A Theoretical Framework for the Study of Socio-Technical Systems

Working Paper

Juste Raimbault

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Abstract

Introduction

Scientific Context

The structural misunderstandings between Social Sciences and Humanities on one side, and so-called Exact Sciences on the other side, far from being a generality, seems to have however a significant impact on the structure of scientific knowledge [Hidalgo, 2015]. In particular, the place of theory (and indeed the signification of this term itself) in the elaboration of knowledge has a totally different place, partly because of the different *perceived complexities*[1] of studied objects : for example, mathematical constructions and by extent theoretical physics are *simple* in the sense that they are mostly entierely analytically solvable, whereas Social Science subjects such as humans or society (to give a *cliché* exemple) are *complex* in the sense of complex systems[2], thus a stronger need of a constructed theoretical (generally empirically based) framework to identify and define the objects of research that are necessarily more arbitrary in the framing of their boundaries, relations and processes, because of the multitude of possible viewpoints : Pumain suggests indeed in [Pumain, 2005] a new approach to complexity deeply rooted in social sciences that "would be measured by the diversity of disciplines needed to elaborate a notion". These differences in backgrounds are naturally desirable in the spectrum of science, but things can get nasty when playing on "common" terrains, typically complex systems problematics as already detailed, as the exemple of geographical urban systems has recently shown [Dupuy and Benguigui, 2015]. Complex System Science[3] is presented by some as a "new kind of Science" [Wolfram, 2002], and would at least be a symptom of a shift in scientific practices, from analytical and "exact" approaches to computational and evidence-based approaches [Arthur, 2015], but what is sure is that it brings, together with new methodologies, new scientific fields in the sense of converging approaches

[1] We used the term *perceived* as most of systems studied by physics might be described as simple whereas they are intrinsically complex and indeed not well understood [Laughlin, 2006].

[2] for which no unified definition exists but of which fields of application range broadly from neuroscience to quantitative finance, incuding e.g. quantitative sociology, quantitative geography, integrative biology, etc. [Newman, 2011], and for which study various complementary approaches may be applied, such as Dynamical Systems, Agent-based Modeling, Random Matrix Theory

[3] that we deliberately call that way although there is a running debate on wether it can be seen as a Science in itself or more as a different way to do Science.

Objectives

Construction of the theory

Perspectives and Ontologies

The starting point of the theory construction is a perspectivist epistemological approach on systems [Giere, 2010]. To sum up, it interprets any scientific approach as a perspective, in which someone pursues some objective and uses what is called *a model* to reach it. The model is nothing more than a scientific medium. Varenne developped [Varenne, 2010] model typologies that can be interpreted as a refinment of this theory. Let for now relax this possible precision and use perspectives as proxies of the undefined objects and concepts. Indeed, different views on the same object (being complementary or diverging) have the property to share at least the object in itself, thus the proposition to define objects (and more generally systems) from a set of perspectives on them, that verify some properties that we formalize in the following.

A perspective is defined in our case as a dataflow machine M (the model) in the sense of [Golden et al., 2012], to which is associated an ontology O in the sense of [Livet et al., 2010]. We include only two aspect (the model and the objctu represented) of Giere's theory, making the assumption that purpose and user of the perspective are indeed contained in the ontology.

Definition 1. *A* perspective on a system *is given by a dataflow machine* $(I, O, \mathbb{T})$ *and an associated ontology* O

Application : co-evolution of subsystems

The particular case of geographical systems

[Dollfus and Dastès, 1975]

Modularity and co-evolving subsystems

Discussion

Conclusion

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