



Federal University of Parana
UFPR



Graduate Program on
Economic Development - PPGDE

Economics and Complexity

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1 Introduction

Economics and Complexity is an introductory course for researchers and graduated students of economy who wish to comprehend the complex approach applied in economics and learn how to build agent based models. The course aims to introduce ontological concepts and definitions, set out examples of what is a complex system and how these systems work and evolve in time. In a more pragmatic way the course aims to introduce two specific tools used to build up economic agent based models: the Laboratory of Simulation and Development (LSD) and Netlogo. Some economic and social models will be built by using computational resources intensively. Massive attention will be spent in theoretical questions in economics and programming methods and activities applied in developing agent-based models (ABM).

2 Course Length

The course accounts for 60 hours distributed in fifteen meetings lasting 4 hours each one.

3 Program

What is complexity. What is evolution. Interactions, creativity, variety, mutations, selections, chaos and order, and emergence concepts. Agent-based models. Evolutionary theory of firm. Evolutionary approach of consumer's behavior. Tools: Laboratory of Simulation and Development (LSD) and NetLogo. Some micro-macro economic models with LSD. An wide research agenda in economics.

Class A1 - Introduction and overview on General Theory of Complexity

The aim of the first class is to introduce the general theory of complexity as a whole and bring out a diversified literature. This includes some philosophical and ontological concepts and different mathematical and computational methods used to access the complexity of world in many dimensions. The maths approach includes: graphs theory, dynamic systems based on non linear differential equations; random networks, cellular automata and self-organized systems, and evolutionary theory. The computational softwares and methods behind this softwares include: Laboratory of Simulation and Development-LSD (which will be thoroughly used in this course), NetLogo, Swarm, Maple or MatLab, NetworkX, Graphviz and others. This first class is only an overview about many different approaches and methods used to access the complexity and has no intention to deep each topic.

- Background and history → [Mitchell \(2009, Cap. 1 to 7\)](#), [Érdi \(2008, cap 1,2,7,9\)](#)
- Complex Adaptive Systems → [Miller and Page \(2007, Cap. 1 to 6*\)](#)
- Dynamic Complex Systems → [Bar-Yam \(1997, Cap. 0 and 1\)](#)
- Emergence: from chaos to order → [Holland \(1998*\)](#)
- Generative Societies → [Epstein \(1996, 2006*\)](#)
- Mathematical Approaches → [Gros \(2008\)](#), [Boccaro \(2004*\)](#)

(*) - Material não disponível eletronicamente no momento.

Class A2 - Complexity and Evolution in Economics Science

The aim of the second class is to bring up an overview about how the economic science has used the complex theory to address a diversified bunch of social and economic problems going beyond the general equilibrium analysis.

- Complexity and the Economy → [Beinhocker \(2006\)](#), [Arthur et al. \(1997\)](#); [Arthur \(1999, 2005, 2013\)](#), [Tefatsion and Judd \(2006\)](#); [Durlauf \(1997\)](#); [Gintis \(2006\)](#)
- Evolutionary foundations of economics → [Dopfer \(2004\)](#), [Tefatsion and Judd \(2006\)](#)
- Self-organization → [Witt \(1997\)](#); [Foster \(1997\)](#), [Tefatsion and Judd \(2006\)](#)
- On the methodology of ABM → [Ormerod \(2004\)](#), [Tefatsion and Judd \(2006\)](#)
- Agent-based models in economics → [Axelrod \(1997\)](#), [Duffy \(2006\)](#), [Chen and Wang \(2011\)](#)

Class A3 to A5 - Simulations using NetLogo

These two classes contemplates the structure of the software, language and programming techniques with NetLogo and some social and economics models implemented in the literature. Its are practical classes using personal computer. Practical exercises will be implemented by the students as home works.

- Netlog's Language and programming techniques
- Model 1 [Tutorial programs](#)
- Model 2 [El Farol](#)
- Model 3 [Wealth Distribution](#)

Class A6 to A8 - Simulations using Laboratory for Simulation and Development - LSD

These three classes teaches how to use the software LSD, developed by Marco Valente, to build micro-macro models with heterogeneous agent interacting. Its are practical classes using personal computer including: how to install LSD, concepts and structure of the software, programming language and functions, implementation of simple examples. Practical exercises will be implemented by the students as home works.

- Thesis LSD → [Valente \(2000\)](#);
- LSD introduction → [Valente \(2008a\)](#);
- LSD documentation;
- Models: Random Walk, Logistic function and chaos, Supply and Demand

Class A9 - ABM(LSD) - Competing Technologies, Increasing Returns, and Lock-In - Brian Arthur

This class presents one of the famous agent-based model where interactions between agents where the aggregated pattern that emerge is different than the simple aggregation mechanism. The model is useful to study how interactions between consumers can produce other results than that embodied in constant scale returns.

Arthur (1989).

Class A10 - ABM(LSD) - Nelson & Winter adapted model

This class presents in details the model built by Nelson & Winter where firms adapt their strategy (innovate or immitate) acording its own performance and the enviroment state. The model will be handled and modified to study other dynamics properties no present in the original paper.

Nelson and Winter (1982); Andersen (2004)

Class A11 - ABM(LSD) - Financial Regime, Innovation and Business Cycle

This class presents different economic models implemented in LSD. After a brief discussion about the theoretic properties of the models, some changing in specific parts of the model will be implemented as exercises.

Higachi et al. (2013)

Class A12 - ABM(LSD) - Structural Change, Growth and Distribution

This class presents different economic models implemented in LSD. After a brief discussion about the theoretic properties of the models, some changing specific parts of the model will be implemented as exercises.

Structural Change, Growth and Distr → Ciarli et al. (2008); Ciarli and Lorentz (2010)

Class A13 - Consumption Theory with Agent-based models 1

A model of consumer behavior using Netlogo.

Fernandes et al. (2013)

Class A14 - Consumption Theory with Agent-based models 2

This class addresses the consumption decision and its interaction with supply side of an economy and inquire its role and consequences in economic growth and personal distribution, using a micro-macro model developed in LSD.

Ciarli et al. (2010a,b); Ciarli and Lorentz (2010)

Class A15 - ABM(LSD) NK and Pseudo-NK models

The NK model is a mathematical model described by its primary inventor Stuart Kauffman as a "tunably rugged" fitness landscape. "Tunable ruggedness" captures the intuition that both the overall size of the landscape and the number of its local "hills and valleys" can be adjusted via changes to its two parameters, N and K. The NK model has found application in a wide variety of fields, including the theoretical study of evolutionary biology, immunology, optimisation and complex systems. The model was also adopted in organizational theory, where it is used to describe the way an agent may search a landscape by manipulating various characteristics of itself. For example, an agent can be an organization, the hills and valleys represent profit (or changes thereof), and movement on the landscape necessitates organizational decisions (such as adding product lines or altering the organizational structure), which tend to interact with each other and affect profit in a complex fashion.

Kauffman and Levin (1987); Kauffman and Weinberger (1989); Valente (2008b); ?

4 Assessment Methods

The appraisal process and final note will be conquered by many partial deliveries and its respective points according to table 1. There will be two short survey in the initial classes, two programming exercise, one test and one draft article at the end of the course.

The subject of draft article will be suggested by professor and must be delivered on 99/99/9999 in electronic form. All the surveys and the drafts article must be written using an Latex editor. Each delivery must contain three files attached: TEX, PDF, BIB and sand off to joaobasilio@ufpr.br until 12:00 on date according to table 1.

Table 1: Deliveries and points

Class	Delivery	Points	Date
A1	Survey paper about Complexity	1.0	04/03
A2	Survey paper about Complexity in Economics	1.0	11/03
A3 to A5	Programming exercises with NetLogo	1.0	??/??
A6 to A8	Programming exercises with LSD	1.0	??/??
A9 to A15	Test about the models and complex theory	2.0	??/??
*	Draft article	4.0	??/??
Total		10.0	

Journals and further readings

Journal of Evolutionary Economics	Structural Changes and Dynamics Economic
Complex Adaptive Systems Modeling	Complexity (since 1995)
Journal of Economic Behavior and Organization	Metroeconomica
Evolution	...

Some Institutes

Center of Studies of Complex Systems	http://www.lsa.umich.edu/cscs
New England Complex Systems Institute	http://www.necsi.edu/
The Observatory of Economic Complexity	http://atlas.media.mit.edu/
LSE Complexity Group	http://www.lse.ac.uk/researchAndExpertise/units/complexity/home.aspx
Santa Fe Institute	http://www.santafe.edu

References

- Andersen, E. S. (2004). *Revisiting Nelson-Winter models in Lsd*. DRUID/IKE, Aalborg University, Denmark. Memo, Downloaded Jan 20, 2014.
- Arthur, W. B. (1989). Competing technologies, increasing returns, and lock-in by historical events. *The Economic Journal*, 99(394):116–131.
- Arthur, W. B. (1999). Complexity and the economy. *Science*, 284(5411):107–109. 2 april 1999.
- Arthur, W. B. (2005). Out-of-equilibrium economics and agent-based modeling. In Judd, K. and Tesfatsion, I., editors, *Handbook of Computational Economics, Vol. 2:Agent-Based Computational Economics*. Elsevier/North-Holland.
- Arthur, W. B. (2013). Complexity and the economy: a different framework for economic thought. *SFI Working Paper: 2013-04-012*, 2013-04-012.
- Arthur, W. B., Durlauf, S. N., and Lane, D. A. (1997). Introduction. In Arthur, W. B., Durlauf, S. N., and Lane, D. A., editors, *The Economy as an Evolving Complex System II*, Massachusetts. Addison Wesley.
- Axelrod, R. (1997). *The complexity of cooperation: Agent-based models of competition and collaboration*. Princeton University Press, Princeton-NJ.
- Bar-Yam, Y. (1997). *Dynamics of Complex Systems*. Addison Wesley Longman, Inc., EUA.
- Beinhocker, E. D. (2006). *The Origins of Wealth: Evolution, Complexity and Radical Remaking of Economics*. Harvard Business School Press, EUA.
- Boccaro, N. (2004). *Modeling Complex Systems*. Springer Verlag New York Inc, USA.
- Chen, S.-H. and Wang, S. G. (2011). Emergent complexity in agent-based computational economics. *Journal of Economic Surveys*, 25(3):527–546.
- Ciarli, T. and Lorentz, A. (2010). Product variety and changes in consumption patterns: The effects of structural change on growth. *13th Conference of the International Schumpeter Society, Alborg University*.
- Ciarli, T., Lorentz, A., Savona, M., and M., V. (2008). Structural change of production and consumption: A micro-macro approach of economic growth and income distribution. *LEM Working Paper Series*, 61(1).

- Ciarli, T., Lorentz, A., Savona, M., and M., V. (2010a). The effect of consumption and production structure on growth and distribution: A micro to macro model. *Metroeconomica*, 61(1):180–218.
- Ciarli, T., Lorentz, A. S., and M., V. (2010b). Structural transformations in production and consumption, long run growth and income disparities. *SPRU Electronic Working Paper*, 182.
- Dopfer, K. (2004). Evolutionary foundations of economics. In Metcalfe, J. S. and Foster, J., editors, *Evolution and Economic Complexity*. Edward Elgar.
- Duffy, J. (2006). Agent-based models and human subject experiments. In Tesfatsion, L. and Judd, K. L., editors, *Handbook of Computational Economics Vol. 2*, Netherlands. North-Holland.
- Durlauf, P. E. (1997). What should policymakers know about economic complexity? *SFI Working Papers*, 1997-10-080. Santa Fe Institute.
- Epstein, J. M. (1996). *Growing Artificial Societies: Social Science from the Bottom Up (Complex Adaptive Systems)*. The MIT Press, Massachusetts, EUA.
- Epstein, J. M. (2006). *Generative Social Science: Studies in agent-based computational modeling*. Princeton University Press, Princeton, New Jersey, EUA.
- Érdi, P. (2008). *Complexity Explained*. Springer-Verlag, Berlin Heidelberg.
- Fernandes, A. S., Fernandes, A. L., and Pereima, J. a. B. (2013). Multiples heuristics in consumption decision. Federal University of Paraná, Brazil. mimeo.
- Foster, J. (1997). The analytical foundations of evolutionary economics: From biological analogy to economic self-organization. *Structural Change and Economic Dynamics*, 8(4).
- Gintis, H. (2006). The economy as a complex adaptative system. *mimeo*. A Review of Eric D. Beinhocker - The Origins of Wealth: Evolution, Complexity, and the Radical Remaking of Economics.
- Gros, C. (2008). *Complex and Adaptative Dynamical Systems: A Prime*. Springer-Verlag, Berlin, Germany.
- Higachi, H. Y., Lima, G. T., and Pereima, J. B. (2013). Regimes de financiamento, mudança tecnológica e ciclo econômico. In *41o. Encontro Nacional de Economia - ANPEC*, Foz do Iguaçu, Brasil.
- Holland, J. (1998). *Emergence: From Chaos to Order*. Basic Books, EUA.
- Kauffman, S. A. and Levin, S. (1987). Towards a general theory of adaptive walks on rugged landscapes. *Journal of Theoretical Biology*, 1987(1).
- Kauffman, S. A. and Weinberger, E. D. (1989). The nk model of rugged fitness landscapes and its application to maturation of the immune response. *Journal of Theoretical Biology*, 141(2).
- Miller, J. H. and Page, S. E. (2007). *Complex Adaptive System: An introduction to computational models of social life*. Princeton University Press, New Jersey-EUA.
- Mitchell, M. (2009). *Complexity: a Guide Tour*. Oxford University Press, Oxford, USA.
- Nelson, R. R. and Winter, S. (1982). *An evolutionary theory of economic change*. Harvard University Press, EUA.

- Ormerod, P. (2004). On the methodology of assessing agent-based evolutionary models in the social sciences. In Metcalfe, J. S. and Foster, J., editors, *Evolution and Economic Complexity*. Edward Elgar.
- Tesfatsion, L. and Judd, K. L. (2006). *Handbook of Computational Economics*. North-Holland, Netherlands. Volume 2.
- Valente, M. (2000). *Laboratory for Simulation Development - A Proposal for Simulations Models in Social Sciences*. PhD thesis, University of Aalborg-Denmark, Department of Business Studies. Volume II.
- Valente, M. (2008a). Laboratory for simulation development - lsd. *LEM Working Papers*, 2008/12.
- Valente, M. (2008b). Pseudo-nk - an enhanced model of complexity. *LEM Working Papers*, 2008/11.
- Witt, U. (1997). Self-organization and economics: what is new? *Structural Changes and Economics Dynamics*, 8:489–507.