COMPLEXITY ECONOMICS AND AGENT-BASED MODELING

COURSE OUTLINE WINTER SEMESTER 2023/24

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CONTENT

Complexity economics is a new school of economic thought that offers a very different perspective on economics issues than conventional neoclassical economics. It is part of the ensemble of complexity sciences that developed since the 1950s and that is now an important approach in natural sciences such as modern physics, biology, and neuroscience, but also in social sciences such as sociology, urban science and planning. This module provides an introduction to complexity economics and explains why this approach is important to understand economic problems of the 21st century.

Agent-based modeling (ABM) is a modern computer simulation method that is very flexible and can be applied to analyze a large variety of problems in many disciplines. Since it is possible to model the interactions of large numbers of heterogeneous agents, ABM is an ideal method for complexity economics. Complexity is the result of such interactions of diverse agents. The module also provides a practical introduction to ABM enabling students to pursue their own research projects using this method, e.g. in their M.Sc. theses.

The module covers five broad topics:

1. Principles of complexity economics
2. Self-organization and cities
3. Emergence of institutions and money
4. ABM and programming with NetLogo
5. Application of complexity thinking to important policy problems

Self-organization and emergence are two key concepts of complexity. These concepts will be illustrated with specific examples concerning cities and institutions. A popular software to implement and simulate ABMs is NetLogo, which will be used in this module. Complexity economics does not only involve modeling methods such as ABM, but also a particular kind of thinking about the world. Practicing how to apply complexity thinking is hence another important element of the module.

LEARNING OUTCOMES

After successful completion of this module, students can

- explain what complexity economics is and how it differs from neoclassical economics;
- explain important complexity concepts, especially self-organization and emergence;
- explain why the complexity perspective is important and apply it to relevant problems;
- apply complex macroeconomic system dynamics models to policy questions;
- implement given models in NetLogo and analyze them;
- extend existing models and implement the extended models in NetLogo.

PREREQUISITES

Familiarity with the models taught in "Principles of Macroeconomics (Grundlagen der Makroökonomik)" in the B.Sc. program is necessary. Completion of Macroeconomics I and Macroeconomics II is helpful, but not required.

Students will need excellent English skills and the willingness to deal with computational models. Students should also be willing to work with models in a hands-on fashion.

ORGANIZATION

This module consists of lectures and tutorials. There are two accompanying **Moodle courses:**
- **Lecture**: "Complexity economics and agent-based modeling (WiSe23/24)"
  No password required.
- **Tutorial**: "Modelling social processes using agent-based models (R&E, Teil II; MAD, Teil I/II) (080351-WS 23/24)"
  Password: *2023abm*

Participants: 20 participants

If there are more than 20 participants in the first lecture, you must write short motivation letter of about one page to explain, why you want to take this module. The selection of participants will be based on the quality of this motivation letter.

Lectures/tutorials: The lectures introduce students to the topics of the module and provide important basic knowledge.

In the tutorial sessions, students apply the knowledge acquired in the lectures. You are expected to **bring your own laptops** and pre-install the software NetLogo to make this feasible. By hands-on work in the tutorials, you learn how to work with agent-based models and how to build them.

For educational purposes, NetLogo is free and can be downloaded here: https://ccl.northwestern.edu/netlogo/6.3.0/

Both the lectures and the tutorials are relevant for the final assessment!

Assessment: Credits and a grade will be given for a **term paper**. In this paper, you present your own extension of an agent-based model and the results of the model concerning a research question.

The term paper is due on **March 18th, 2024**.

More information about the term paper will be provided in the Moodle course.

In order to qualify for the term paper, students will need to submit and pass **five ungraded homework assignments** (Studienleistungen).

Time and place:	**Lecture**: Monday, 12:15 to 13:45 (GD 03/218)			
	Tutorial: Wednesday 10:15 to 11:45 (GD 2/208) and			
	Thursday 12:15 to 13:45 (GD 03/158)			
	(See schedule below for details)			

Start: **Lecture**: October 16th, 2023, 12:15 – 13:45
                                Tutorial: October 18th, 2023, 10:15 – 11:45

Flexnow Registration and De-Registration: 11th December 2023 - 5th January 2024

The only binding registration for the module can be made via **FlexNow in the registration period.**
If you miss registering, you cannot get credits and a grade for the module.

SELF-STUDY

This module contains 250 hours of self-study and applied homework. Without this amount of time spent on self-study, it is unlikely that you will pass the module.

COURSE TEXTBOOK

Relevant material will be provided on Moodle.

Some parts of the module will be based on the book

Roos, M. (2023). Principles of Complexity Economics – Concepts, Methods, and Applications. Springer (forthcoming).

Parts of the book will be provided on Moodle.

SCHEDULE

The following course schedule is preliminary. Any change will be announced on Moodle in due time.

Week	Date	Type	Lecturer	Topic
1	16.10.23	Lecture (L)	MR	Introduction: Complexity
	18.10.23	Tutorial (T)	MA, DS, KP	Practical information and NetLogo
2	23.10.23	L	MR	Introduction: Agent-based modeling
	25.10.23	T	MA	Examples of ABMs
	26.10.23	T	MA	NetLogo basics
3	30.10.23	L	MR	Complexity worldview and thinking

	02.11.23	T	MA	Motion of agents
4	06.11.23	L	MR	Complex adaptive systems and neoclassical economics
	08.11.23	T	MA	Exchange between agents
	09.11.23	T	MA	Networks
5	13.11.23	L	MR	Complexity concepts
	15.11.23	L	MR	Behavior and decisions
	16.11.23	T	MA	Decisions of agents
6	20.11.23	L	MR	Self-organizations: flocking and magnetism
	22.11.23	T	DS	Analysis of flocking and magnetism models
7	27.11.23	L	MR	Cities as complex systems and the Schelling model
	29.11.23	T	DS	Analysis and extension of the Schelling model
8	04.12.23	L	MR	Distribution and urban sprawl
	06.12.23	T	DS	Analysis of city models
9	11.12.23	L	MR	Self-organization, emergence and institutions
	13.12.23	T	KP	PD games
10	18.12.23	L	MR	Norms game and emergence of language
	20.12.23	T	KP	Extensions of PD games
11	08.01.24	L	MR	Emergence and use of money
	10.01.24	T	KP	Money model
12	15.01.24	L	MR	Macroeconomic models
	17.02.24	T	MA, DS, KP	Ideas for own projects
13	22.01.24	L	MR	Lessons from complexity thinking
	24.01.24	T	MA, DS, KP	Ideas for own projects
14	29.01.24	L	MR	Climate change
	31.01.24	T	MA, DS, KP	Questions
	01.02.24	T	MA, DS, KP	Questions