UK)

Regional innovation systems (RIS) have always captured the interest of policy makers, who aim to emulate their success, and scholars, who aim to understand why businesses in related value chains

agglomerate in certain places, or how geographical proximity facilitate their innovativeness. While RIS of global importance and scale such as Silicon Valley, Detroit and Hollywood are investigated from various angles, and industrial clusters in OECD countries in general are observed via longitudinal analyses, our knowledge of innovation systems in low income countries remains scant. We do not know if innovation systems in low income countries impact upon global trade and global innovation systems. We also do not know how firms operating in industrial clusters in low income countries develop their dynamic capabilities, identify opportunities, respond to consumer affordability constraints and exchange knowledge across value chains. These gaps in the existing literature is not due to lack of interest, but, as we try to highlight in this study, due to inherent challenges related to researching the negative space. While it is easy to identify and possible to empirically study complex and dynamic processes and networks of innovation in Silicon Valley, it is hard to know what to look for when such clear instances of RIS do not emerge. In this study, we regard negative space as an important but problematic epistemological field and suggest exploring it through dialectical knowledge creation. In this context, we evaluate the use of agent-based models for capturing the negative space it in silico. This extended abstract positions the on-going study in the existing literature and specifies our methodical approach.

Finance and decreasing business dynamics: Using macroeconomic agent-based simulation
Tae-Sub Yun, Hanbit Lee & Il-Chul Moon (Korea Advanced Institution of Science and Technology (KAIST), South Korea)

This paper analyzes the impact of finance on business dynamism using an agent-based simulation. We extend the Keynes meeting Schumpeter model and validate the model on South Korea's economy. We use Debt-to-Sales ratio and interest rate as measures of quantity and cost of corporate finance services respectively, and economic growth rate, market concentration, and labor share as indicators for business dynamism. Simulation results show that improvement in quantity and cost of finance have positive linear effect on economic growth rate, whereas for market concentration and labor share the effects are non-linear. Additionally, we observe a negative correlation between market concentration and labor share. We investigate the underlying reasons for the aggregated results through firm-level analysis.

Exploring credit relationship dynamics in an interbank market benefiting from Blockchain-based distributed trust: Insights from an agent-based model

Morteza Alaeddini, Julie Dugdale, Paul Readdy & Philippe Madiès (Université Grenoble Alpes, France)

Trust is crucial in economic complex adaptive systems, where agents frequently change the other side of their interactions, which often leads to changes in the system's structure. In such a system, agents who seek as much as possible to build lasting trust relationships for long-term confident interactions with their counterparts decide whom to interact with based on their level of trust in existing partners. A trust crisis refers to the time when the level of trust between agents drops so much that there is no incentive to interact, a situation that ultimately leads to the collapse of the system. This paper presents an agent-based model of the interbank market and evaluates the effects of using a voting-based consensus mechanism embedded in a blockchain-based loan system on maintaining trust between agents and system stability. In this paper, we rely on the fact that blockchain as a distributed system only manages the existing trust and does not create it on its own. Furthermore, this study uses actual blockchain technology in its simulation rather than simply presenting an abstraction.

Embedding social simulation in the design of wine pricing policies

Nikitas M Sgouross (University of Piraeus, Greece)

We provide an overview of Politika, a policy design prototype, and explain how it is applied in developing and analyzing pricing policies for wine brands versus their competitors. These policies seek to maximize the purchase motivation for specific brands of wine relative to their competitors in a population. Politika provides explicit representations for the policy parameters and their base case values that reflect the current state of the market. It then represents each policy alternative as a set of alternative values for a subset of the policy parameters. Furthermore, it is able to describe a set of

constraints in the simulation of each alternative that can facilitate comparisons between alternatives. Finally, Politika allows the definition of criteria that will be automatically applied to the outcomes of the simulations and will allow the designer to estimate whether each alternative fulfills the policy goals.

– **Track: “Norms, values & institutions” - Section I** –

(Room 13)

Chair: Amineh Ghorbani (Delft University of Technology, The Netherlands)

Formalising empirically-based heterogeneous decision makers in a social dilemma experiment under risk

Nanda Wijermans, Eva Vriens & Giulia Andrighetto (Institute for Future Studies, Stockholm, Sweden)

Norms are widely considered to be the bottom-up means to address the core challenges of humanity faces in these times. However, when and how are norms working in our favour and when not? To unpack the role of norms under risk we combine agent-based modelling and behavioural experiments to understand when and how norms are powerful and when not. In this paper we detail about the development of agents reflecting different decision mechanisms inspired by the results of a behavioural lab experiment in a public good game under risk. We detail how each type of agent decides whether and how much it will contribute under different normative and risk circumstances and show what that behaviour looks like. Opening up the a stage in the modelling process that often is hard to take space for, and welcome a critical discussion with our peers during the conference on our formalisation.

Extending partial-order planning to account for norms in agent behavior

Tokimahery Ramarozaka, Jean-Pierre Muller & Rakotonirainy Hasina (University of Fianarantsoa, Madagascar)

Following a couple of models aiming to assess the effectiveness of norms in Madagascar on the MIMOSA platform, Müller et al, has noticed that the current architecture was not expressive enough to deal with all relevant norms, their different aspects, and how they interfere with the agents’ behavior for such complex systems. In response, this paper proposes a new agent architecture and its dedicated language to enhance the expressiveness of norms in multi-agent systems. The architecture has to 1) identify all the applicable norms given a temporal, spatial, and social context, and 2) generate an agent behavior to account for these norms. We propose to extend automated planning and to use a Model-Driven Engineering approach to build the abstract and concrete syntaxes of the language and its semantics. The resulting architecture will allow modelers to express a wider spectrum of norms and provides a normative decision tool that will ease further discussions and interpretations.

An agent-based model of the role of epistemic vigilance in human cooperation

Mariusz Rybniak, Ivan Puga-Gonzalez, F. Leron Shults, Ewa Dąbrowska-Prokopowska & Konrad Talmont-Kaminski (University of Białystok, Poland)

This paper uses an agent-based model with an adapted stag hunt style scenario to explore the role of the social transmission of correct information about stag hunting and potentially incorrect information about the costs of defection on cooperation in a small artificial society. The computational architecture of the model draws upon Daniel Sperber and Hugo Mercier’s concept of epistemic vigilance as well as Brian Skyrms’ work on cooperation in stag-hunt scenarios. In the model, communities of 100 hunters begin with no knowledge of stag hunting or punishment for defection and via imperfect social learning, guided by source or content vigilance, move toward a stag hunting or hare hunting equilibrium, where stag hunting may be motivated by the expectation of cooperation or by the fear of punishment. Most successful communities end up using content vigilance to determine their beliefs regarding stag hunting but use source vigilance to determine their beliefs regarding punishment, as predicted in the theoretical work of Konrad Talmont-Kaminski. These findings contribute to the ongoing debate in a variety of disciplines about the conditions under which - and the mechanisms by which - cooperation emerges

and is maintained in human societies.

Compliance patterns reconstructed

Katharina Luckner & Veronika Fikfak (University of Hamburg, Germany)

We develop an agent-based model to investigate the mechanisms that determine state compliance with European Court of Human Rights judgments. Tasked with upholding the European Convention on Human Rights, the Court sanctions human rights violations and, and the Council of Ministers oversees the state-side implementation of remedies in response to judgments rendered by the Court. To increase compliance with Court judgments, we must understand why some cases remain unenforced, while others are complied with, how states learn from each other, interact with the Court, and the Council of Ministers. We use an agent-based model to connect individual state behavior with the overall outcome of many compliance processes running in parallel and include learning processes as well as information exchange between states.

A theoretical agent-based model to simulate the rise of complex societies

Saida Hachimi El Idrissi, Mohamed Nemiche & Bezza Hafidi (Ibn Zohr University, Morocco)

Nowadays, societies consist of hundreds of millions of people governed by one political system, and cooperation between individuals transcends face-to-face cooperation. However, in early history, groups of people did not exceed hundreds of individuals, and cooperation existed at low levels. So how did human societies evolve from small groups known by face and name into the huge anonymous groups of today? Our model tries to answer this question based on Freud's hypothesis stating that civilization could not arise and evolve without the repression of satisfaction (repression of human desires). In social evolution the repression of satisfaction can be interpreted as the repression of competition between society members the thing that increases the society power and helps on the formation of complex societies. In order to test this hypothesis we implemented an agent-based model where a large number of primitive societies are distributed in a grid of cells; initially, each cell is an independent polity. In each time step, all border cells (cells having at least one neighbor of a different polity) have a chance to start an attack and take over one cell from its neighbors. During the simulations we can observe the emergence of complex societies the thing that validates our hypothesis.

12.45-14.00 - Lunch

14.00-15.45 - Parallel Tracks

– Track: “Methodology” –

(Room 11)

Chair: Gary Polhill (The James Hutton Institute, UK)

Heterogeneity in agent-based models

Deborah Olukan, Jonathan Ward, Nicolas Malleson & Jiaqi Ge (University of Leeds, UK)

Agent-based models are an incredibly flexible tool that perform exceptionally well when capturing heterogeneity in agent attributes, characteristics, and behaviours. Heterogeneity in agent-based models is often presented through a large number of model parameters which may result in increasingly complex models. Consequently, parameter estimation and identification become a challenging task. This paper presents the preliminary work undertaken thus far to introduce and present the parameter identification problem in agent-based models.

Rejection sampling for complex models facing limited data

Ernesto Carrella (University of Oxford, UK)

Often we do not have enough data to calibrate our models. We then face an under-identification problem: there may be very many parameters sets that fit equally well the model to the data. Running an estimation algorithm becomes dangerous as it will arbitrarily pick one parameter set over all others, papering over the actual uncertainty. When the model is fast enough, a simple approach to deal with under-identification is rejection sampling. This involves running the model with random parameters, setting an acceptance threshold and then collect all parameter sets that fit the model "well enough". We can then use this ensemble of parameter sets for both policy simulations and sensitivity analysis. We show three applications for agent-based models of this simple technique.

All the right moves? Systematically exploring the effects of random travel in agent-based models

Edmund Chattoe-Brown (University of Leicester, UK)

Movement processes in Agent-Based Models (and particularly so called random movement) often seem to be treated as a black box (with the implication that the details of their implementation don't matter to model outcomes). This paper illustrates the general lack of concern with the details of movement processes using a literature review, shows that implementation details can actually matter dramatically to model outcomes and considers the wider implications of these findings both for future research and modelling practice. The effect of movement assumptions is explored using the "switchable" approach in which pairs of models (differing only in the aspect of interest) are directly compared. The paper shows that Agent-Based Models apparently fail to distinguish between rates of movement which effectively ensure random mixing of the population and those which do not (in which case details of implementation are shown to make a considerable difference). Both the literature review and subsequent analysis shows that there is considerable room for a more systematic and evidence based analysis of the role of different types of movement in Agent-Based Modelling.

Model mechanisms and behavioral attractors

H Van Dyke Parunak (Parallax Advanced Research, USA)

In social modeling, a computational environment runs a model that represents the world. The states the model explores (its behavioral attractor) are typically fewer than its description suggests. The mapping between model and attractor depends not only on its parameters (exploring variants of the world) and its conventions (imposed by the computing environment), but also its mechanisms (components of the model representing selected dimensions of the world). We illustrate the impact of different mechanisms on the attractor. In our case, in general, the more mechanisms one implements, the smaller the attractor ("the more you model, the less you see"), but with unexpected twists.

Conducting systematic reviews of agent-based models – Current practice and potential improvements

Sebastian Achter, Melania Borit, Clémentine Cottineau, Birgit Müller, Gary Polhill, Vikoriia Radchuk & Matthias Meyer (Hamburg University of Technology, Germany)

Although agent-based models (ABM) are increasingly used in ecology and related fields, it has been recently criticized that model after model is developed to analyze specific cases while often missing the opportunity to incorporate insights from previous models systematically. This study discusses whether and how systematic literature reviews (SLRs) of ABMs can contribute to cumulative science and theory development. For this, we (a) synthesis recommendations on how to conduct SLRs in ABM-based research, (b) carry out a meta-review on ABM reviews to take stock of current practices, (c) compare those practices to the recommendations, and (d) scrutinize SLRs potential for theory development in ABM-based research. We find a substantial number of reviews, which are more traditional than systematic. Our analysis shows that reviews can be improved with respect to formulating the research question and the sample selection process. Nevertheless, the greatest potential for fostering sustainable theoretical development in ABM-based research can be found in the analysis step of SLRs. We make several suggestions on how to improve the current practice concerning systematic reviews of ABMs.

(Room 12)

Chair: Bruce Edmonds (Manchester Metropolitan University, Manchester, UK)

Opinion polarization caused by misestimation of opinion distributions

Taisei Ninomiya, Fujio Toriumi & Hitoshi Yamamoto (The University of Tokyo, Japan)

With the development of social networking services in recent years, polarization of opinions has become a social issue. Polarization is one of the causes of the spread of fake news and flame wars online, and although countermeasures such as improving recommendation algorithms have been considered and implemented, they have not been sufficiently effective. Understanding the mechanisms of polarization will provide important clues for designing effective social systems. Existing models assume that agents send messages honestly and that receivers accept it and change their opinions. However, opinions do not change so easily in real social situations, and it has been confirmed that the spiral of silence can occur as a result of the desire to avoid social isolation. Therefore, Existing models based on changes in opinion do not fully explain the mechanism of polarization. This study aims to clarify whether polarization still occurs even where internal opinions do not change and, if so, what the drivers of the polarization are. We constructed a model of opinion expression that preserves internal opinions and analyzed the effect of conflict avoidance on opinion polarization. In this study, we propose a model that distinguishes between internal and expressed opinions, and states opinions based on others’ belief estimates. Each individual in the network has two parameters: an internal opinion and, and an estimated opinion based on the surroundings. In our model, agents express their opinions about incidents that occur at each time step, and learn parameters based only on the opinions expressed and social feedback from neighboring agents. We also assume that they will be silent when they expect conflict based on the estimated opinions of their surroundings. Even in cases where diverse internal opinions were maintained, mis-estimation of surrounding opinions caused a polarization of expressed opinions. We found that the cause was the existence of a positive feedback loop, where the bias of the expressed opinion due to conflict avoidance and the mis-estimation of the opinion mutually reinforced each other. When the network was localized, small opinion clusters were formed by local majorities, whilst large opinion clusters were formed when the network was dense. In addition, we found that the number of agents who were suppressed from speaking increased as the opinion clusters became larger. The results of this study explain the relationship between pluralistic ignorance, the spiral of silence phenomena, and polarization, which have not yet been addressed by existing models. Since this model can link the microscopic process of individual oppression with the macroscopic phenomenon of opinion polarization, it has the potential to contribute to the design of social systems that deter polarization and reduce individual dissonance.

Opinion polarization, influencers, & endogenous online social networks

Louis Dalpra (BETA, University of Strasbourg, Belgium)

In this paper, we model an online social network (OSN) such as Twitter or Facebook. Since the rise of the internet and OSN, we’ve witnessed various issues such as echo chambers and opinion polarization induced by these new forms of interactions. We propose to enrich the literature on both opinion formation and endogenous social network formation. In our model, three types of agents are considered: regular users, influencers, and the platform. while users are only seeking to interact, both the platform and the influencers are looking for monetary rewards. We use the basic Attraction-Repulsion model proposed by Axelrod (2021) and expand it by allowing influencers to seek new followers by publishing content and updating their behavior with reinforcement learning. The platform plays a role by highlighting the content it thinks will keep users on the platform longer. We believe this model will allow us to find interesting tipping points that would allow us to better understand the impact of both influencers and platforms on opinion polarization. Furthermore, this model has the potential to shed light on how scale-free networks exhibiting power-laws degree distributions are naturally forming beyond the classical preferential attachment explanation. Finally, we hope that the model will provide a prediction tool for the level of polarization of the population from the opinion distribution of

influencers.

Identity causes polarization: Advancing the Hegselmann-Krause model focusing on identity groups

František Kalvas, Ashwin Ramaswamy, Ashley Sanders-Jackson & Michael Slater (University of West Bohemia, Czechia)

Opinion polarization is the formation of antagonistic camps of opinions such that each camp has strong consensus within itself across many issues. There exist a number of environmental, social, emotional, and cognitive factors that are believed to play a role in the development of opinion polarization in a society. We apply Agent-Based Modeling to simulate some elements of this complex dynamic process by starting with a simplistic Hegselmann-Krause bounded confidence model of opinion dynamics (2002, hereinafter HK), and loosening some of HK's assumptions. We advanced the HK in the following ways: we added more opinion dimensions (Nedić, Tuori 2012), we randomly assigned agents their individual value of a boundary controlled by a common parameter of an average boundary, and we allowed agents to form identity groups based on proximity in the opinion space. We used the Louvain algorithm for community detection (Blondel et al. 2008) to implement identity. We turned agents in opinion space into a weighted full network of opinion distances where agents were nodes and opinion distances were weighted edges, then we dropped the edges representing distances less salient than common parameter (we called the parameter 'salience of distances in identity relevant opinions', hereinafter SDIRO), and finally, we applied the Louvain algorithm to detect identity groups. The higher value of SDIRO the even closer distances were dropped and not used for the Louvain algorithm, the lower SDIRO the even further distances were also used for the group detection. Identity groups served as an additional constraint. The agents must fulfill two criteria to be heard and to influence others: they must be inside the boundary of other agents and they must also be in the same identity group. We ran simulations 120 times for each combination of investigated parameters: number of opinion dimensions (1, 2, 4), average boundary (0.05–0.5), and SDIRO (0.05–0.85). We measured polarization in these simulations by the Equal-Sized Binary Grouping (ESBG) algorithm (Tang, Ghorbani, Squazzoni 2021) that we generalized for more than one opinion dimension. We performed stepwise regression on simulated results to identify predictors of polarization. We show that severe polarization can occur also in HK if agents are allowed to form identity groups, possibly simulating the role of social identity or echo chambers based on identity-relevant opinions. We also find that the strongest predictors of polarization are the SDIRO, and the average boundary. The relationship between average boundary, SDIRO and polarization in our model is non-linear: for certain combinations of SDIRO and boundary polarization only occurs at very low and very high levels but we do not see intermediate levels of polarization.

Influence and similarity in social networks. A study of the opinion dynamics among teenagers through an agent-based model

Dario Germani, Barbara Sonzogni & Federico Cecconi (CNR-IRCrES, Italy)

The main goal of this research was focused on study the dynamics of the opinion among teenagers by reconstructing the process of influence that take place during their interactions, raising further questions about the ways and reasons why individuals get in touch with others. The integration between Agent-Based Modelling and sociometry allowed the conceptualization of the phenomenon as a diffusion study, considered as the outcome of the imitative process triggered by any compliance motives especially in view of the sociological tradition. In particular, the concepts of personal influence and homophily can be traced back to a dual mechanism able of explaining it: (1) the behaviour of peers occupying a relevant position within relational groups (school classes); (2) the interaction favoured by specific elements linked to the similarity between individuals. The empirical data obtained from a web survey will be compared with the data from the simulation model in order to reproduce the above social phenomenon and to confirm the theoretical assumptions behind the model itself.

There are (almost) no chain reactions in T.C. Schelling's Checkerboard Model

Daniel Mayerhoffer (University of Bamberg, Germany)

T.C. Schelling's Checkerboard Model is one of the most famous Agent-Based Simulation Models. With

about 15000 citations of Schelling’s papers on the model alone, it is the standard reference for cascade effects and chain reactions that explain macro effects as the mutual influence of agents’ individual decisions. This article shows that chain reactions only marginally contribute to the final rate of segregation in the Checkerboard Model. Instead, the visually striking cluster structures at the end of a model run are already present in its initial situation as proto-clusters of initially content agents. Initially discontent agents attach themselves to proto-clusters of their kind and thereby cause high levels of segregation. Therefore, one should describe movement in the model as individuals’ adaption to the initial situation rather than the interaction between agents, which would involve chain reactions.

– **Track: “Norms, values & institutions” - Section II** –

(Room 13)

Chair: Christopher Frantz (Norwegian University of Science and Technology, Norway)

Gossip promotes cooperation only when it is pro-socially motivated

Martina Testori, Charlotte Hemelrijk & Bianca Beersma (Vrije Universiteit Amsterdam, The Netherlands)

Humans are often shown to cooperate with one another. Most of the mechanisms that foster cooperation among humans rely on reputation, which itself relies on the acquisition of information about other people’s behaviors. Gossip has been proposed as a cheap yet efficient tool to acquire information, and it has largely been proved to be an effective means to foster and maintain cooperation. However, empirical studies supporting this claim have ignored two aspects: (1) they often compared gossip to treatments in which no reputation was available, impeding a direct assessment of whether it is gossip that promotes cooperation or rather the introduction of a reputation system; and (2) they focused on pro-social gossip (e.g., gossip aimed at helping the receiver), neglecting the impact of other types of gossip. We show here that, in contrast with the widespread notion that gossip promotes cooperation, gossip mostly depletes cooperation compared to first-hand information. If lying is fruitful for individuals or if a group’s behavior is largely uncooperative, gossip leads to negative reputational information and decreased cooperation.

Social preferences in the public goods game – An agent-based simulation with EconSim

Christoph Bühren, Jan Haarde, Christian Hirschmann & Janis Kesten-Kühne (Clausthal University of Technology, Germany)

Using a reinforcement learning algorithm, we model an agent-based simulation of a public goods game with endogenous punishment institutions. We propose an outcome-based model of social preferences, which determines the agent’s utility, contribution, and voting behavior during the learning procedure. Comparing our simulation to experimental evidence, we find that the model can replicate human behavior and we can explain the underlying motives of human behavior. We argue that our approach can be generalized to more complex simulations of human behavior.

On the diffusion of Schwartz values

Marcin Czupryna, Katarzyna Growiec, Bogumił Kamiński & Paweł Oleksy (Cracow University of Economics, Poland)

In the literature, human values are defined as desirable, trans-situational goals serving as guiding principles in people’s lives. Schwartz introduced the concept of ten different human values. The values are acquired in the childhood in the process of socialization. The Schwartz values are considered in the literature, on one hand to be relatively stable in the adulthood but on the other hand may be transformed according to the situation, as part of interaction with the environment. We consider different mechanisms, that may provide the potential explanation how the Schwartz values evolve in the societies in the agent-based model. Using the empirical data from European Social Surveys, we found that the social integration mechanism provides the best fit to the real data. We could also observe the limited impact of the random fluctuations and only slight decrease of the propensity to adjust the individual Schwartz values due to social influence, when getting older.

Relation between the public and the private and evolution of food sharing

Elpida Tzafestas (University of Athens, Greece)

We are studying food sharing and the conditions of its evolution in sedentary, agricultural societies. We start from the conjecture that when food, and by extension any type of wealth, can be stored for public use in greater quantities than what can be stored for private use, then sharing evolves, otherwise it does not. We present a simulated environment where agents represent families that produce, consume and store food privately or in public stores. The relative capacities of the private and public stores are responsible for evolution or not of generalized sharing in the population. Although storage capacity is represented in the model as a technological parameter, it is not purely technological, but it is also the result of a social and cultural choice and it goes hand in hand with communal or individualist behavioral profiles and stances. We show that when the public sphere is given a culturally greater value than the private sphere and therefore public storage capacity is higher than private capacity, then sharing emerges. This is more pronounced in risky and unstable environments. Inversely, if private capacity rises to very high levels compared to the public one, sharing collapses. Similar results are obtained even when other processes are present, such as costly sharing and theft. Our conclusion is therefore that sharing can emerge in a sedentary population when storage is possible and it will be maintained as long as individuals can store only limited amounts of food or other wealth. We delineate the implications of our study for further research on sharing and inequality.

15.45-16.15 Coffee break

16.15-18.00 - Parallel Tracks

– Track: “ABM in Economics” - Section II –

(Room 11)

Chair: Silvia Leoni (University of Leicester, UK)

The equity premium puzzle: An application of an agent-based evolutionary model

Luca Gerotto, Paolo Pellizzari & Marco Tolotti (Ca' Foscari University of Venice, Italy)

We describe an agent-based model of a financial market with a stock and a bond. Agents compete in repeated rounds, decide whether to acquire costly information and can pick one of 16 strategies to allocate their investments, under evolutionary pressure driven by the comparison of the realized short-term revenues from trading. We show that, while informed traders survive in some cases, the equilibrium shares are strongly biased in favor of strategies that make little use of information and systematically overestimate the riskiness of the stock. As a consequence, the majority of the population ends up in buying less stock than would be otherwise expected or optimal in rational setups. This evolutionary dynamics offers a novel way to explain the equity premium puzzle first described by Mehra and Prescott, according to which it's hard to find reasons for the widespread lack of investment in risky assets. Evolution based on a straightforward comparison of revenues is a simple and cognitively appealing avenue to reach a population of traders using (over-)cautious strategies to curb the risk of long-term “financial extinction”. Simulations run in NetLogo also demonstrate that very little information may be used in noisy markets or when the cost of information is substantial.

Endogenous network cross markets

Fan Gao & Daniel Ladley (University of Leicester, UK)

This paper studies the formation process of an inter-dealer network in OTC markets. In our model, there are two trading groups with few dealers connecting between the two groups. Dealers provide liquidity to consumers and trade with their counterparties to rebalance the inventory risk in the inter-dealer transaction. Dealers find their optimal inventory and the optimal number of connections with

other dealers by machine learning. Dealers adjust their inventory capacity and change their trading relationship, finding new counterparties or breaking existing relationships. We find that an inter-dealer network with a core-peripheral structure that allows inventory risk to be shared among dealers arises endogenously. The result shows that the bid-ask spread in the inter-dealer transactions depends on whether a dealer trades with a core dealer or a peripheral dealer. There is a centrality premium—higher prices are demanded by core dealers. The effect of increasing demand from consumers is analyzed.

A micro-foundation framework of national accounts to study macroeconomic phenomena: Integrating the stock-flow consistent approach with agent-based modelling

Jack Birner, Marco Mazzoli, Eleonora Priori & Pietro Terna (University of Turin, Italy)

In the past, macroeconomic models have often neglected the accounting framework to focus mainly on the statics and the dynamics of an array of aggregate quantities. They can be either theoretical or empirical, and they are often used to observe trends emerging over time, to illustrate theoretical principles, to compare and test different theories, to study cause-effects relationships, to produce forecasts, and for many other purposes. Keeping the focus on the aggregate dimension of economic phenomena has made the accounting consistency a marginal aspect of economic theory until a few years ago. The outbreak of the 2007 Great Recession has called into question many of the theoretical underpinnings of economics; many scholars and commentators have launched a call for “rethinking economics” (for an example of an outstanding critique from within, see Rodrik, 2015). Most of these criticisms stress the need for more diversity within the discipline. That is considered a plus as diversity is expected to produce a more adequate self-portrait of the discipline (Mäki, 2018). In addition, different models should be considered as complementary rather than competitive because they serve different purposes (Grüne-Yanoff and Marchionni, 2018). In the wake of this call for more diversity, the stock-flow consistent (SFC) approach is gaining popularity. First developed in the mid-1970s with the pioneering work of Godley and Tobin, it has recently drawn the attention because of its success in predicting the Great Recession. That success can be attributed to the fact that it uses a general framework for the analysis of economic systems that integrates real markets with a flow-of-funds analysis (Nikiforos and Zezza, 2017). It relies on a rigorous accounting framework, which guarantees the integration of all the flows and stocks in an economy. In fact, there are four main accounting principles underlying this approach: i) the flow consistency; ii) the stock consistency; and iii) the stock-flow consistency. Together they imply iv) the quadruple entrance principle. As all these principles must hold at the same time, the SFC approach provides a framework that treats the real and the financial sectors of the economy in an integrated way. As a result, the accounting structure of these models can be summarized within two matrices, the balance-sheet matrix and the transactions-flow matrix. Our project proposes an agent-based model (ABM) that is consistent from the stock-flow point of view. The model aims at creating an “empty” skeleton where agents interact on i) the labor market; ii) the goods market (both consumption and investment goods); and iii) the financial market. The first objective of the model is to track all of these exchanges in a way that also takes into account the corresponding cash movements. The purpose is to preserve consistency from the national accounts point of view: i.e., for each agent that registers a financial out-flow, there must be an agent recording a financial in-flow: a zero-sum system. To put it in the SFC language, we want to construct a model in which the four accounting principles hold true. Once that this general framework has been realized, the model can be used to study a vast array of economic problems (such as business cycles, the rise of monopolistic systems, the role of financial speculation, and many others). The basic idea of combining the ABM techniques with the SFC approach is that of creating a macroeconomic framework with a rigorous micro-foundation, that is also stock-flow consistent. So, when agents interact on each of the markets, we trace their exchanges both in the transaction-flow matrix (which records the exchanges in the real sector) and in the balance-sheet matrix (which records the cash movements in the financial sector). The ABM approach considers the agent as its basic unit; so, our model tracks the activities of each agent in both matrices. This allows us to record the generated aggregate results without any “black holes” in the national accounts system. By importing this rigorous accounting approach into the ABM framework, we can focus on the complexity of economic systems without neglecting the consistency of the national accounts that is the vice of many economic models. The present work does not represent

the first attempt of integrating the two approaches to obtain an agent-based SFC model, where the aggregate behaviors of the system, with their corresponding stock and flow movements, emerge from the behavioral rules specified for each individual agent and from the matching between the agents, rather than from behavioral rules set for each sector as a whole. Nikiforos and Zezza (2017) provide a detailed review of this specific literature. Discussing the advantages of combining these approaches, they present the applications of this integrated approach and show their potentialities. Of special interest is Caiani et al. (2016), who advocate using this integrated approach as a foundation of a new macroeconomic framework that is not subject to the limits of classical DSGE models. They develop a fully decentralized AB-SFC model with several innovative features, claiming that its properties match many empirical regularities and is robust across different parameterizations. Our model fits into this frame but it is slightly different from that of Caiani et al in that we move from a theoretical and flexible “general purpose” model to study different economic problems that also go beyond policy analysis. In the basic version of the model, there is a unique product, that we refer to as a magic good, since both firms and banks produce it, and it is considered both as a consumption and an investment good. Then, we have three classes of agents: i) individuals, who could be either entrepreneurs or workers, ii) firms and iii) banks, which are both owned and managed by entrepreneurs. The interactions between the agents occur: On the labor market, where entrepreneurs employ the individuals as workers in their enterprises (i.e., firms or banks); On the consumption goods market, where firms supply a chosen quantity of a magic good according to their productivity, and individuals buy the magic good produced by firms according to their consumption functions; On the investment goods market, where firms buy the magic good produced by other firms according to their investment strategies; On the financial market, where firms and individuals can either borrow money from banks or deposit it in them. The model is designed for studying the emergence of mismatching phenomena, measuring their dimension, and to studying their effects on the system. We expect to observe three types of mismatches: i) between supply and demand on the consumption goods market; ii) between supply and demand on the investment goods market; and iii) between individuals’ savings and firms’ investments channeled through the financial market. This approach could be relevant in the social simulation field for the following reasons: the flexibility of the model allows for studying multiple economic problems by starting from the behavioral rules that we assign to the agents; yet, it does not lose sight of their effects on the economic system because it also takes into consideration national accounts and financial consistency.

Incorporating price expectations into agent-based representations of land developer decision models

Dawn Parker, Shahab Valaei Sharif, Paul Waddel & Ted Tskiakapoulis (University of Waterloo, Canada)

Price expectations impact decisions of housing and land market actors and the dynamics of price formation. While some agent-based models of land and housing markets (ABM/LHM) represent price expectations, systematic comparisons of different expectations algorithms have not been done. We incorporate and compare several price expectation strategies in the developer decision model. We modify an existing development pro-forma that includes primary factors influencing the development profitability, such as construction costs, expected market demand, and expected market supply and evaluate the impact of alternative price expectation mechanisms on development decisions. We present the results of a numerical sensitivity analysis of expected construction costs on Internal Rate of Return (IRR) in a test case. Our results may improve developer representations in ABM/LHM used for market and policy analysis. Moreover, the study results can shed light on possible solutions to the housing market affordability crisis by investigating the primary barriers to housing supply.

The added value of using the ODD Protocol for agent-based modelling in economics: Go for it!

Emiliano Alvarez & Volker Grimm (Universidad de la República, Uruguay)

Agent-based modeling (ABM) is a modeling tool that has increased its use in different sciences as well as in economics. Among other reasons, this is due to the extension of the complex systems paradigm

in different sciences and the increase in multidisciplinary work. This phenomenon manifests itself in the social sciences from the realization that social organizations are interactive systems of multiple agents, with feedback, reflexivity, and non-linear effects on the rest of the system. The way in which information is structured is conditional on the paradigms applied and the problem addressed. Since economies are assumed to be complex adaptive systems, theories and their representations must be consistent with this principle. Therefore, their modeling must allow for a faithful representation of the problem under analysis while being clear and allowing for analysis and subsequent replication. In this paper, we demonstrate how the ODD (Overview, Design concepts, and Details) Protocol fosters transparency and coherence for economic ABMs. To do so, three published ABMs from economics are taken, analyzing the structure and content of their descriptions, and rewritten according to ODD. It discusses in particular the added value of using ODD and how all this could help to overcome different obstacles to a wider use of Complex Systems and ODD in Economics identified in the preceding literature.

– **Track: “Social identity modelling”** –

(Room 12)

Chair: Nanda Wijermans (Stockholm University, Sweden)

Social identity shapes consensus formation in opinion dynamics models

Peter Steiglechner, Paul E. Smaldino, Deyshawn Moser, Achim Schlüter & Agostino Merico (Jacobs University, Germany)

First step towards a new understanding of radicalisation: Modeling identity fusion

Mijke van den Hurk, Mark Dechesne & Frank Dignum (Utrecht University, The Netherlands)

We want to understand in which circumstances identity fusion occurs. We propose a model in which individual needs and interactions between agents and their social environment come together. We argue the personal identity of an agent will fuse with a group when it has a high need for significance, there is a group providing a means to gain significance, the agent has a direct contact belonging to that group and the agent is accepted within the group. The model allows for multiple scenarios to occur. Agents with a need for significance not necessarily become fused and will find alternative ways to satisfy their need.

Emergence of group hierarchy

Guillaume Deffuant & Thibaut Roubin (Université Clermont Auvergne, France)

We consider an opinion dynamics model where, during random pair interactions, each agent modifies her opinions about both agents of the random pair and also about some other agents, chosen randomly. Moreover, each agent belongs to a single group and the opinions within the group are attracted to their average. In simulations starting from neutral opinions, we observe the emergence of a group hierarchy. We derive a moment approximation of the average opinions in groups about groups that explains this emergence.

HUM-e emo-socio-cognitive agent architecture for representing human decision-making in the presence of fear

Patrycja Antosz, Leron Shults, Ivan Puga-Gonzalez & Roger Normann (University of Groningen, The Netherlands)

This paper introduces HUM-e emotive-socio-cognitive decision-making architecture of human agents. The HUM-e is an extension of the HUMAT architecture representing socially influenced decision-making. The new architecture was designed to be used in contexts where fear and social identity play significant roles in attitude formation. Crucially, we propose that fear changes the goal of information exchange between interlocutors and influences the persuasiveness of information sources in face-to-face communication. The development of HUM-e was theoretically inspired by emotional contagion theory, identity fusion theory, and social identity theory.

Observations on modeling social identity: Suggestions to address the challenges of social identity

Norman Johnson (Referentia Systems Inc, USA)

In the last two decades, the modeling and simulation of social identity (SI) have significantly advanced and are building on and, in many cases, improving the over a half-century of validated SI experimental studies and theories. In this paper, observations on modeling and simulation of SI explore niches of additional opportunities, based upon multiple perspectives: the evolution of social organisms, non-competitive theories of evolution, emergent properties of collective problem solving, advances in non-social computational modeling, epidemiological simulations, and complexity science. Based on these observations, specific recommendations are provided for expanding SI modeling and simulation. The main recommendation is to develop a general model of SI based on the observation that all social organisms share common traits, such as the innate drive to form SI or how SI is triggered by individual states of uncertainty or stress, but also recognizing that complex species present more complex expressions of SI. Other recommendations are: SI models must accommodate that not all expressed SI traits have origins in or require higher fitness, all or many SI traits have triggers and maybe thresholds of expression that must be modeled, the inclusion of emergent group performance that may change SI behavior and strategies, and the development of a SI community model for research and realistic applications.

– Track: “Policy modelling & applications” –

(Room 13)

Chair: Bruce Edmonds (Manchester Metropolitan University, Manchester, UK)

Hand in (Latex) glove: A discussion of agent-based modelling and public health

Corinna Elsenbroich, Alison Heppenstall & Petra Meier (University of Glasgow, UK)

This paper discusses the developing relationship between ABM and public health, highlighting areas of potential strong integration and fruitful collaboration as well as potential hurdles for collaboration.

Governing change: A dynamical systems approach to understanding the stability of environmental governance

Nusrat Molla, John DeIono, Thilo Gross & Jonathan Herman (University of California, Davis, USA)

The ability to adapt to social and environmental change is an increasingly critical feature of environmental governance. Yet, an understanding of how specific features of governance systems influence how they respond to change is still limited. Here we focus on how system features like diversity, heterogeneity and connectedness impact stability, which indicates the system’s capacity to recover from perturbations. Through a framework that combines agent-based modeling with generalized dynamical systems modeling, we model the stability of thousands of governance structures consisting of groups of resource users and non-government organizations interacting strategically with the decision centers that mediate their access to a shared resource. Stabilizing factors include greater effort dedicated to venue shopping, and a greater fraction of non-government organizations in the system. Destabilizing factors include greater heterogeneity among actors, a greater diversity of decision centers, and greater interdependence between actors. The results suggest that while complexity tends to be destabilizing, there are mitigating factors that may help balance adaptivity and stability in complex governance. This study demonstrates the potential in applying the insights of complex systems theory to managing complex and highly uncertain human-natural systems in the face of social and environmental change.

Inside the bounds of ecological policy-making: human needs and political feasibility in the context of sustainable consumption

Michelle Alferts, Frederik Banning, Jessica Reale & Elias-Johannes Schmitt (Ruhr-Universität Bochum,

Germany)

Who exercises the power in European agri-food systems? A meta-study of the diversity of actors and network configurations

Tim Williams, Sibylle Bui, Costanza Conti, Niels Debonne, Christian Levers, Rebecca Swart & Peter Verburg (Vrije Universiteit Amsterdam, The Netherlands)

Farmers are frequently viewed as key decision-makers in models of agricultural systems, but in reality their behaviour is shaped by a wider network of agri-food system actors. Understanding the balance of power in these actor networks is therefore critical to realistically portray farmer decision-making in simulation models and thereby to identify pathways towards sustainable agri-food systems. Here, we conduct a meta-study of 71 case studies in European agri-food systems to synthesise the academic evidence on the diversity of actors and network configurations. We first characterise the reported power relations to generate actor networks for each case study and then create a typology of distinct and recurrent network configurations. Our study provides two major insights. First, we find a large diversity of actors and complexity in network configurations. This suggests that the predominant focus on farmers in policy and models is likely often misguided. Second, the typology demonstrates that farmer autonomy can be fostered within both conventional and alternative value chains, and with both top-down state support and bottom-up civil society mobilisation. This implies distinct entry points to foster agri-food transformation and therefore to explore in future simulation models.

Finding the sweet spot between efficacy and acceptance of COVID restrictions

Oscar de Vries, Wander Jager & Rineke Verbrugge (University of Groningen, The Netherlands)

Social distancing is a strategy to mitigate the spread of contagious disease, but it bears negative impacts on people's social wellbeing, resulting in non-compliance. This paper uses an integrated behavioural simulation model, called HUMAT, to identify a sweet spot that balances strictness of and obedience to social distancing rules.

18.00-18.30 - Virtual gathering event

(Room 11)

20.00-22.00 - Social dinner at Festa del Perdono's cloister

Thursday 15 September 2022

09.00-10.00 - Invited Talk

Beyond allocation: How institutional ensembles can harness internal and external complexity

Scott E. Page (University of Michigan, Ann Arbor, USA)

Chair: Nigel Gilbert (University of Surrey, UK)

Traditional mechanism design considers a single domain and focuses on the properties of an allocation, such as whether it satisfies Pareto efficiency. As an approach for considering institutions in isolation, it has proven powerful. Institutions, do not, however, operate in isolation. They function within ensembles and produce internal and external complexity. Internal complexity arises because political and economic mechanisms, by they democratic, market based, hierarchical, self-organized, or algorithms, not only make allocations, they also build social networks, shape beliefs, incentivize behaviors, coordinate categorizations, and facilitate cognitive specialization and depth. These non allocative dimensions create the dynamic contexts within which institutions operate. That context, generally taken to the exogenous, is in fact, emergent. External complexity arises through interdependencies – not mere externalities – of actions. As recent empirical work on attempts to achieve the UN’s Sustainability Development Goals has shown, successful efforts on one goal either hinder or enable success on others. A research agenda that leverages the flexibility of agent based models to include both internal and external complexity of our political, economic, and social systems has much to offer.

10.00-10.45 - Selected papers

Status, competition and incomplete network information in advice-seeking dynamic networks: An agent-based model

Francesco Renzini, Federico Bianchi & Flaminio Squazzoni (University of Milan, Italy)

In competitive organizational environments, advice seeking requires professionals to navigate a social space with imperfect network information following heterogeneous search heuristics. By using Stochastic Actor-Oriented Models (SAOM), previous research has tried to identify micro-level mechanisms behind advice-seeking network formation. However, these models assumed lack of status-driven tie selection, perfect network information and a sequential continuous-time Markov chain dynamic process of advice formation. Here, we have ‘agentized’ a previous SAOM model to relax these assumptions while fitting our simulated networks to Lazega’s classical advice network dataset used in previous research. Our results showed that the same empirical regularities found in previous research can also be reproduced by assuming status-driven heterogeneous advice-seeking heuristics for cognitively bounded professionals with only local network information. Our findings would testify to the advantage of agent-based models when examining multiple paths of network formation.

The power of social networks and social media’s filter bubble in shaping attitudes: An agent-based model

Cristina Chueca Del Cerro (University of Glasgow, UK)

Much of the recent debate in political sciences has been regarding the role of social media’s filtering algorithms in the emergence of polarisation as well as the existence or prevalence of the so-called echo chambers. Social simulation scholars have provided valuable insights into the subject through opinion dynamics models and agent-based modelling approaches. While these models continue to be relevant, attitude polarisation remains an unsolved puzzle, especially in the current media environment of social media platforms. This article proposes a social simulation approach to the topic of opinion dynamics from a political communication perspective to understand how social network configurations and the media environment contribute to the emergence of attitude polarisation. We built an agent-based model of attitude dynamics with a multilayer multiplex network of interacting agents in a hybrid

media environment of both, traditional media and social media platforms. We found that the initial social network setup conditions had a large impact in the emergence of attitude polarisation amongst agents. In particular, homophily-based networks were found to produce greater attitude polarisation and homophilous clustering (echo chambers) compared to random networks specially in the presence of social media filtering algorithms, selectively exposing agents to attitude-supportive information. Our results emphasise the importance of selective exposure by social media filtering algorithms in the process of attitude polarisation and echo chamber formation while evidencing the need for further exploration of the role of social networks in this context.

Chair: Nigel Gilbert (University of Surrey, UK)

10.45-11.15 - Coffee break

11.15-12.45 - Parallel Tracks

– Track: “Socio-ecological systems and social behaviour” - Section II –

(Room 11)

Chair: Patrycja Antosz (University of Groningen, The Netherlands)

Modeling innovations as a social-ecological phenomenon

Udita Sanga & Maja Schlüter (Stockholm Resilience Centre, Sweden)

While there have been several attempts to model innovation, most models are influenced by economic and behavioral theories of innovation that view innovation as a social process with limited inclusion of social-ecological dynamics. In this paper, we develop a stylized but empirically informed agent-based model, Ag-Innovation, to (i) expand the conceptualization of innovations as a complex adaptive process operating across scales within social-ecological systems (ii) explore and compare the effects of two alternative mechanisms of innovation development and diffusion (exogenous, linear and endogenous, non-linear) on emergent properties of food security and income inequality among farmers. We demonstrate how modelers can effectively diagnose and incorporate social-ecological action situations within their models, through the use of the SE-AS framework, We develop three insights from model results: 1) incorporation of social-ecological interactions in the conceptualization of innovation leads to a stronger relationship between food security and income inequality outcomes. 2) Endogenous mechanism leads to higher income inequality and food security than the exogenous mechanism 3) Effectiveness of endogenous and exogenous mechanisms on adoption rates depends on the type of innovation. Our result demonstrates that the interpretation of model outcomes changes with the inclusion of social-ecological interactions and dynamics and makes a strong argument supporting the inclusion of social-ecological interactions in models of social-ecological phenomena such as agricultural innovations.

The role of household adaptation and migration on flood resilience in Jakarta, Indonesia

Puck Merceij (Delft University of Technology, The Netherlands)

Due to the crucial role humans play in climate change, there is a need to include human interactions with the environment, their ability to learn, reorganize and adapt within climate change in risk analysis. The dynamics of adaptation behaviour is complex, differs among people and is influenced by local cultural, socio, economical, environment and political factors. While adaptation is most urgently needed places like Latin-America, Middle East, parts of Asia and Africa, the impacts of adaptation in these regions are least well understood due to scarcity of data and our limited ability to derive quantitative assessments from behavioral insight on adaptation. Starting from survey data on households' adaptation and historic floods maps in Jakarta, Indonesia, this study presents a spatial agent-based model to study the cumulative impacts of structural adaptation actions of citizens on societal flood

resilience under different flood risk and policy scenario. The objective of this study is to better understand the emergence of adaptation behaviour and its role in relation to socio-economic flood resilience. Individual agents can mitigate their flood risk via protective structural changes to their home or by re-locating. Agents' decision rules consider heterogeneous subjective risk perception and coping appraisal following the Protection Motivation theory extended to account for socio-personal factors, flood experience, social norms, climate change beliefs, trust in public protection. Results show that adaptive behaviour only happen in certain areas, as a lock-in situation within the very flood-prone and poor areas of Jakarta could occur. Under extreme climate change conditions, all agents are, however, forced to migrate.

Co-simulation of socio-technical energy systems: An interdisciplinary design process

Fabian Adelt, Matteo Barsanti, Sebastian Hoffmann, Debopama Sen Sarma, Jan Sören Schwarz, Ben Vermeulen, Tom Warendorf, Claudia Binder, Bert Droste-Franke, Sebastian Lehnhoff, Johanna Myrzik, Christian Rehtanz & Johannes Weyer (TU Dortmund University, Germany)

Modeling several components that are either a part of or externally connected to the energy system is primary in exploring the complex challenges in analyzing future transition pathways. In this context, co-simulation approaches facilitate integrated simulation scenarios by coupling simulation models developed in different programming languages, based on different modeling paradigms, and depicting various domains of the energy system (e.g., industry, households, or the electricity grid). However, co-simulation approaches exhibit a range of challenges and are thus under-exploited when investigating socio-technical transitions. A design and modeling process for an agent-based co-simulation framework, which aims to foster interdisciplinary collaboration considering multiple socio-technical elements of the energy system, is introduced in this paper. On the one hand, this includes an information model for simulation planning and collecting inputs and outputs of different models. On the other hand, a modularization approach defines simulation sub-scenarios to simplify modeling interdependencies. Additionally, we present two preliminary examples. We combine models from different disciplines to design integrated sub-scenarios dealing with individual challenges of the current energy transition, i.e., (i) the impact of households' energy-related behavior on power grid stability and (ii) the co-evolutionary supply and demand dynamics of energy storage technologies in the industrial sector.

Understanding the dynamics of nature experience and nature appreciation: An agent-based approach

Fernanda Reintgen Kamphuisen, Yannick Joye & Wander Jager (University of Groningen, The Netherlands)

Climate change increasingly endangers the health and well-being of people, ecosystems, and biodiversity. A major challenge is to address climate change as a complex problem and facilitate a societal transition towards sustainability. A growing line of research identifies the decrease in humans' nature experience and appreciation as a fundamental hurdle to achieve a sustainable transition. Nature experience describes situations in which an individual is engaged in contact (and interaction) with various types of natural environments. Nature appreciation is referred to as a generic psychological phenomenon incorporating positive attitudes towards, emotional affiliation with nature, as well as connectedness to nature. The amount of individuals' nature experience impacts their level of nature appreciation which in turn, relates to their tendency to seek nature experiences. These reinforcing mechanisms constitute a dynamic relationship that may either lead to a vicious cycle, where nature experience and appreciation decrease over time (i.e., extinction of experience) or to a virtuous cycle, where nature experience and appreciation increase over time. The present study advances the current understanding of the dynamics of nature experience and appreciation by investigating the underlying mechanisms over time and across interacting individuals. Interacting individuals influence each other via assimilative social influence, meaning that both adjust their attitudes in the direction of the other's attitudes. Within a social network, assimilative social influence operates via network links making connected individuals more similar. A stochastic agent-based model was developed simulating heterogeneous agents that are influenced by and influence their social and physical environment. The percentage of green spaces and the impact of assimilative social influence was evaluated via experi-

mentation with the model. Simulation results indicate that indeed, the dynamics of nature experience and appreciation give rise to either a vicious or a virtuous cycle. A tipping point was identified when green spaces covered a quarter of agents' physical environment, regardless of whether assimilative social influence was included or not. Sensitivity analyses reveal that the model is robust to the size of the social network, but highly sensitive to the effect of nature experience. Implications and limitations will be discussed.

A multilevel process perspective on resistance to change

Claudia Estevez-Mujica & César García-Díaz (Universidad de los Andes, Colombia)

A bottom-up multiagent model was built to explore how important facets of social interdependence might influence the micro-level behavior of the individuals that leads to a macro-level pattern of resistance to change. In particular, the model is aimed to explore under which conditions the (mis)alignment of the dispositions of individuals with respect to the change can lead to the success/failure of a cooperative change initiative (e.g., organizational, pro-environmental or citizen behavior changes). The model discloses an artificial system of agents with individual dispositions toward change. Agents are connected through two different kind of networked relationships, one formal (fixed) and one informal (dynamic), which shape the social interdependence setting. Agents use this social information along with their own mindset to dynamically update their dispositions toward change. Agents' dispositions at the micro-level are then aggregated to get a picture of the visible pattern of change at the macro-level.

– Track: “Opinion dynamics and polarisation” –

(Room 12)

Chair: Guillaume Deffuant (INRAE, France)

The strength of weak bots

Marijn Keijzer & Michael Mäs (Institute for Advanced Study in Toulouse, France)

There is substantial concern about the harmful potential of social bots in online social media in recent years. While fear exists for their ability to propagate falsehoods that harm public opinion formation and disrupt democratic decision making, empirical evidence is mixed. There appears to be a mismatch between macro-level patterns and micro-level behavior: alarmingly large numbers of bots seem to be able to quickly spread content through entire platforms, yet bots' ability to contact human users tends to be very limited. Social influence models can help us understand how information tied to beliefs disseminates through online social media. Here, we present a theoretical model that solves the puzzling mismatch of bot effectiveness in online social media through indirect influence. The model implies that bots with limited direct impact on humans may be more and not less effective in spreading their views in the social network, because their direct contacts keep exerting influence on users that the bot does not reach directly. Highly active and well-connected bots, in contrast, may have a strong impact on their direct contacts, but these contacts grow too dissimilar from their network neighbors to further spread the bot's content. To demonstrate the proposed strength-of-weak-bots effect, we included stubborn bot agents in Axelrod's seminal model of the dissemination of culture and conducted simulation experiments demonstrating when and why weak bots may be more successful. This bot agent is initialized like any other agent in the model, except for one unique trait on one feature. The dissemination of this trait in equilibrium, is taken as the effectiveness of the bot in persuading the whole network of their unique belief. The bot itself never changes its cultural profile. We vary the rate at which the bot is chosen as the sending agent in interaction, and the share of other agents that the bot is connected to, and find that both are negatively related to the relative effectiveness of the bot in equilibrium. A series of analyses show that the finding is robust, in particular when the model is tailored to the context of online social networks.

Networked models of social influence: Explaining left-right political landscapes in Europe through opinion dynamics and network structure

Daniel Reisinger, Michael Vogrin, Guilherme Wood, Thomas Schmickl & Georg Jäger (University of Graz, Austria)

Traditional models of social influence typically use assimilative or repulsive influence to study how consensus or polarization emerge. Given simple network structures, such as fully connected graphs, traditional models often fail to account for the multi-modal opinion distributions found in empirical data. In this study, we focus on more realistic social network structures in terms of clustering coefficient and average shortest path length and construct a model that allows both assimilative and repulsive influence to drive opinion changes in individuals. We find that non-trivial patterns emerge when the forces of assimilative and repulsive influence are kept at a specific ratio and the network structure is highly clustered. Comparisons with empirical left-right political opinion landscapes show that our model produces realistic results that share the multi-modal characteristics as observed in data collected by the European Social Survey program.

How the availability heuristics, confirmation bias and fear may drive societal polarisation: An opinion dynamics simulation of the case of COVID-19 vaccination

Teng Li & Wander Jager (Huazhong Agricultural University, China)

The stark contrast between different opinions suggests that the opinion dynamics about COVID-19 vaccination is a topic worth studying. Here we build a comprehensive agent-based model by integrating the fear emotion into the HUMAT framework to study how biased information processing and fears may impact the opinion polarisation and vaccination rate in the case of the COVID-19 pandemic. Four scenarios are designed and experimented with to investigate the effects of network hubs (opinion leaders), confirmation bias, availability heuristics, and the disease severity on COVID-vaccination opinion polarisation and the vaccination rate. The simulation results show that: 1) The vaccination rate goes high quickly when there are no competing hubs or cognitive biases. 2) The presence of hubs with opposite opinions and availability heuristics tend to promote opinion polarisation among people. 3) Confirmation bias leads to higher opinion polarisation and a higher vaccination rate through the mechanism of temporally cumulative advantage. 4) Greater fear of disease drives up the vaccination rate and accelerates people's uptake of COVID vaccines.

The biased-voter model: How persuasive a small group can be?

Christos Charalambous, Agnieszka Czaplicka, Raul Toral & Maxi San Miguel (IFISC, Spain)

We study the voter model dynamics in the presence of confidence and bias. We assume two types of voters. Unbiased voters whose confidence is indifferent to the state of the voter and biased voters whose confidence is biased towards a common fixed preferred state. We study the problem analytically on the complete graph using mean field theory and on an Erdos-Renyi random network topology using the pair approximation, where we assume that the network of interactions topology is independent of the type of voters. We find that for the case of a random initial setup, and for sufficiently large number of voters N , the time to consensus increases proportionally to $\log(N)$, with the fraction of biased voters and v the parameter quantifying the bias of the voters ($v = 0$ no bias). We verify our analytical results through numerical simulations. We study this model on a biased-dependent topology of the network of interactions and examine two distinct, global average-degree preserving strategies (model I and model II) to obtain such biased-dependent random topologies starting from the biased-independent random topology case as the initial setup. Keeping all other parameters constant, in model I, BU , the average number of links among biased (B) and unbiased (U) voters is varied at the expense of UU and BB , i.e. the average number of links among only unbiased and biased voters respectively. In model II, BU is kept constant, while BB is varied at the expense of UU . We find that if the agents follow the strategy described by model II, they can achieve a significant reduction in the time to reach consensus as well as an increment in the probability to reach consensus to the preferred state. Hence, persuasiveness of the biased group depends on how well its members are connected among each other, compared to how well the members of the unbiased group are connected among each other.

Modelling the emergence of opinion misperceptions in online interactions

Daniele Vilone & Eugenia Polizzi (CNR, Italy)

In this work we present a couple of models able to describe the emergence of opinion misperception in online interactions, and the role of cognitive and topological factors in driving such phenomenon. By means of numerical simulations, the models we propose show that topology is not enough to generate a sensitive effect, and that cognitive ingredients are required to get realistic results.

– **Track: “Agriculture, sustainability and food”** –

(Room 13)

Chair: Marco Cremonini (University of Milan, Italy)

Modelling the potential impact of cultured protein on the agricultural sector

Nick Roxburgh & Gary Polhill (The James Hutton Institute, Aberdeen, Scotland, UK)

In the near future, the global food system is likely to undergo significant transitions in order to achieve crucial sustainability goals and meet the nutritional and calorific needs of a growing population. In particular, the production of protein is undergoing a profound revolution, but the consequences are difficult to anticipate due to the complexity of interconnected systems and a myriad of actors and institutions. Agent-based models have attributes that make them ideally suited to the task of simulating potential transition dynamics in socio-technological systems. For the Protein 2.0 project, we have designed an agent-based model to explore plausible ways in which the Norwegian protein sector could be affected by the development of the cultured protein industry in the coming decades. The model consists of five main agent types: import-export firms, farmers, cultured protein firms, food retailers, and consumers. We develop a series of plausible storylines that can be run as model scenarios, each composed of a different set of assumptions around how core uncertainties might play out.

An agent-based model of UK farmers’ decision-making on adoption of agri-environment schemes

Chunhui Li, Meike Will, Nastasija Grujić, Jiaqi Ge, Birgit Müller, Arjan Gosal & Guy Ziv (University of Leeds, UK)

Agri-environment schemes (AES) are government-funded voluntary programs that incentivise farmers and land managers for environmental friendly farming practices. Understanding farmers’ decision-making process and its impact on AES adoption can aid policy makers in designing AES schemes that meet adoption goals and environmental targets. Farmers’ decision-making is complex and involves a range of social, behavioural, economic and ecological factors. In this paper, we present a spatially explicit agent-based model (ABM) – BESTMAP-ABM-UK that simulates farmers’ decision-making process, inclusive of farmers’ social, behavioural and economic factors, on adopting buffer strips, cover crops, grassland management and arable land conversion to grassland schemes in the UK. The model produces farmers’ AES adoption under varied AES scheme designs in term of the contract length, the offered payment level, the bureaucracy level and the required minimal area. We apply the Morris screening method to analyse the importance of the model parameters in a status quo scenario, in which current UK AES designs are used. The results show that farmers’ mean accepted payments for buffer strips and grassland management and farmers’ intrinsic openness to buffer strip have the most significant impact on the farm adoption rate.

How distance affects the service quality of agricultural outsourcing: A study integrating econometric, game theoretical and agent-based models

Hang Xiong & Peng Jiang (Huazhong Agricultural University, China)

Agricultural outsourcing is the practice of hiring outside suppliers to perform farming services. It is an effective way of increasing farming efficiency. Hiring agricultural machinery is the most widely used practice of agricultural outsourcing. This service is often provided by both nearby local suppliers (e.g., within a county) and distant nonlocal suppliers. It has been commonly observed that the quality of the service provided by distant suppliers is not as good as that of the nearby ones. How distance affects the quality of agricultural machinery services? Our study explores this question using three types of models. First, we use econometric models to test if the service quality of distant machinery suppliers is

significantly lower than that of nearby suppliers. This analysis informs us about the static relationship between the distance of service suppliers and the service quality in statistics. Then, we use a game theoretical model to represent the strategies of two major players, the consumers (i.e., farmers) and the suppliers, in situations of nearby and distant services. These strategies depict the basic behavioral rules that major players follow in the machinery service market. Finally, we use an agent-based model to simulate the interactions between farmers and suppliers in different distance. On top of the players in the game theoretical model, the agent-based model additionally includes middlemen as a type of agent to represent more complex interactions in the real world. Simulations using the agent-based model can explicitly represent dynamic behavioral mechanism underlying the influence of distance on the quality of agricultural machinery services and thus address the research question. Our analyses using the three types of models lead to several interesting conclusions and useful policy implications. This study shows that econometric, game theoretical and agent-based models can jointly contribute to the analysis on complex phenomena. It is a great example of integrate the three types of models.

Consumer behavior and product circulation simulation of emerging circular economy strategies: An agent-based model for sustainability and circularity assessment

Ryu Koide, Shinsuke Murakami, Haruhisa Yamamoto & Keisuke Nansai (National Institute for Environmental Studies, Japan)

New business models such as sharing and refurbishing consumer durables may significantly change consumer behaviors related to the acquisition, use, and discharge of products. Although such a shift to a circular economy is expected to reduce environmental impacts, we lack the tools to evaluate its consequences fully, considering the dynamic changes and heterogeneity of consumer behavior. We propose a novel agent-based simulation model of consumer behavior and product circulation that can be used for the ex-ante assessment of emerging circular economy strategies. The model consists of households, products, and circular supply chains as agents. The main processes of the model are: i) a survival model of product lifetime distinguishing failure and relative obsolescence; ii) passive and active search through word-of-mouth and advertisement; iii) three key decision-making processes in the circular economy, i.e., acquisition, repair, and discharge choices, based on the formulation of awareness and consideration sets, random utility theory, and social influence. The model can dynamically simulate the dissemination of a single or combination of seven circular economy strategies, such as leasing, renting, sharing, repairing, and refurbishing of products. It quantifies sustainability impacts, such as greenhouse gas emissions, and product circularity, such as product flows and stocks, by incorporating the methods of life cycle assessment and material flow analysis. The preliminary results of the simulation experiment demonstrated its usefulness for simulating the dissemination of the leasing of refurbished/upgraded appliances and the reuse, rental, and sharing of electronics over a 30-year period, showing the reduction in new manufacturing, waste generation, and greenhouse gas emissions.

How many refugees can a forest system hold? Deforestation and prevention in a Zambian refugee settlement

Brigitte Ruesink & Steven Gronau (Leibniz University Hannover, Germany)

Refugee numbers are notably high in Africa and integration instead of repatriation is an increasingly popular approach. It is thus essential to investigate long-term effects of refugees on the hosting area, to ensure a successful and sustainable integration. This paper focuses on environmental effects, more specifically, deforestation. As refugees usually arrive in large numbers, there is a high pressure on forest stocks in the host country. Refugee settlements need space and materials to build a living, and the day-to-day life of refugees requires firewood and charcoal. Literature on effects of refugees on their host environment is increasing. However, agent-based models, which enable a simulation of future effects, rarely focus on refugees' effects on their environment. This study is unique in utilizing an agent-based model to focus on refugees' effects on deforestation in their host area. In particular, the ABM aims (1) to predict how forest resources will develop without any refugees or intervention, (2) to analyze how the model expansion by a refugee settlement changes this development and (3) to predict how certain policy interventions change the sustainable use of forest resources in future. The analysis utilizes a 2018

dataset from a refugee hosting area in rural Zambia including 277 host households. Secondary data on forest characteristics, energy contents, etc., adds to the dataset. Preliminary results show the maximum sustainable yield of forest resources. The analysis enables the derivation of policy recommendations to build refugee settlements in a more sustainable way in future to counter deforestation and support integration.

12.45-14.00 - Lunch

14.00-15.45 - Parallel Tracks

– Track: “Experiments, networks and behaviour” –

(Room 11)

Chair: Federico Bianchi (University of Milan)

Exploring routine dynamics from the ‘bottom-up’: A mixed-method approach by combining agent-based modeling with laboratory experimental research

Dehua Gao, Jiangfeng Ni & Shuang Zhao (Shandong Technology and Business University, China)

Routines capture the typical ways in which organizations accomplish their tasks. It has been widespread consensus that routines are certain practices with internal structure, processes and dynamics that contribute to both stability and change in organizations. During the past decades, some scholars re-sorted to agent-based modeling (ABM), whilst others employed laboratory experiments, to explore routine dynamics from the ‘bottom-up’. In this paper, based on a brief overview of the literature, we described the potential and possible benefits to combine ABM with laboratory experiments in routines research. We then presented a theoretical framework for doing this, and shortly discussed both challenges and limitations of our work. We contribute to the current literature by bringing forward some theoretical and methodological foundations for an innovative mixed-method approach which would throw light on enriching people’s understanding of organizational routines.

Need for cognitive closure and the structure of social networks

Katarzyna Growiec, Beata Łopaciuk-Gonarczyk & Bogumił Kamiński (Warsaw School of Economics, Poland)

We investigate the relationship between agents’ social networks and their psychological characteristics. Psychological research indicates that social ties have heterogeneous nature. Following this insight, we model social network of an agent in three social circles from the closest to the most distant: support clique, sympathy group, and Dunbar circle. The objective of the paper is to understand how structure of the relationships in different social circles depends on agents’ psychological characteristics. Following the empirical evidence, we identify four such characteristics that influence the process of social network formation: (1) need for cognitive closure, (2) self-esteem, (3) agency and (4) communion. An important insight is that they affect the mechanisms of tie creation in each of the investigated social circle in a different way. We model the mechanisms describing the dynamics of social network formation conditional on agents’ psychological traits using agent-based model. The design and calibration of the model is guided by literature study and the results of a survey of a representative sample for Polish population. In this work we focus on the impact of agent’s need for cognitive closure on social network structure.

Social network dynamics and sustained grading discrimination

Dorottya Kisfalusi & Karoly Takacs (Linköping University, Sweden)

School grades are important determinants of educational attainment since they are taken into account at tracking and admission to the next educational level in many countries. Several empirical studies

find evidence for grading discrimination for different groups of students controlling for blind and unbiased test scores. Teacher assessments are often intentionally or unintentionally biased and influenced by other factors than students' competence. Certain groups of students might perform below their achievement level during the class because of feelings of stereotype threat or due to peer pressure arising from anti-achievement norms. Social network processes may amplify the negative effects of biased grading and peer pressure on achievement: selection into homophilous friendship groups and peer influence with regard to academic motivation and efforts might increase the gap in grades over time. These mechanisms are hard to disentangle in empirical studies, because they influence each other over time. Using agent-based simulation, we examine to what extent various sources of the gap between grades and competence can influence students' later academic achievement and educational attainment. We investigate how and to what extent network mechanisms such as homophilous friend selection and peer influence are able to amplify the negative effect of biased grading on students' academic achievement and attainment. We calibrate our agent-based model using data from a longitudinal social network study in Hungarian schools.

The friendship field – An agent-based model on dyadic friendship formation driven by social battery

Chrisja van de Kieft & Eva Timmer (Wageningen University & Research, The Netherlands)

Humans have an intrinsic need for friendship, especially in adolescence when entering a new social environment where they do not know anybody. The question as to how friendships form is frequently asked. In research, three important factors have been identified in the formation of friendship: extraversion, resemblance and social status. To our best knowledge, a missing aspect in current research on friendship formation is the concept of "social battery". The social battery comprehends an individuals' energy level to engage in social contact. When the social battery is exhausted, it can prevent an individual from social contact, and consequently from making new friends. The recharging and exhaustion of the social battery heavily depends on the person's extraversion level. In this paper, we develop an agent-based model "the Friendship Field" that simulates real-life dyadic friendship formation where the individuals' interactions are motivated by their social battery. With this model, we investigate emergent patterns regarding extraversion, resemblance and status. The model reproduces a pattern of the mere-exposure-effect, an existing theory on friendship formation. Moreover, it proposes a new factor for friendship formation in social sciences: the social battery.

Influence of social networks in private climate adaptation

Thorid Wagenblast, Tatiana Filatova, Brayton Noll, Lauren Grimley & Antonia Sebastian (Technische Universiteit Delft, The Netherlands)

Social influences play an important role in opinion formation and decision making of individuals. When it comes to private adaptation against climate change, households' willingness to take measures is significantly influenced by their perceptions and beliefs regarding the likelihood of events, worry, and effectiveness and costs of adaptation measures. Empirical evidence suggests that besides these individual factors, people look at their social network when making decisions regarding risks and adaptation. This is especially relevant in the era of 'new normal' driven by climate change, where own experience with unprecedented hazards or protective solutions could be limited. Hence, individual drivers of action are embedded in the social environment, where the interactions either facilitate or hinder dynamics of private adaptation uptake. Yet, the effects of social interactions and the structure of social networks are rarely considered in the design of climate adaptation policies. Here we show that the presence of social networks has an impact on how private adaptation diffuses and how effective various policy instruments could be promoting adaptation. Using an agent-based model we explore how households take flood adaptation measures with no interaction versus interacting within three different network structures. We employ unique micro-level survey data on socio-behavioral drivers of adaptation to floods, and combine it with the empirical flood maps from Houston (TX, USA). Depending on the nature of interactions among agents, opinions change over time, in turn influencing the adaptation uptake. Furthermore, we test generic information, regulatory, market-based, and structural policies. The results demonstrate whether and how social network structures impact the decision making of

households, and quantify an effect on the performance of policies in terms of damage reduction. These results can be seen as a starting point to further explore how social network structures influence the effectiveness of climate adaptation policies. Furthermore, the testing of how network characteristics can enhance positive effects or can be used in breaking negative feedbacks of public adaptation alone, like the 'safe development paradox', will be relevant for designing more efficient and effective policies.

– **Track: “Social and behavioral models for climate change mitigation and adaptation” - Section I** –

(Room 12)

Chair: Tatiana Filatova (Delft University of Technology, The Netherlands) & Leila Niamir (IIASA-International Institute for Applied Systems Analysis, Vienna)

Public acceptance of green mobility policies

Marie Lisa Kogler, Daniel Reisinger & Annina Thaller (University of Graz, Austria)

We present an agent-based model to simulate policy acceptance for push and pull policy measures. Push measures are generally perceived as restrictive and are often directed towards the reduction of private car use, e.g. fuel price increases and inner-city car bans. Pull measures relate to diverse incentives to facilitate climate-friendly travel choices, e.g. attractive offers for public transport such as interregional cost reductions and expansion of the public transport infrastructure. The model is informed by empirical data regarding agents' travel mode utilities and allows to evaluate agents' satisfaction and acceptance of diverse policy scenarios. Regional dependencies are tested for the case of Austria. The results show that the political acceptance of push measures increases when they are combined in packages of measures considering the expansion of public transport infrastructure. Furthermore, the general acceptance of green mobility measures is closely linked to the existing infrastructure of the individual districts.

Integrating households climate change adaptation in a complex evolving economy: the role of different behavioral assumptions

Alessandro Taberna, Tatiana Filatova & Brayton Noll (Delft University of Technology, The Netherlands)

Quantifying benefits of behavioral adaptation requires a better understanding of interactions between individual adaptation decisions and hazard dynamics in face of climate change. This paper combines an evolutionary economic agent-based model with rich socio-economic micro-data to study the implications of different behavioral assumptions regarding household protective behavior on damage reduction. We find that diffusion of adaptations among households is significantly overestimated when assuming a representative perfectly-rational individual pursues adaptation compared to behaviorally-rich bounded-rationality choices. Additionally, our results display that households with low adaptive capacity take fewer measures and take longer to recover when a flood occurs than those with medium or high adaptive capacity.

An agent-based model of environmental tax reform

Franziska Klein & Jeroen van den Bergh (Universitat Autònoma de Barcelona, Spain)

The climate crisis demands immediate and profound action. The level of decarbonisation needed to reach the goals of the Paris agreement will induce considerable shifts in our modes of consumption and production. A multitude of policies have been suggested to address excessive greenhouse gas emissions, but designing policies for an effective and just low-carbon transition requires models that enable us to understand transformations of complex social-ecological systems with humans as heterogeneous and social beings. This study develops an agent-based model to investigate impacts of a revenue-neutral environmental tax reform (ETR). The model takes an activity-based perspective, where households make allocation decisions starting from their given time availability, including the necessity for consumption time. Agents are heterogeneous beyond typical ETR models in three ways: (1) initial time endowment is limited by distinct amounts of binding unpaid work, (2) households depend on different levels of

subsistence polluting consumption, and (3) they have varying preferences for leisure and consumption. Household decisions are further characterised by habitual behaviour and imitation dynamics. On the production side the model differentiates between three representative sectors, producing goods varying in labour- and energy-intensity during production, and in time- and energy-requirements during consumption. Firms are satisficers, innovating when triggered by falling profits or changes in demand. While the model is built mainly for theoretical exploration, its focus is on rich Western economies with high per capita emissions. Parameters are estimated to fit the German context, building on survey data. We analyse the impacts of a carbon tax when tax revenues are recycled through: (1) income tax reductions, (2) a per capita climate dividend or (3) earmarking for green innovation. The carbon tax is implemented as a tax on energy use, thus abstracting from potential shifts to renewable energy. Policy outcomes are evaluated in terms of environmental improvement (*environmental dividend*), changes in purchasing power (*economic dividend*), and redistribution potential (*equity dividend*). The contribution of our study is three-fold. First, it offers a level of complexity that analytical models cannot provide, but which we argue is crucial for the understanding of any policy in complex systems. Second, using multiple dimensions of household heterogeneity improves our understanding of the sources of income inequality and how they relate to a carbon tax. Third, this heterogeneity further allows us to address the impact of carbon taxation on several horizontal (non-income-related), inequalities. These include the urban-rural divide in tax incidence (through subsistence consumption), as well as gender-related differences (through time availability and sectors of employment). While geographical disparities have come to the fore increasingly, gendered impacts of policies for climate change mitigation have not yet received much attention.

Investing in rural infrastructure and education to improve rural resilience under shifting climate in Senegal: an application of capabilities and aspirations theory using the MIDAS ABM

Andrew Bell, Alex de Sherbinin, Fabien Cottier & Nicolas Choquette-Levy (Wageningen University & Research, The Netherlands)

We present preliminary work examining the role of rural infrastructure and education investments in managing rural resilience under a changing climate in Senegal. Our conceptual model design follows from a workshop on key processes driving mobility in Senegal held with research and policy stakeholders, in which the dual role of local investments in rural areas in i) increasing local opportunities while ii) raising aspirations for possible choices elsewhere was highlighted as a key mechanism to consider in the coming decades of shifting climate. We apply an extension of the MIDAS ABM with a capabilities and aspirations-derived decision module, along with best available data for households, health, mobility, and climate in Senegal to inform two key questions. First, what programs of rural investment best build rural resilience to expected shifts in rainfall and temperature in the coming decades. Second, who benefits from these investments, and do they shift the profile of who leaves and who stays?

Simulating the leverage points for the upscaling of innovative organic agri-food systems

Alba Alonso-Adame & Siavash Farahbakhsh (ILVO, Belgium)

Sustainability transformations of agri-food systems have become a timely phenomenon. However, the conditions enabling such transformations are under-explored. Against this backdrop, this research investigates the mechanisms and enabling factors as leverage point for the diffusion of sustainable agricultural systems. Relying on the case of Community-Supported Agriculture (CSA) in Flanders, we developed an agent-based model (ABM) in a participatory way, highlighting the role of factors such as the effect of innovative consumption demand, farms' social network, and the degrees of which farms are willing to go below their target revenues in the uptake of innovative practices towards sustainability. In our preliminary results, we found that the combination of these parameters could play a significant role as a mechanism for the upscaling of innovative and organic agri-food systems.

– Track: “Human deliberation and decision-making” –

(Room 13)

Chair: Lois Vanh  e (Ume   universitet, Sweden)

Formalising agent reasoning – The Paso Doble of data and theory

Nanda Wijermans & Harko Verhagen (Stockholm University, Sweden)

One of the core assumptions made when building agent-based simulation models is how the agents decide or reason about the action to take next. The mode of reasoning is usually the same for all agents and over time within the simulation run. However, is this adequate? There exist several frameworks that describe multi-mode reasoning, however how do we know what we need? To engage with this core question, we reflect on this modelling process, by using CAFCA - one of these multi-mode frameworks - and reflect on the reasoning dimension in a social dilemma decision situation. More specifically, using existing qualitative inquiry on group dynamics in a common pool resource dilemma - not designed to elicit different types of reasoning - we introduce our hunt for reasoning hints and reflect on what insights/data we would need to make an informed decision about the reasoning(s) in our modelling and how to obtain this.

Utilizing the full potential of norms for the agent’s decision process

Christian Kammler, Frank Dignum & Nanda Wijermans (Ume   University, Sweden)

Norms are a crucial part in human behavior, and have seen a lot of attention within the social simulation community. Up until now however, their motivational aspects as well as their importance and full impact in planning and action selection have not been incorporated in existing agent architectures. This is exactly what we doing in this paper. We present an agent architecture capable of grasping the full potential. We use perspectives to reflect how different people engage with a norm. and how it effects their long-term goals, their planning, and course of action. Our architecture is capable of having very fast habitual-like behavior, as well as pulling in more complex deliberation if necessary.

From threatening pasts to hopeful futures, A review of agent-based models of anxiety

Arvid Horn  d & Lois Vanh  e (Ume   University, Sweden)

Despite being understated, anxiety is critical factor affecting all levels of society, directly impacting individual decisions and with well-identified ramifications on social play, social constructs, and collective outcomes, as well as being a significant direct social toll tied to yearly trillion-USD social cost. Through a systematic literature review of social simulation research featuring models of anxiety, this paper frames the state of the art on anxiety modelling, and identifies trends and patterns in bibliographic indicators, aspects of anxiety that are modelled, how they are modelled, and their purpose and integration within agent based models. Based on these findings, this paper proposes a way forward as to structure the field as to enable the social simulation community as a whole to cover this critical aspect.

A cognitive model of epistemic vigilance in situations of varying competence, consistency, and utility

Piotr Pawe   Laskowski, Ivan Puga-Gonzalez, F. Leron Shults and Konrad Talmont-Kaminski (NORCE Center for Modelling Social Systems, Kristiansand, Norway)

This paper outlines a computational, cognitive model representing how hu-mans may use epistemic vigilance to evaluate socially-provided information in a way that reacts flexibly to differences in the reliability of content versus source vigilance strategies. Furthermore, the model explores how the system reacts in situations where the utility of the information provided is either un-related to its accuracy or, even, is inversely proportional to it. We find that even a simple model is able to react flexibly to variation in these parameters, providing a basis for further exploration of the phenomenon.

Simulating bounded rationality in decision-making: An agent-based choice modelling of vehicle purchasing

Khoa Nguyen, Valentino Piana & Ren   Schumann (HES-SO Valais Wallis, Switzerland)

This paper investigates the possibility of simulating bounded rationality effects in an agent’s decision-making scheme by limiting its capability of perceiving information and utilising a decision-making

framework of Triandis’ Theory of Interpersonal Behaviour. Based on previous work on an agent-based platform, BedDeM, we propose how to capture the effects of sequential, emotional, habitual and multi-criteria decision-making. The Perception component in the agent is further extended to take into account confirmation bias and the bandwagon effect. We demonstrate the functionality of this model in the context of purchasing vehicles in Switzerland’s households.

15.45-16.15 - Coffee break

16.15-18.00 - Parallel Tracks

– Track: “Inverse generative social science” –

(Room 11)

Chair: Joshua M. Epstein ((NYU School of Global Public Health, USA)) & Tuong Manh Vu (University of Sheffield, UK)

Black-box Bayesian inference for agent-based models

Joel Dyer, Patrick Cannon, J. Doyne Farmer & Sebastian M. Schmon (Institute for New Economic Thinking, University of Oxford, UK)

Simulation models, in particular agent-based models, are gaining popularity in economics. The considerable flexibility they offer, as well as their capacity to reproduce a variety of empirically observed behaviors of complex systems, give them broad appeal, and the increasing availability of cheap computing power has made their use feasible. Yet a widespread adoption in real-world modelling and decision-making scenarios has been hindered by the difficulty of performing parameter estimation for such models. In general, simulation models lack a tractable likelihood function, which precludes a straightforward application of standard statistical inference techniques. A number of recent works (Grazzini et al., 2017; Platt, 2020; Platt, 2021) have sought to address this problem through the application of likelihood-free inference techniques, in which parameter estimates are determined by performing some form of comparison between the observed data and simulation output. However, these approaches are (a) founded on restrictive assumptions, and/or (b) typically require many hundreds of thousands of simulations. These qualities make them unsuitable for large-scale simulations in economics and can cast doubt on the validity of these inference methods in such scenarios. In this paper, we investigate the efficacy of two classes of simulation-efficient black-box approximate Bayesian inference methods that have recently drawn significant attention within the probabilistic machine learning community: neural posterior estimation and neural density ratio estimation. We present a number of benchmarking experiments in which we demonstrate that neural network based black-box methods provide state of the art parameter inference for economic simulation models, and crucially are compatible with generic multivariate time-series data. In addition, we suggest appropriate assessment criteria for use in future benchmarking of approximate Bayesian inference procedures for economic simulation models.

Learning Interpretable Logic for Agent-Based Models from Domain Independent Primitives

Rory Greig, Jordi Arranz & Chris Major (Improbable Defence, London, UK)

Genetic programming (GP) is a useful method which can be applied to Inverse Generative Social Science (IGSS) for learning non-trivial agent logic for agent-based models (ABMs). Previous attempts at using evolutionary algorithms to learn the structure of ABMs have focused on recombining primitives from the domain in question. This paper extends previous work on techniques which are able to evolve interpretable agent logic of an ABM from scratch using a highly flexible domain-specific language (DSL) which consists of domain independent primitives, such as basic mathematical operators. The flexibility of our method is demonstrated by learning symbolic models in two different domains: flocking and opinion dynamics, targeting data produced from reference models. We show that the evolved solutions

are behaviourally identical to the reference models, and generalise extremely well, which includes quantifying their robustness to noise. We also provide an in-depth analysis of the generated code and intermediate behaviours, highlighting the progression of the training process.

Evolutionary model discovery of human behavioral factors driving decision-making in irrigation experiments

Lux Miranda, Ozlem Ozmen Garibay & Jacopo Baggio (University of Central Florida, USA)

Small farms are thought to produce around a third of the global crop supply. Such farms are also likely to be increasingly vulnerable to changes in the spatial and temporal availability of water. In this context, it is key to assess the effect of the social mechanisms which promote resilience in small-scale irrigation systems and, more widely, in complex social-ecological dilemmas under changing conditions. Small-scale irrigation systems are characterized by upstream farmers having prevailing access to a canal's resources, yet all farmers along the canal must contribute to maintaining the irrigation infrastructure. To further assess the ensemble of social mechanisms promoting the resilience of irrigation systems, we build on previous work in which a stylized irrigation dilemma was simulated via a social lab experiment. Studies of the data produced from this experiment modeled participants' behavior with multiple, theoretically grounded agent-based models (ABMs). These models encode causal, human-interpretable hypotheses of decision making which generates the real-world behavior observed in the experiment. However, the accuracy of these models in fitting the experimental data is limited. Using Evolutionary Model Discovery, a recent algorithm for inverse generative social science (iGSS), we show the ability to automatically generate a wide variety of unique new ABMs which fit the experimental data more accurately and robustly than the original, manually-constructed ABMs. To do this, we algorithmically explore the space of possible behavioral rules for agents choosing how to contribute to the maintenance of the irrigation infrastructure. We find that, in contrast to the original models, our best-performing models typically have an additional element of stochasticity and favor factors such as other-regarding preferences and perceived relative income. Given that this change in just a small part of the original model has yielded such an advance, our results suggest that iGSS methods have great potential for continuing to derive more accurate models of complex social-ecological dilemmas.

Towards Eusociality Using an Inverse Agent Based Model

John Stevenson (Long Beach Institute, USA)

The emergence of eusocial species is both very rare in evolutionary history and results in remarkably successful species. By inverting an agent based model, agent rules are discovered that display behaviors characteristic of eusocial species as well as other behaviors that lead to unexpected population dynamics. By holding the agents' genome constant across the colony and allowing the agents' rules to evolve, the individual behaviors exhibit phenotypic plasticity in response to environmental cues. The phenotypically driven reduction of intrinsic growth rates and the emergence of non-reproducing phenotypes both demonstrate selection pressure at the colony-system level. The fitness of an evolved colony is shown to have a strong relationship to the computational capacity of the agents. Various other emergent behaviors, both eusocial and otherwise novel, are identified and discussed. A path forward to more capable eusocial populations and inter-colony evolution is outlined.

– Track: “Social and behavioral models for climate change mitigation and adaptation” - Section II –

(Room 12)

Chair: Tatiana Filatova (Delft University of Technology, The Netherlands) & Leila Niamir (IIASA-International Institute for Applied Systems Analysis, Vienna)

Role of households' climate change adaptation to coastal floods: The case of Shanghai

Jonas Lechner, Brayton Noll, Tatiana Filatova, Amineh Ghorbani, Alessandro Taberna & Jie Yin (Delft University of Technology, The Netherlands)

Climate change intensifies the frequency and severity of floods - the most devastating and costly

climate-induced hazard. Top-down adaptations by governments (such as dikes or beach nourishments) are important, yet insufficient in the face of worsening hazards. They reduce the probability of a hazard, but it is the local actions at the households' level that define the extent of damages and inequalities in its distributional impact on various societal groups. To design appropriate policy measures that enable effective household-level or private adaptation it is necessary to understand how and why people adapt. Quantifying the cumulative impacts of household behavioural changes related to climate adaptation on flood risk is crucial as it facilitates policymakers to prioritise the most effective adaptation strategies across municipal, provincial, and national levels. We present a spatially explicit agent-based model that uses a range of empirical data on both the hazard and the households' adaptation behaviour side. Specifically, we use geospatial inundation data under various climate change scenarios in Shanghai. Furthermore, besides grounding agents' behaviour in the Protection Motivation Theory, we use rich micro-level survey data from Shanghai to parameterise drivers of agents' adaptation behaviour. Our model is one of the first agent-based flood models that combines downscaled climate scenarios with unique behavioural micro data on adaptation to floods, and, to our knowledge, is the first of this sort to be applied in China. Our results show the cumulative impact of socio-behavioural factors motivating household adaptation on the flood risk in Shanghai, both in terms of aggregated prevented damage as well as distributional impacts of hazards under varying degrees of adaptation diffusion in the population. Quantifying the impacts of behavioural drivers provides a foundation for deriving policy recommendations for multi-actor cross-scale climate change adaptation strategies.

Human behavior and forestry – A comparison of agent-based models

Hanna Ekström, Nils Droste & Mark Brady (Lund University, Sweden)

Effectful climate change action requires understanding human behavior in complex socioecological systems. Forest management is a case where we see conflicting interests and where better understanding of behavioral responses to policies is needed. Using models for studying and planning forest management has a long history, but only recently the interest has been raised for diversifying models by including stakeholder behavior, values, and a broad range of forest management objectives. We provide a systematic comparison of agent-based models used for studying human behavior and forests, and reflect on the models' functionality, scope, and ease of use. The compared agent-based models vary in complexity considered, in utility and spatial scope as well as level of programming skills required from the user. The results are aimed as support for agent-based modelers studying behavioral responses to policies to determine which ABM is the best approach for a given purpose and how these could be integrated with other models.

COASTMOVE: A global agent-based model of adaptation and migration decisions in face of sea level rise

Lars Tierolf, Toon Haer, Jens de Bruijn, Wouter Botzen, Lena Reimann & Jeroen Aerts (Vrije Universiteit Amsterdam, The Netherlands)

Sea-level rise (SLR) and socioeconomic trends are increasing the population and assets exposed to extreme coastal flood events in the coming decades. People residing in communities experiencing this increase in coastal flood risk may choose to stay, to stay and adapt, or to migrate towards safer areas. However, these migration decisions are influenced by many socio-economic and environmental factors. For example, current assessments of SLR adaptation and migration do often not address risk perceptions of residents related to different environmental risks, such as flooding and erosion. These factors influence adaptation decisions, and thus exposure and vulnerability. In this study, we aim to improve the representation of the dynamics of adaptive behavior of coastal communities in flood risk assessment by including human behavior and its effect on adaptation decisions, in face of SLR. Therefore, we develop a global agent-based model grounded in subjective expected utility theory and simulate adaptation- and migration decisions of households facing coastal flood risk, coastal erosion, and saltwater intrusion. The model is empirically calibrated using survey data on risk perceptions and on people's willingness to implement adaptation measures or migrate. Then, we use Shared Socioeconomic Pathway (SSP) scenarios to estimate future changes (2020-2080) in demographic composition and sea level, and apply the model to simulate coastal adaptation and migration. The agent-based

model presented in this study functions as a platform for further development of 1) more realistic decision models and 2) global modelling approaches of both coastal adaptation and migration under projections of future development.

How beliefs on food and climate change impact the dietary adoption? An agent-based approach

Maël Franceschetti, Cédric Herpson & Jean-Daniel Kant (Sorbonne Université, CNRS, France)

This paper introduces G-Impact, an agent-based model that combines modelling of household consumption and belief diffusion. Household decisions integrate personal impacts (quality, cost), perceived consequences (climate change, human responsibility), and social norms. The evaluation of these different criteria relies on household beliefs, which can be exchanged during social interactions. These beliefs can be used to explain household decisions on a macro and micro scale, and thus to target information or incentive policies. The model is applied to dietary choice in France, among the omnivorous diet (INCA3), the flexitarian diet and the vegetarian diet. The costs and greenhouse gases emissions of the different diets are initialized from real data. The initial beliefs of households are derived from opinion surveys. In the control simulation, we observe a significant increase in the proportion of flexitarians, and a slight increase in the proportion of vegetarians. We also illustrate the need to properly inform households with the emergence of fake news.

Simulating collective risk management from experimental data

Omid Roozmand, Guillaume Deffuant, Giulia Andrichetto & Mario Paolucci (CNR Rome, Italy)

We propose a new analysis of the data from a large-scale experiment about managing collective risk (Szekely et al. 2021). We distinguish three behaviours (free riding, default cooperation, and fluctuating contribution) which were mixed in previous analyses. We show that free riding and default cooperation strongly determine the outcome of the game. Social norm features (personal normative belief, empirical expectation, normative expectation) are significant predictors of these behaviours but the decision models derived with or without these variables perform very similarly on the data. However, we also run two agent based models, one with agents not using normative features (reactive agents) the other with agents using them (normative agents). In the average result of numerous simulations, the normative agents tend to keep a significantly lower frequency of free-riding and a significantly higher frequency of default cooperation. This confirms the previous analyses concluding that the normative variables play a key role in the emergence of a norm.

– Track: “Frameworks, tools and applications” –

(Room 13)

Chair: Bogumił Kamiński (Warsaw School of Economics, Poland)

Online platform for Agent-based Building Blocks Architecture (ABBA)

Tatiana Filatova, Amineh Ghorbani, Igor Nikolic, Martijn Warnier & Liz Verbeek (Delft University of Technology, The Netherlands)

Agent-based models (ABMs) become increasingly popular across a range of applications. Consequently, more efficiency and transparency in the code development process, improvements in the algorithmic representation of human behavior and institutions, and their alignment with social science theories are desired. For more than a decade the ABM community has been contemplating the idea of reusing building blocks of code that are repeatedly employed across applications, like the ‘Mr Potatohead’ framework for land-use ABMs. A modular approach with the core code standardized and tested is less error-prone, allowing ABM developers to focus more on modeling and ontologies of context-dependent human decisions, and less on coding. Furthermore, while theories conceptualizing human behavior and social institutions is vast, most of them operate with vague theoretical constructs. Their operationalization in the code often remains a black box, depends on intuitive judgements of modelers. Instead of reproducing code for recurring decisions and theories, the community will benefit from learning based on experience and reusing code fragments that are tested across contexts. Grounding

in the principles of software engineering, we define key elements required to describe such a reusable building block for decisions and processes that ABMs’ developers routinely face. Software engineering suggests that reusable modules must have compatible underlying assumptions and model formalisms, and clear protocols for connecting blocks. Aligning different modules requires a clear ontology and a meta-model for each module that formally describes its semantics. ABM developers could benefit from semantic alignment checks (e.g. assertions) and tooling that allows visual composition of modules (like model driven architectures). In this talk we present a new initiative on standardizing agent-based building blocks (ABBA) to make the way we code human decisions and social institutions transparent, discussible with social scientists, reproducible and reusable. Besides proposing a minimum set of principles that reusable agent-based building blocks architecture could leverage from, we present an online platform with the first generation of reusable ABM blocks and discuss the steps forward.

A global synthetic population for simulation models

Marijn Ton, Michiel Ingels, Hans de Moel, Jens de Bruijn, Wouter Botzen & Jeroen Aerts (Vrije Universiteit Amsterdam, The Netherlands)

Currently, most agent-based models are applied to small spatial scales, such as the level of villages, towns and cities. One challenge in agent-based modelling is upscaling the models to larger spatial scales and ultimately to the global scale. A first and crucial step in the development of an agent-based model is the initialization of an agent population. To enhance upscaling of agent-based models, this paper creates a global agent population consisting of households and individuals with socio-demographic attributes that are statistically consistent at an administrative unit 1 level. The socio-demographic data, such as income levels, age and education levels, are obtained from two large databases of survey data for around 80 countries. For each country, we apply Iterative Proportional Updating to generate a synthetic population that takes into account the dependencies between household and individual characteristics. We find that our synthetic population greatly outperforms synthetic populations that are generated at a lower spatial scale (national scale) or generated with merely marginal distributions (not taking into account dependencies between characteristics).

Utilising the AgentsX.jl platform for ease of ABM development – A case study with the predator-prey model

Rajith Vidanaarachchi, Jason Thompson, Branislava Godic & Roderick McClure (The University of New England, Australia)

AgentsX.jl is a proposed extension to the Agents.jl package designed to enable the rapid development of Agent-Based Models for socio-technical systems. Its primary motivation is to make building ABMs in Julia language faster, easier, more transparent, and more robust than current packages available to computational social scientists. In this extended abstract, we describe the adaptation of the predator-prey model (featuring wolf, sheep and grass) in the AgentsX.jl framework.

A template for transfer of NetLogo models to high-performance computing environments for enhanced real-world decision-support

Jason Thompson, Haifeng Zhao, Sachith Seneviratne, Rohan Byrne, Rajith Vidanaarachchi & Roderick McClure (The University of Melbourne, Australia)

The sudden onset of the COVID-19 global health crisis and as-sociated economic and social fall-out has highlighted the im-portance of speed in modeling emergency scenarios so that ro-bust, reliable evidence can be placed in policy and decision-makers’ hands as swiftly as possible. For computational social scientists who are building complex policy models but who lack ready access to high-performance computing facilities, such time-pressure can hinder effective engagement with end-users. Popular and accessible agent-based modeling platforms in com-putational social science such as NetLogo can be fast to devel-op, but slow to run when exploring broad parameter spaces on individual workstations. However, while deployment on high-performance computing (HPC) clusters can achieve marked performance improvements, transferring models from workstations to HPC clusters can also be a technically challenging and time-consuming task for social scientists. In this paper we present a set of generic templates that can be used and adapted by NetLogo users who have access to HPC clusters

but require additional support for deploying their models on such infrastructure. We show how model run-time speed improvements of between 200x and 400x over desktop machines are possible using 1) a benchmark ‘wolf-sheep predation’ model in addition to 2) an example drawn from our own applied policy modeling work surrounding COVID-19 management settings for Government in Australia. We describe how a focus on improving model speed is a non-trivial concern for model developers and discuss its practical importance for improved policy and decision-making in the real world. We provide all associated documentation in a linked git repository.

An exploration on agent-based simulations and process mining

Emilio Sulis (University of Turin, Italy)

This paper investigates the interactions between agent-based modeling and process mining, which is an increasingly widespread applied discipline in the context of business process management. In particular, we propose three types of practical applications using NetLogo, as a free and open source reference tool for agent-based modeling and simulation, widely used for both educational and research purposes. First, we provide an example of process discovery from event logs for visualizing and explaining the basic Alpha Algorithm. Second, we analyse and execute a Petri net model imported from PNML file format. Third, we introduce an Extension for NetLogo to automatically import a XES files, the standard format for event logs.

18.00-18.30 - Virtual gathering event

(Room 11)

Friday 16 September 2022

09.00-10.00 - Invited Talk

(Room 11)

Models of human identity signaling

Paul Smaldino (University of California, Merced, CA, USA)

Chair: Harko Verhagen (Stockholm University, Sweden)

Identity signals inform receivers of a signaler's membership in a subset of individuals, and in doing so shape cooperation, conflict, and social learning. Understanding the use and consequences of identity signaling is therefore critical for a complete science of collective human behavior. And, as with all complex social systems, this understanding is aided by the use of formal mathematical and computational models. I will present some formal models of identity signaling, sorted into two categories. First, I will discuss models used to study how identity functions as a signal, with a focus on public-health-related behavior and disease transmission. Second, I will discuss models used to understand how identity signals operate strategically in different social environments, with a focus on covert, or encrypted, communication. I will end by discussing a recent effort to test some of the latter model's predictions empirically.

10.00-10.45 - ESSA awards and announcement of SSC2023

(Room 11)

Chair: Harko Verhagen (Stockholm University, Sweden)

Rosaria Conte Outstanding Award

Best PhD Dissertation

Best Student Paper

Best student Poster

Presentation of Social Simulation Conference 2023

10.45-11.15 - Coffee break

11.15-12.00 - Special “welcome back” talks

(Room 11)

Chair: Patrycja Antosz (University of Groningen, The Netherlands)

Rigour for agent-based modellers

Bruce Edmonds (Manchester Metropolitan University Business School, UK)

The trade-off between realism and experimental control in a spatial agent-based model

Thomas Feliciani, Jochem Tolsma, Andreas Flache & Michael Mäs (University College Dublin, Ireland)

12.00-13.00 - ESSA general assembly

(Room 11)

13.00-14.00 - Lunch (end of the conference)