Results in Physics 4 (2014) 135–136

Contents lists available at ScienceDirect

Results in Physics

journal homepage: www.journals.elsevier.com/results-in-physics

Microarticle

Stylized facts and multiple realizability in econophysics

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ARTICLE INFO

Article history:
Received 6 May 2014
Accepted 4 August 2014
Available online 20 August 2014

Keywords:
Stylized facts
Econophysics
Agent-based modelling
Multiple realizability

ABSTRACT

Stylized facts are persistent macro-regularities which cannot be described in terms of microeconomic theory. Through the argument of multiple realizability, this methodological paper claims that a top down agent-based econophysics can contribute to a better understanding of complex economic systems in two ways: on the one hand, it clarifies the gap between micro and macro scales by proving an algorithmic derivability of the latter; and on the other hand, this modelling provides microfoundations (and then potentially an economic meaning) to macro-patterns usually identified in the observation of these complex systems.

For several years economics has been facing with an accumulation of "stylized facts" (persistent macro-regularities which cannot be described in terms of microeconomic theory [1]) – among the most studied stylized facts, one can mention: heavy tails of financial distributions, volatility clustering, volume/volatility correlation, absence of autocorrelation etc (see 2 for a review literature on these empirical facts). All these statistical phenomena cannot be expressed in economic mainstream terms based on a microscopic approach in which macro-scale is a mere aggregation of micro-components. Buchanan [1] emphasized similarities between stylized facts and phenomena usually studied in statistical physics explaining why some physicists decided to develop what we today call "econophysics". Although all econophysical literatures are not dedicated to stylized facts, the vast majority of these works focus on macro-regularities observed in complex economic systems [1]. Econophysics is a phenomenological field mainly based on the description of macro scale of economic systems whose micro-interactions are judged to be too complex to be reduced (and then defined) through a mere analytical form [3]. Because econophysicists assume that micro-interactions are too complex to be captured, they do not provide a framework compatible with the classical idea[1] of reduction. When they refer to agents, econophysicists implicitly assume the agents' behaviour is random and the result is mathematically analogous to a reaction of diffusion model in physics. This phenomenological methodology reducing the agents' heterogeneity to a collective activity on the macro-scale preserves a mystery gap between the micro and the macro levels. Although econophysicists acknowledge the existence of micro-interactions, this concept often appears to be a filler term in order to characterize the fact that "something is moving" between units whose behaviours generate macroscopic results.

By doing so, econophysicists are in line with a micro-indeterminism inducing, by coarse-graining, a macro-determinism. This "coarse-graining situation" is well-known in hard science but not so common in social sciences in which agents are endowed with intentions. The impossibility to define the high number of microscopic configurations for individuals implicitly refers to what we call "the multiple realizability argument" which acknowledges that a macro property can emerge from a diversity of micro-properties. "Because the higher-level properties are multiple realizable, the mapping from lower to higher is many-to-one" [Sober, 5, p. 545]. The author explained that multiple realizability argument does not deny that higher-level properties are determined by lower-level ones but it rather refutes the reductionist idea that higher configuration results from a specific (causal) configuration of micro-properties. When this argument is applied to social sciences, it is called "multi-desiderability" [5] in order to emphasize the complexity of individual psychology of agents. In the same vein, Batterman [7] explained that multiple realizability is an appropriate conceptual framework for describing the occurrence of universal statistical macro patterns in social sciences, "The multiple realizability of the properties of the special sciences such as psychology [or social sciences] is best understood as a kind of universality, where 'universality' is used in the technical sense one finds in the physics literature" [Batterman, 7, p. 115]. Some authors

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[1] Nagel [4, p. 338] explained that "reduction [...] is the explanation of a theory or a set of experimental laws established in one area of inquiry, by a theory usually though not invariably formulated for some other domain". Reduction is therefore defined through the logical idea according to which a theory can be a definitional extension of another [4, p. 351].

http://dx.doi.org/10.1016/j.rinp.2014.08.001
2211-3797/

[6] presented that notion is in total contradiction with the idea of reduction because the description of the macro-level (reduced theory) cannot integrate a unique functional definition of the micro-states (whose behaviour cannot be captured through a mere analytical form). In other words, the theory describing the macro-level cannot be presented as a unique definitional extension of the reducing one. However, as Sober [5] it, multiple realizability, gives no argument against classical (Nagelian) reduction because the uniqueness of derivability between reduced and reducing theories is not a necessary condition. The derivability is, as a corollary, only a sufficient condition making this argument of multiple realizability compatible with reduction. This possibility can be looked on as an opportunity for econophysicists. Indeed, a plausible top-down derivability paves the way for a combination of strictly phenomenological econophysics dealing with macro-patterns (stylized facts) with an approach such as agent-based modelling which can clarify the gap between macro and micro scales of economic complex systems. The necessity to give a meaning to this gap between micro and macro scales is a key point for the acceptance of econophysics in a micro-based economics for which "the implications of this new literature [econophysics] for economic complexity are still very unclear [today]" [Durlauf, 8, p. 232].

This methodological paper claims that econophysicists have all conceptual tools they need to meet usual expectations in economic modelling (i.e. necessity to provide micro-foundations). More specifically, a top down agent based econophysics can meet this necessity to provide micro-foundations to emerging macro-patterns. Indeed, once a macro-pattern is phenomenologically identified in the study of a complex economic system, a model based on an algorithmically generated behaviour of individual market participants quantitatively reproduces the initial macro power law. The method is based on computerized simulations of a large number of learning decision-makers and it provides a specific way to study micro-interactions that cause macro-properties. In opposition to agent-based economics, individual incentives are not the constraint for the calibration of micro-interactions, the real constraint for this category of works is actually defined by the initial macro-laws modellers would like to reproduce through the agent-based modelling. The macro-pattern initially identified for this financial system will then be constraining for the calibration of the rules governing interactions between agents, as Feng and al [9, p. 8388] explained it, "the interaction strength between agents need to be adjusted with agent population size or interaction structure to sustain fat tails in return distributions [i.e. power-law]". When agent-based modelling generates the same regularities then those observed by econophysicists; it provides micro-foundations to the statistical regularities that emerge at the macro-level of economic systems (such as stylized facts). A top-down agent-based approach can therefore be considered as a complementary field with a strictly statistical approach. Moreover, a top down agent-based modelling can contribute to econophysics in two ways: on the one hand, it clarifies the gap between micro and macro scales by proving an algorithmic derivability[2] of the latter; and on the other hand, this modelling provides micro-foundations (and then potentially an economic meaning) to macro-patterns. Aware of this situation, some econophysicists [9] initiated a "top-down agent-based econophysics" but the movement is still at its infancy in the study of stylized facts the vast majority of econophysicists using agent-based modelling do not work on stylized facts allowing them to use a classical bottom-up approach (see [3] for further information about that literature).

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[2] See Ellis [10] for further details on the algorithmic top down causation.