**Discipline**: [Methods]

## 1. Language:

English

## 2. Title:

Simulation Modelling for Business Research

## 3. Lecturer:

Prof. Dr. Catherine Cleophas, CAU Kiel
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## 4. Date and Location:

Online, 6. bis 16. März – synchrone Termine am 6., 9., 13., und 16. März

## 5. Course Description

### 5.1 Abstract and Learning Objectives

Business research increasingly considers wicked problems and complex dynamic systems. Analytical models of such problems and systems quickly become untraceable and unsolvable. Given increasing computational power, simulation models provide an alternative tool. They can fuel studies tracing the long-term evolution of systems and comparing the outcomes of alternative scenarios. However, successfully applying simulation modelling for business research requires expertise on applicable simulation paradigms, approaches to model validation and the analysis of stochastic results. This course focuses particularly on understanding and applying paradigms of stochastic discrete-event and agent-based simulation but also covers the basics of system dynamics.

### 5.2 Content

Participants gain theoretical background knowledge in the following areas:

- system dynamic, discrete event-based and agent-based simulation paradigms
- analysis of stochastic simulation results
- the role of simulation validation and calibration
- challenges of computational efficiency

They also gain hands-on experience in applying these concepts to case scenarios in

- implementing event-based and agent-based simulation models in Python and Net Logo
- data analysis and visualization

5.3 Schedule (including start and end time

| Date | Sessions |
|---|---|
| **Asynchronous preparation** | Video lectures: Introduction to modelling, simulation paradigms, and stochastic simulation. |
| **March 6, online session:**<br>**9:00-12:00** | Participants introduce their own project topics.<br>Participants work jointly on exercises on abstract modelling in break-out-sessions and present their work. |
| **Asynchronous work** | Homework: Participants create models of aspects of their own project topics and prepare to present them on March 4.<br>Video lectures: Introduction to the simulation paradigms system dynamics, discrete-event-based and agent-based modelling. |
| **March 9, online session:**<br>**9:00-12:00** | Participants present and discuss models.<br>Online session to work on exercises with Netlogo. |
| **Asynchronous work** | Participants research existing Netlogo models that may be related to their own project and assess their usefulness.<br>Video lectures: Challenges of computational efficiency and result analysis. |
| **March 13:**<br>**9:00 – 12:00** | Participants present and discuss existing Netlogo models.<br>Online session introducing discrete-event-based modelling in Python. |
| **Asynchronous work** | Participants consider applicability of discrete-event-based paradigm to their own project and, if applicable, design a first model including events and resources.<br>Video lectures on simulation validation and calibration as well as on combining simulation and data analytics. |
| **March 16:**<br>**9:00 – 12:00** | Joint session to reflect on issues of validation and calibration with regard to participant's projects, reflect on findings and discuss frequently asked questions. |
| **Evaluation Task** | Working paper in WSC format describing a simulation model, applications, and challenges, ideally connected to the participants' PhD topic – due 6 weeks after the course. |

5.4 Course format

This course focuses on providing both a theoretical background in simulation modelling as well as first expertise in applying these concepts using relevant software packages. Each day will consist of lectures focusing on theoretical concepts followed by exercise sessions focusing on relevant problems. In a series of project sessions, participants will work alone or in teams to apply the knowledge gained to a project of their own choice. Accordingly, participants are encouraged to bring in their own application problems.

During project sessions, the participants can work on the respective projects in a self-organized fashion. Each project session offers the opportunity to discuss aspects and challenges of the project with the instructor.

Several sessions will be dedicated to first discussing the project topics, intermediate results, and finally the conclusion of the project.

The course is aimed at PhD-students from all disciplines of business and economics. By bringing together participants with different methodological backgrounds and problem domains, we will experience the whole spectrum of simulation modelling.

## 6. Preparation and Literature

6.1 Prerequisites

- Previous experience with Microsoft Office recommended.
- Standard university knowledge of statistical concepts.
- Programming experience is helpful, but not required

6.2 Essential Reading Material

- Robinson, S. (2005). Discrete-event simulation: from the pioneers to the present, what next? Journal of the Operational Research Society, 56(6), 619-629.
- Chan, W. K. V., Son, Y. J., & Macal, C. M. (2010, December). Agent-based simulation tutorial-simulation of emergent behavior and differences between agent-based simulation and discrete-event simulation. Proceedings of the 2010 Winter Simulation Conference (WSC), (pp. 135-150). IEEE.
- Sterman, J. (2018). System dynamics at sixty: the path forward. System Dynamics Review, 34(1-2), 5-47.
- Sargent, Robert G. Verification and validation of simulation models. Journal of Simulation 7, no. 1 (2013): 12-24.

6.3 Additional Reading Material

- Law, A. (2014) Simulation Modeling and Analysis. McGraw-Hill
- Railsback, S. F., & Grimm, V. (2019). Agent-based and individual-based modeling: a practical introduction. Princeton university press.

- Sterman, J. (2010). Business dynamics. Irwin/McGraw-Hill

6.4 To prepare

- Download and install software:
  - Netlogo: https://ccl.northwestern.edu/netlogo/
  - Python and SimPy: https://simpy.readthedocs.io/en/latest/simpy_intro/installation.html
- Think about your own research project and the role simulation may play.

## 7. Administration

7.1 Max. number of participants

The number of participants is limited to 20.

7.2 Assignments

Assignments are announced in the course

7.3 Exam

The final grade will be based on class participation (50%) and the students' presentations (50%).

7.4 Credits

The course corresponds to a scope of 6 LP/ECTS

## 8. Working Hours

| **Distribution of Working Hours** | |
|---|---|
| *General preparation for course* | 18 h |
| Active participation in online sessions | 12 h |
| Watching and understanding video lectures | 10 h |
| Independent work with modelling software | 40 h |
| Independent research for model conceptualisation | 40 h |
| Preparation of working paper | 60 h |
| **SUM** | **180 h** |