# EL FUTURO DE LAS CIUDADES: UN ENFOQUE DESDE LA COMPLEJIDAD

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**Objetivos del Curso:**

-Discutir el proceso actual de formalización del conocimiento urbano en el marco de la teoría de la complejidad.

-Desarrollar cuestiones prácticas relacionadas con los efectos locales y globales del cambio climático, la sostenibilidad urbana, reformas políticas, fluctuaciones económicas, desarrollo tecnológico y evoluciones culturales.

-Proponer puntos de vista híbridos para entender los sistemas urbanos con apoyo de las ciencias físicas, sociales y computacionales.

**Lugar, Fecha y Hora:**
Auditorio Gustavo Gutiérrez
Facultad de Ciencias Sociales en la Pontificia Universidad Católica del Perú
Martes 13 a jueves 15 de diciembre
De 6.30 a 9.30 p.m.

## Programme

**Summary of objectives**:

I will discuss a few critical points in the actual process leading to formalising the urban knowledge within the framework of theories of complex systems. Our knowledge of urban processes is still in infancy when queries are made for planning purposes about the possible future of cities. Practical questions related to the local and global effects of climate change, to urban sustainability, as well as changes to be expected in urban systems from political reorganisations, economic fluctuations, technological substitutions or cultural evolutions are still very difficult to anticipate in a deductive way from existing urban theories. I will argue that a few obstacles to the development of a sound and useful urban theory can be removed if a hybrid perspective is adopted including fundamental principles from scientific knowledge in physical and social sciences. Examples of possible hybridising will be discussed about an evolutionary theory of complex urban systems including ontology of urban systems, cities and systems of cities, referring to fractal structures and scaling laws, as well as dynamic social processes of co-evolution through directed innovation and selection. Integrating energetic physical processes and the role of intentionality and social institution is a major challenge in the discussion.

**Suggested readings:**

-Berry B.J.L. 1964, Cities as systems within systems of cities. *Papers of the Regional Science Association*, 13, 147-163.

-Pred A. 1977, *Cities systems in advanced economies*. London, Hutchison.
-Pumain D. 1998, Urban Research and Complexity, in Bertuglia C.S., Bianchi G., Mela A. (eds) *The City and its Sciences*, Heidelberg, Physica Verlag, 323-362.
-Pumain D. 2000, Settlement systems in the evolution. *Geografiska Annaler*, 82B, 2, 73-87.
-Pumain D. 2004, *Scaling laws and urban systems*. Santa Fe Institute, Working Paper n°04-02-002, 26 p.

**Course 1: Urban growth and urban hierarchy: Zipf, Gibrat and beyond**

We start from various observations about the size of cities today and questions about their possible evolution within the next decades. A striking universal feature of urban systems is the strong hierarchical differentiation in cities of different sizes in any region of the world. Either described by statistical models as Zipf Rank-size rule or lognormal distribution, the urban hierarchy is usually explained by a statistical model of urban growth, the Gibrat's model. In order to integrate in an evolutionary theory of urban systems all empirical observations about actual urban growth processes, including the most frequent deviations from Gibrat's model, we designed a geographical model for simulating the distribution of urban growth in systems of cities. The model incorporates the hierarchical and spatial diffusion of innovation cycles through gravitational interactions within a set of cities. Using theoretical simulations, we demonstrate that this model is able to reproduce the observed properties of urban systems for the log-normal distribution of city sizes, as well as the observed distribution of growth rates. Our experimentation was performed on a large harmonized historical database that includes a few hundred French urban agglomerations between 1831 and 1999 (Pumain-INED database). Both spatial interaction and innovation cycles are necessary ingredients to explain the evolution of urban hierarchies. We suggest that Gibrat's generic stochastic growth model based on independent entities should be replaced by a more relevant model of spatially and temporally interdependent geographical entities.

**Suggested readings:**


-Robson B. 1973, *Urban growth, an approach*. London, Methuen.

-Bretagnolle A., Pumain D., Rozenblat C. 1998, Space-time contraction and urban systems dynamics. *Cybergeo,* 61, 12 p.

-Pumain D. 2006, Alternative explanations of hierarchical differentiation in urban systems, in Pumain D. (ed.) *Hierarchy in natural and social sciences*, Springer, Methodos series 3, 169-222.

-Favaro J.-M. Pumain D. 2011, Gibrat Revisited: An Urban Growth Model including Spatial Interaction and Innovation Cycles. *Geographical Analysis*, 43, 3, 261-286.

**Course 2: Scaling laws, innovation cycles and functional diversity of urban systems**

Scaling properties of urban systems can be described by some very general models of complex systems but also have to be interpreted in terms of societal processes. Urban systems exhibit a hierarchical organisation including three relevant levels of observation: individual actors, cities, and networks or systems of cities. In previous work, we identified two types of scaling relations: 1) at city level, between built-up densities and surface, including two zones with different fractal dimensions and a fractal-non fractal transition towards rural space, according to the concept of urban field (Guérois, Pumain, 2008); 2) at the level of system of cities, between population size and employment in economic activities (Pumain, Paulus, Vacchiani-Marcuzzo, 2006, 2009), that differentiate them according to their stage in economic cycles, as expected from an evolutionary theory of integrated urban systems. We try to specify which consequences for the sustainability of urban systems can be derived form such a spatial organisation and functional differentiation, according to the geodiversity of urban systems in various regions of the world.

**Suggested readings:**

-Pumain D. 2004, *Scaling laws and urban systems*. Santa Fe Institute, Working Paper n°04-02-002, 26 p.
-Pumain D. Paulus F. Vacchiani C. Lobo J., 2006. An evolutionary theory for interpreting urban scaling laws, *Cybergeo*, 343, 20 p.
-Guérois M., Pumain D. 2008, Built-up encroachment and the urban field: a comparison of forty European cities, *Environment and Planning A*, 40, 2186-2203.
-Bettencourt L.M.A., Lobo J., and Geoffrey B. West, 2009, The self similarity of human social organization and dynamics in cities, in D. Lane, D. Pumain, S. Van der Leeuw, G. West (eds.), *Complexity perspectives on innovation and social change*, ISCOM, Springer, Methodos Series, Berlin, chapter 7.
-Rozenblat C. Pumain D. 1993, The location of Multinational Firms in the European Urban System. *Urban Studies*, 10, 1691-1709.

## Course 3: Multi-agents models for the simulation of urban systems

The theories of complex systems challenge our representation of emergence and evolution in geographical systems. We emphasize especially the challenges in system specification, including problems of identification and categorisation of subsystems in interaction, as well as processes driving geographical changes. We develop as an example a theory of urban systems as a spatial organisation of interacting cities on the long run. We show how the many stylised facts from urban theory can be integrated in a multi-agents system simulation model. Hierarchical distribution of city sizes including scaling laws of urban activities, functional specialisation according to major economic cycles and a growth process resulting from specific types of spatial and economic interactions are brought together in a generic model. The SIMPOP2 model helps reconstructing the interactions which generate the observed dynamics of a large set of cities over a long period of time. We suggest that comparing applications of the model to different types of urban systems in the world and developing different ways of understanding the necessary adaptations could be a possible specific method for validating such a model of complex system. The model could thus become a useful predictive tool for simulating the urban explosion of the next decades in developing countries.

**Suggested readings:**


-Bura S. Guérin-Pace F. Mathian H. Pumain D. Sanders L. 1996, Multi-agent systems and the dynamics of a settlement system. *Geographical Analysis*, 2, 161-178.

-Sanders L. Pumain D. Mathian H. Guérin-Pace F. Bura S. 1997, SIMPOP: a multiagent system for the study of urbanism. *Environment and Planning B*, 24, 287-305.

-Sanders L., Favaro JM., Glisse B., Mathian H., Pumain D. 2007, Artificial intelligence and collective agents :the EUROSIM model, *Cybergeo,* 392, 15 p.

-Bretagnolle A., Pumain D. 2010, Simulating urban networks through multiscalar space-time dynamics (Europe and United States, 17th -20th centuries), *Urban Studies,* 47, 13, 2819-2839.