Complexity: Theory and Computational Models - Course Outline

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Please note that this is a very preliminary schedule that is still subject to change. Nothing of this reading is required to understand the lectures. If you do not have any prior knowledge about the subject, taking a look into the readings beforehand might help you to understand basic ideas more quickly. The main purpose of the readings, however, is to give those of you particularly interested in the topics the change to go deeper into the material. At the end of the course, we will also distribute a more extensive and commented list of further readings, which will include advanced material that is less useful for the preparation, but rather for follow-up study.

Nb.	**Date**	**Type**	**Content**	**Reading**
1	Sat, 9:00-10:30	Lecture	Introduction of the course outline, getting-to-know each other, and introduction to 'systemism' as the meta-theoretical framework.	Gräbner and Kapeller (2017), Gräbner (2017)
2	Sat, 11:00-12:30	Lecture	The relation between ontology, epistemology, and methodology, and its implications for complexity economics. Maybe start with networks.	Rosser Jr (2004), Arthur (2010)
3	Sat, 14:30-16:00	Lab 1	Introduction to Python: basic algebra, data types, functions	See Python readings below
4	Sun, 9:00-10:30	Lecture	The structure of complex systems: introduction to network theory	EK ch 1 and 2, vS: ch 2
5	Sun, 11:00-12:30	Lecture	Networks: statistical measures	vS: ch 6, Newman (2003) (selective)
6	Sun, 14:30-16:00	Lab 2	Networks in Python	The NetworkX documentation
7	Mon, 9:00-10:30	Lecture	Dynamical systems	MCE, chap. 11, Intro of Albin and Foley (1998)
8	Mon, 11:00-12:30	Lab 3	Simulating functions	See Python readings below
9	Tue, 9:00-10:30	Lecture	Dynamical system theory, Evol Game Theory and Replicator Dynamics	MCE, Chap 2,8
10	Tue, 11:00-12:30	Lab/Lecture	Agent-based models and OOP	MCE, Chap 9; Tesfatsion (2017)
11	Tue, 14:30-16:00	Lab 4	Intro to OOP and ABM	NA
12	Wed, 9:00-10:30	Lecture	Complexity and heavy-tailed distributions.	Clauset et al. (2009), Shalizi (2014)
13	Wed, 11:00-12:30	Lab 5	More ABM: games on graphs, discussion on building your own models	NA
14	Thu, 9:00-10:30	Lecture	Open lecture: build your model	NA
15	Thu, 11:00-12:30	Lecture	Wrapping up and future directions to explore.	NA

MCE: Elsner, W., Heinrich, T. & Schwardt, H., 2015. *The Microeconomics of Complex Economies: Evolutionary, Institutional, Neoclassical, and Complexity Perspectives*, Amsterdam et al.: Elsevier/Academic Press.

EK: Easley, D. & Kleinberg, J., 2010. *Networks, Crowds, and Markets*, Cambridge, UK et al.: Cambridge University Press. A free pre-print of the book is available on the web.

vS: van Steen, M., 2010. *Graph Theory and Complex Networks*, Amsterdam: Maarten van Steen. Available online.

The lab sessions will cover topics in the programming language Python and its use for research in complexity economics. While we try to make the lectures as interactive as possible, the labs really focus on group work and collective programming.

Readings for Python

As for most programming languages, textbooks for Python are rare. In fact, we found that most of the online tutorials do a better job, because they are more frequently updated than books. Also, learning a programming language is much learning-by-doing: you try to solve a problem, you look up the pieces you do not know about in an online tutorial or on Stack Overflow (which is *the* place to find answers).

There are, nevertheless, some resources that you might want to have a look at, particularly if you have not prior programming experience: First, John Stachurski offers a nice intro to Python in his Lectures in Quantitative Economics.[1]

Second, the official documentation is really good. You might check out the tutorial, or the FAQ on the main page.

Finally, Jeffrey Elkner, Allen B. Downey, and Chris Meyers wrote the book How to Think Like a Computer Scientist It is free and the introduction might be interesting for people without any background in programming. But keep in mind the book is written for Python 2.X and we will be using Python 3.X in the course!

For those of you who have experience in other programming languages, there are specialized tutorials on the web, such as 'Python for C programmers', which might be worth a look before the course. Make sure to check out the page on moving to Python from other languages page on the official documentary.

References

P. S. Albin and D. K. Foley. *Barriers and bounds to rationality.* Princeton University Press, Princeton, NJ, 1998.

W. B. Arthur. Complexity, the Santa Fe Approach, and Non-Equilibrium Economics. *History of Economic Ideas*, 18(2):149–166, 2010.

A. Clauset, C. R. Shalizi, and M. E. J. Newman. Power-Law Distributions in Empirical Data. *SIAM Review*, 51(4):661–703, 2009.

D. Easley and J. Kleinberg. *Networks, Crowds, and Markets.* Cambridge University Press, Cambridge, UK et al., 2010.

W. Elsner, T. Heinrich, and H. Schwardt. *The Microeconomics of Complex Economies: Evolutionary, Institutional, Neoclassical, and Complexity Perspectives.* Elsevier/Academic Press, Amsterdam et al., 2015.

[1] The whole course is very mainstream and focused on rational expectations economics. While it is not very critical, it is a good course if you want to learn the techniques as such.

C. Gräbner. The Complementary Relationship Between Institutional and Complexity Economics: The Example of Deep Mechanismic Explanations. *Journal of Economic Issues*, 51(2):392–400, May 2017.

C. Gräbner and J. Kapeller. The micro-macro link in heterodox economics. In T.-H. Jo, L. Chester, and C. DIppoliti, editors, *The Routledge Handbook of Heterodox Economics*, pages 145–159. Routledge, London and New York, 2017.

M. E. J. Newman. The Structure and Function of Complex Networks. *SIAM Review*, 45(2):167–256, Jan. 2003.

J. B. Rosser Jr. Epistemological Implications of Economic Complexity. *Annals of the Japan Association for Philosophy of Science*, 13(1):45–57, 2004.

C. R. Shalizi. Power law distributions, 1/f noise, long-memory time series. 2014. Working Paper, available online: http://bactra.org/notebooks/power-laws.html.

L. Tesfatsion. Modeling Economic Systems as Locally-Constructive Sequential Games . *Economics Working Papers*, 2017.

M. van Steen. *Graph Theory and Complex Networks*. Maarten van Steen, Amsterdam, 2010.