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HOW COMPLEXITY, NETWORK AND BIG DATA MAY FACILITATE OUR UNDERSTANDING OF CONTEMPORARY CITIES?

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Abstract

*"The session will be devoted to a topic titled as **The Science of the City** … Through this session we expect to lead into deeper discussion and reflection on **how such concepts as complexity, network and big data may facilitate our understanding of how contemporary cities actually work and evolve."** (From the letter of invitation).*

Terminology

First we have to clarify the relations between the terms complexity, network and big data:

***Complexity** is a theory or rather a family of theories that deal with open, complex, far from equilibrium systems that achieve their order spontaneously by means of self-organization. **Network**, or rather **the new science of networks** is one of the family – the recent complexity theory that explores the network properties of complex systems by means of graph theoretic methodologies. The notion of **big data** (BD) refers to the large amount of data that recently became available due to the progress made in ICT and data mining methodologies. Finally, the **science of cities** is an old notion that claims/aims to transform the study of cities from a "soft" social theory oriented 'study' into a "hard science". Recently, it has been suggested that complexity theories, with their arsenal of methodologies (CA, AB, networks), can genuinely give rise to **The New Science of Cities** (Batty 2013).*

Complexity, Cognition and the City

How complexity (network and big data) may facilitate our understanding of how contemporary cities actually work and evolve? Implicit in this question is a parallel question: How complexity, networks and BD can give rise to a new science of cities?

The answer as evolving in the last three and a half decades is: by applying complexity theories as originally developed in the "hard" sciences to the study of cities. Such applications started from the findings that there are genuine similarities between complex systems revealed in nature and the way cities work and evolve; and, that models developed to deal with natural complex systems can be successfully applied to cities. This attempt and project gave rise to CTC – complexity theories of cities.

My personal view is that the above is a partial answer – one way is indeed to look at similarities *between phenomena of complexity revealed in nature and the dynamics of cities. However, in order to answer the question in full, one has also to search for differences – for the uniqueness and peculiarities of cities as complex systems and the methodological implications thereof.*

CCCity – ***Complexity, Cognition and the City*** *(Portugali 2011) – was a first attempt at this direction. Following CCCity and subsequent studies the suggestion here is that cities as complex systems differ from natural (material and organic) complex systems in several interrelated respects: First, cities are artifacts – artificial complex systems. By this I mean a hybrid system composed of artifacts, which by their nature are simple systems, and urban agents, which by their nature are complex systems. Second, the parts of cities – the urban agents – differ from the parts of natural complex systems: they differ from material parts (atoms particles) in that they have mind and they differ from organic parts (e.g. animals) in that due to their specific embodied mind they produce artifacts/culture. Third, as a consequence, they are subject to two evolutionary processes: biological and cultural; the outcome is that cities are* ***dually complex systems****. Fourth, urban agents produce artifacts in a specific way – by a process of SIRN (synergetic inter-representation networks), that is, an on going interaction between internal and external representations (ibid. Chap. 7). In the latter, the production of artifacts as external representation is part of cognition as a thinking process. Fifth, urban design is such a SIRN process (Portugali and Solk, 2013/14).*

Small data is beautiful

The title echoes Schumacher's (1973) classic Small is Beautiful, and in line with the sub-title of Schumacher's book (A study of economics as if people matter) it comes to suggest 'a study of the complex system 'city' as if people matter'.

How to study cities as complex systems? The fashionable answer these days is Big Data: The new ICT with data mining and visual analytic techniques make it possible for the first time to make use of the huge amount of data that is accumulating in the internet and other networks. "Smart cities will need big data", declares the title of a recent article in Physics Today [66(9), 19 (2013)]: In it physicist S. Koonin, director of the new New York University's Center for Urban Science and Progress (CUSP), says:

> *"Physics is an attitude as well as a subject. The kind of skills physicists bring to thinking through complicated situations, data driven and so on, are not all that common in urban science and technology at this point. Physicists have a lot to bring to the table here."*

The fact that the new CUSP is headed by a physicist is not an accident: Big data represents physicalism – a physicist view on cities. On the other hand, Koonin, as well as his interviewer, are simply wrong in implying that it is only now that physicists step into the study of cities: For more than 40 years physicists are deeply involved in the study of cities; in fact the study of cities as complex self-organizing systems was founded and developed by a collaboration between physicists and urbanists. There is no doubt that using big data can be beneficial and add new insight (e.g. Kennett and Portugali 2013), but putting all the urban eggs in one basket is not a good strategy.

The basic methodological question here is 'how to study complex systems?' Take for example the ultimate complex system – the brain: how to study the brain? There are two basic approaches: top-down approaches (EEG, MEG, fMRI) that similarly to big data approaches, searches for overall patterns when the brain is executing certain tasks, and there are bottom-up small data approaches that explore the behavior of individual neurons. As illustrated by Nobel Laureate Eric Kandel (2006), studying single brain neurons entailed major breakthroughs about the way our memory works. According to Kandel (2012), the operation of the brain itself in tasks such as visual *perception evolves as an interaction between analytical bottom-up local processes ("small data") and synthetic top-down global processes ("big data"). In fact, all complexity theories deal with this play between the local and the global, the small and the big. As conceptualized by Haken's (1983) synergetics, the local parts, by mean of their interaction, give rise to the global system, which then enslaves the parts to its rhythm and so on in circular causality.*

How to generate and use small data in the study of the complex system city? While a comprehensive answer has yet to be given, some directions can be identified: One source of inspiration is the cognitive science – part of the methodologies developed in this domain focus on individuals, their motivations and action. Such methodologies range from "hard" laboratory experiments, through observations and questionnaires to "soft" deep/open interviews. An interesting small data methodology is Hägerstrand's (1970) ***time geography*** *that by mapping the daily and life paths of individuals exposes the various personal, collective and institutional constraints within which urban agents live and act.*

The Janus face city

"How such concepts as complexity, network and big data may facilitate our understanding of how contemporary cities actually work and evolve?" The answer suggested here is, by developing Janus face theoretical and methodological approaches. Firstly, by complementing the natural sciences derived CTC by a cognitive dimension that will take account of the peculiarity of cities as hybrid artificial-natural complex systems. Secondly, by complementing the big data methodologies by soft data approaches that will enable 'a study of the complex system 'city' as if people matter'.

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