Philosophy of the Social Sciences
1–31
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sagepub.com/journalsPermissions.nav
DOI: 10.1177/0048393117713982
journals.sagepub.com/home/pos
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Can Analytical Sociology Do without Methodological Individualism?

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Abstract

The explanatory power of structures in analytical sociologists' agent-based models brings into question methodological individualism. We defend that (a) from an explanatory point of view, the syntactic properties of models require semantic conditions of interpretation drawn from a conceptual research framework; (b) in such a framework, social/relational structures have only partial, explanatory power (counterfactual); and (c) taking the explanation further through generative mechanism modeling necessitates calling upon methodological individualism's generic framework of interpretation that relies on social actors' rational capacity. According to this interpretive framework, forces in action in society are governed by the subjective meaning of/the reasons for individual actions.

Keywords

methodological individualism, analytical sociology, explanation, causality, generative mechanism, agent-based models, agent-based computational sociology, multiple-realizability

1. Introduction

In a recent article, Caterina Marchionni and Petri Ylikoski assert that there are no inherent links between the "generative mechanism-based explanations"

Received 2 September 2016

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agent-based models can deliver and methodological individualism. Relying on the latter is therefore unnecessary: "The association of ABS [Agent Based Computational Sociology][1] with methodological individualism does nothing to advance our understanding of how ABS models explain" (Marchionni and Ylikoski 2013, 331).

The agent-based modeling (ABM) approach in sociology, which the authors refer to as generative, consists of finding a relational microstructure that generates through simulation the macrostructure that will be explained ("grows from the bottom up"). The possibility of modeling the micro–macro transition is held to be a necessary condition of explanation (according to the motto "If you didn't grow it, you didn't explain it"; Epstein 2007; Epstein and Axtell 1996)—that is, if it can be explained, it can be simulated. Conversely, as has been fully emphasized in the literature, generation of a pattern is far from explanatory power of the postulated causal structures.[2]

In this article, we propose, based on a discussion of the explanatory power of the structural properties of models in general and agent-based models in particular, to clarify the role of individualistic methodology in the social sciences. Modeling by means of agent-based models is mainly promoted by analytical sociology. We will therefore discuss the relationship between analytical sociology and methodological individualism.

First, we differentiate between the general features of works falling within analytical sociology and methodological individualism, respectively. Analytical sociology tends to focus on the syntactic dimension of the explanation associated with complex systems modeling—that is, the generic structural properties of the models. For its part, methodological individualism provides a generic semantic framework of interpretation for generative mechanisms in the social sciences. On this basis, we defend that (a) from an explanatory point of view, the syntactic properties of models require semantic conditions of interpretation drawn from a conceptual research framework; (b) in such a framework, social/relational structures have only partial (counterfactual) explanatory power, limited by ceteris paribus conditions; and (c) taking the explanation further through generative mechanism modeling necessitates calling upon methodological individualism's generic framework

[1]See, on this subject, Squazzoni (2012).

[2]Although a "generative" simulation can be seen as a necessary condition for a computational social science, it is not enough to provide an ultimate explanation of the considered phenomenon of interest: the identification of an *explanatory candidate* does not mean it is the only possible one, or necessarily the relevant explanation in all cases (cf. "ceteris paribus" conditions).

of interpretation that relies on social actors' rational capacity (in a broad sense). According to this framework, forces in action in society are governed by the subjective meaning of/the reasons for individual actions.

2. Relationships between Methodological Individualism and Analytical Sociology

Methodological individualism is the generic approach in the social sciences that relies on social actors' rational capacity (in a broad sense) and according to which forces in action in society are governed by the subjective meaning of/the reasons for individual actions.[3] This methodological principle does not lead us to deny the explicative power of the "passive" factors that are social and relational structures.[4] It only leads us to the following assertion (Proposition G):

> **Proposition G:** For methodological individualism, social/relational structures have an explanatory or causal role in the representation of generative mechanisms only insofar as they affect the subjective meaning of/the reasons for individual actions by the contextual properties they define.[5]

Analytical sociology is focused on the study of social mechanisms, with the help of computational models in particular. Because of its formal

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[3]We note that methodological individualism does not exclude that under certain conditions, a collective entity might be legitimately treated as an individual, for example, a group, such as a government or a political party, equipped with procedures allowing it to transform the individual opinions of its members into collective decisions issued in their name (as specified, for instance, in Boudon 2007).

[4]These structures are conceived of here in a broad sense: they encompass all the structural forms that we are likely to come across in the social sciences: cognitive, interpersonal, organizational, institutional, and so forth.

[5]Our definition of methodological individualism complies with those put forward by its proposers in various fields in the social and human sciences, since its initial explicit formulations. This definition does not offer a "summary" of the points of view on this subject but proposes an epistemological characterization. The following statements, for instance, are consistent with this characterization.

Ludwig von Mises ([1949] 1998, 47): "A collective operates always through the intermediary of one or several individuals whose actions are related to the collective as the secondary source. It is the meaning which the acting individuals and all those who are touched by their action attribute to an action that determines its character. It is the meaning that marks one action as the action of an individual and another action as the action of the state or of the municipality. The hangman, not the state, executes a criminal. It is the meaning of those concerned that discerns in the hangman's action the action of the state."

dimension, it inherits, to a certain extent, from the mathematical sociology developed in the 1950s and 1960s, which included the causal process conception as its "largest single area" (Berger 2010; Sorensen 1978, 349). Taking into account the evolution of techniques that, in this respect, give the advantage to computational models over mathematical models, analytical sociology has as its preferred terrain the development of agent-based models. The latter can be used to study the effects of the interdependence of the actions/interactions of "decentralized" active units and, in so doing, the representation of mechanisms that cannot be solved mathematically.[6] On this basis, analytical sociology defines a relatively ambitious research strategy, which does not have an unequivocal articulation with methodological individualism. Points of view on this subject vary, even if they overlap in parts. It is interesting to refer to the editors of handbooks on the question. Pierre Demeulenaere (2011) emphasizes the match between the explanatory preoccupations of analytical sociology and the general principles of methodological individualism, with the accent on the analysis of causality. Peter Hedström and Peter Bearman (2009), while retaining for analytical sociology some of methodological individualism's achievements—explanation brings into play intentional individual actions—explain that its interest lies in the disclosure of patterns of

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Ian Jarvie (1972, 124): "Institutions are social causes only insofar as they are part of a person's situation."

Joseph Agassi (1975, 144): [Methodological individualism] ascribes "The power to act to all and only to those who have the power to decide."

Raymond Boudon (2007, 46): [MI] refuses the idea "that a social phenomenon might have its source anywhere other than in the theoretically understandable motivations and reasons of the social actors responsible for the phenomenon Holism, by contrast, is the doctrine according to which "individual aims and decisions are created by social forces" (Agassi 1975, 145). "Behavior can be explained by forces that are external to the individual" (Boudon 2007, 46).

We note that Francesco Di Iorio recently published an article on Popper and methodological individualism that was in agreement on this point with our characterization of methodological individualism: "If the agent is a self-determined being, human intentions matter, and to explain action, one must understand the meaning attached by the individual to his or her action. This does not mean that the agent is absolutely free from social constraints (absolute freedom is a view supported by atomism), but only that these constraints must be analyzed with account taken of the individual subjective standpoints" (Di Iorio 2016, 353).

[6]Or can only be solved in very special cases (see Axtell 2000; Squazzoni 2012).

phenomena likely to account for a greater or lesser number of facts.[7] With Lars Udehn, Hedström places analytical sociology in the Mertonian tradition of middle-range theories (Hedström & Udehn 2009), which is not a betrayal of methodological individualism, but reveals a less methodologically unifying and more pragmatic preoccupation. Gianluca Manzo (2010) defends its relative originality based on the programmatic development of theoretical, methodological, and epistemological principles surrounding the test by the effects the models proposed.

A methodological individualism theorist, Raymond Boudon (2012), attributes the new terminology proposed by the proponents of analytical sociology to a desire to call a halt to erroneous interpretations of methodological individualism. The main criticisms concern in particular implementations of methodological individualism by rational choice theorists, especially the reductionist trend of numerous neoclassical economic models.[8] In particular, these criticisms unfairly accuse methodological individualism of ignoring the role of institutions and structures in the explanation. However, with analytical sociology a change in direction of methodological work presents itself, as revealed in the programmatic literature. This change is pointed out by Boudon (2012, 31): analytical sociologists are not as interested in the conditions that form the basis of illuminating explanations in sociology as they are in the discussion of certain technical problems associated with agent-based models.

The introduction of the notion of structural individualism seems to want to conclude the terminological change in question by substituting the (analytical sociology, structural individualism) couple with that of (comprehensive sociology or sociology of action, methodological individualism). This change reveals more than a desire for demarcation from methodological

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[7]Hedström and Bearman (2009, 6) refer on this subject to the "argument patterns" developed by Philip Kitcher (1981, 515-16; 1989, 432) identifying the explanatory worth of a set of arguments instantiating a common pattern.

[8]The rational choice theory (RCT) implemented by neoclassical economics in the 1960s and 1970s minimized the constraint exercised by social/relational structures on behavior and the cognitive capacities of individuals by postulating individuals as consequentialist, selfish, optimizing, and omniscient. In its strongest version, the absence of heterogeneity and interdependence of the agents aimed at enabling the aggregation of their actions in the form of a "representative individual." In the 1980s and 1990s, critical extensions developed around the "core" of the neoclassical model. The hypotheses of information and rationality tended to be weakened and numerous new dimensions were introduced later: social influence, beliefs, emotions, altruism, and so forth.

individualism and its reductionist interpretations. The introduction of the notion of structural individualism put emphasis on the explanatory importance of the social and relational structures in which individuals are embedded (Hedström and Bearman 2009, 4, 8). This new term would correspond, according to Udehn (2001, 2002), to a "weak" version of methodological individualism that would be a "mix, or synthesis, of individualistic and holistic elements" (Udehn 2002, 493).

We point out that holism is classically defined in opposition to methodological individualism, on the grounds given by (G), due to its rejection of a search for subjective meaning/reasons for individual actions. In this respect, it places at the level of social wholes the location of the meaning and the general logic of social action that are assumed to dominate individual actions. The fact that Udehn does not characterize methodological individualism epistemologically reveals, in our opinion, a displacement of the research problematics that interest structural individualism. If the latter brings individualism and holism closer, this is due to indifference to their epistemological demarcation. Structural individualism is manifestly constructed on different bases, independent of the reference to the meanings of/reasons for individual actions. Therefore, by comparison with methodological individualism, structural individualism accentuates the explanatory role of "structures," not because it rejects (explicitly) a ghostly form of "strong" methodological individualism without structures, but because it denies (implicitly) the epistemological bases of the latter, that is, the necessary reference to the meanings of/reasons for individual actions. This denial finds, at first sight, two utilitarian justifications, which are not exclusive:

1. The integration of the bias (often implicit but relatively general among behavioral types of approaches in sociology) of those who consider that sociology can do without going back to the meaning of/reasons for individual actions when it is interested in the social effects of social/relational structures.
2. The focus on the explanation offered in terms of model-based agents. The individual whose action is modeled is interpreted on the basis of causal patterns brought into play by the models. It then seems that the reference to reasons for action can be eliminated because the explanation by the model is self-sufficient, and therefore the "properties" of entities—linked to formal structures—supersede the individual "reasons" as grounds for the explanation. This appears quite clearly in the presentation proposed by Hedström and Bearman (2009, 7-8):

> The basic explanatory principle behind the mechanism approach is that proper explanations identify the entities, activities, and relations that jointly produce the collective outcome to be explained. When we apply this idea to the explanation of social facts it implies a form of structural individualism. As we define the term, structural individualism is a methodological doctrine according to which all social facts, their structures and changes are in principle explicable in terms of individuals, their properties, actions and relations to one another.

In support of this idea, we note the more directly simulatable character of the "Desires–Beliefs–Opportunities" triplet from the theory of action proposed by Hedström (2005) as well as, correlatively, the forms of cognitive automatisms, such as habits or emotions, advanced in works by partisans of analytical sociology. Without betraying a broad version of rationality, these behavioral problematics favored by analytical sociologists tend to conflate the properties of the entities of models formally at work in the simulation and the meaning of social action.

If the proponents of analytical sociology very generally call for methodological individualism, the relationships that appear between methodological individualism and analytical sociology are not relationships of either identity or partial or total inclusion. The points of view mentioned above, as well as the terminological displacements made, reveal relationships of complementarity that we will attempt to clarify. According to the thesis developed here, analytical sociology tends to shift toward a position more centered on the syntactic dimension of the explanation offered by the modeling of complex systems. We defend in what follows that the generic structural mechanisms that it studies require, from an explanatory point of view, a conceptual framework of interpretation, and that, in such a framework, they only play the role of partial causes subjected to ceteris paribus conditions.

3. Structural Properties and Conceptual Framework of Interpretation of Models

We propose to clarify what the "syntactic" and "semantic" dimensions of explanation represent where the modeling of complex systems is concerned.

The phenomena, entities, and relationships that we perceive can be "thought of" in terms of agents and this form of conceptualization has contributed to the success of agent-based models in the social sciences. The implementation of an agent-based model can be carried out, although this is not strictly necessary, using a computerized system known as a "Multi-Agent

System" (MAS).[9] A MAS is constructed by defining at least two components: (a) the agents (active entities), which are generally "heterogeneous," and give the MAS its specificity, and (b) the relationships between the agents. The central property attributed to the agents is a form of "autonomy" that can be linked to "reasons for action" within a conceptual framework where persons are formalized as agents, but can also be linked to other causes reflected by an agentive autonomy, according to other points of view (e.g., the city-agents of geographers).[10] The relationships between agents are the support for their interactions. They represent a structured system that has its own identifiable properties. Work by researchers on these approaches has shown the generic aspect of these tools, which can be used to enrich our approach in various fields seen as complex systems (natural, social, or artificial). In this way, there are no mandatory links between the modeling of individual actions and the use of a MAS (Livet, Phan, and Sanders 2014).

The syntactic properties of a formal system that implements an agent-based model are generic and can be applied to all forms of interactions that are structured in the same way. These structural generic properties of the models (as formal systems) are asemantic by nature. This requires an initial form of interpretation from the point of view of the modeler, account taken of the formally postulated links between the entities of the model, which we will identify as the "conceptual modeling framework." Hence, in the framework of agent-based models, there is an initial semantic level that belongs to the "model's world" and has by itself no interpretative virtue with respect to the phenomenal world. This level associates the model with a "generic" meaning that is specific to the modeling techniques used.

It is therefore relevant to differentiate between two levels of meaning, corresponding to two distinct functions: the agent-based conceptual modeling

[9]In information technology, Multi-Agent Systems (MAS), developed from the 1990s, formally implement a set of executable concepts and techniques for relatively autonomous software components called "agents," which are able to interact within these systems (Dignum 2009). More specifically, an agent is an "active" piece of software, located in a structured environment, that perceives and processes information from this environment, interacts and possibly communicates with other agents (Ferber 1999). An MAS can be seen as an "artificial world" in which some computer scientists have designed anthropomorphic agent architectures in conjunction with the fields of artificial intelligence and robotics: the "actions" of an agent may be motivated by objectives, and controlled by resources, capabilities, and available information (Ferber, Stratulat, and Tranier 2009).

[10]See, for instance, Sanders (2007).

framework and the thematic conceptual framework of research (here, within social sciences). The first is not related to the empirical domain but to the formal system developed and simulated in the model domain. The second is related to the conceptualization of the empirical phenomena considered in one thematic domain of research. This second semantic level gives meaning to the generic structural properties of the models in relation to a given thematic conceptual framework.

Hence, Proposition A is suggested:

> **Proposition A:** A formal system or model is, from the point of view of the phenomenal world, asemantic; it "speaks" of nothing. It is given its meaning by an interpretation of the entities, properties, and relationships that define it in a thematic conceptual framework.

The links established between the entities and relationships of the model interpreted in the conceptual modeling framework and those of the thematic conceptual framework authorize the elaboration of "shared semantics" between the model and the empirical domain.

The relationships between three "worlds" are therefore in play in the model: the "world" of the model, the thematic conceptual framework of the research, and the phenomenal world (Livet et al. 2010). The concepts, or constructs, of the first two worlds are theoretical, that is, postulated. The concepts arising from the phenomenal world are empirical: they represent the common traits of factors isolated from and referring to the phenomenal world. "Epistemic" links are supposed to be defined between the theoretical constructs of the thematic conceptual framework, associated with certain constituents of the world of the model, and the empirical concepts that refer to factors arising from the phenomenal world.[11] These links are said to be epistemic because they connect elements of a different nature. The meaning of the constituents of the model is defined by their structural relationships to

[11]In the epistemology of Filmer Northrop (1947) from which we borrow this terminology, Northrop speaks of epistemic correlations between concepts by postulation—theoretical constructs—and concepts by intuition that refer to the phenomenal world. In Northrop, the relationships between concepts by postulation and concepts by intuition are defined in narrower ways than they are in the use of agent-based models. Our argument here is free of bias concerning these questions, apart from the hypothesis, which is common to them, according to which scientific knowledge is founded on theoretical constructions whose relative validity can only be tested indirectly using an experimental approach (here, through the use of modeling).

the other constituents. It is the same for the meaning of the theoretical constructs of the thematic conceptual framework. By contrast, the meaning of the empirical concepts is defined by reference to the phenomenal world.

Let us propose a metaphor to illustrate the relationships between (a) the generic constituents of the conceptual modeling framework, (b) the constructs of the thematic conceptual framework, and (c) the factors abstracted from the empirical domain. The purpose of the activities of the model's entities is to simulate the shadows of reality on a given plane of projection (point of view)—that is, a phenomenal regularity observed and reflected by data and a formal language for the purpose of experimentation. The shadows refer to the phenomenal world, whereas the elements, relationships, and processes of the model are formal constructs, some of which are associated with constructs from the thematic conceptual framework. An active entity (an agent), defined by its relationships with the other entities and certain rules of action, is associated, for example, with a social actor, and the rules of action are interpreted according to the reasons for action attributed to this actor. The model is supposed to represent, through the intermediary of the interpretation of the thematic conceptual framework, the internal logic of the different situations subsumed under the phenomenal regularity to be explained. The explanation itself implements the postulated relationships between the formal constructs of the model, the conceptual constructs arising from the thematic conceptual framework, and the empirical concepts that refer to elements of the phenomenal world.[12]

We think that this distinction between the model seen as a formal (syntactic) system, an intermediary semantic level proper to the generic activity of modeling and the semantic level defined by the thematic conceptual framework, enables clarification of the role of models in explanation. The syntactic properties of the model, even when supplemented by the generic semantics of the conceptual modeling framework, only have explanatory virtues when associated with a defined thematic conceptual framework.[13]

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[12]According to strict logic, the causal relationships revealed by an agent-based model are proper to that model, with its specific hypotheses, and cannot be applied to that model's empirical domain of reference. At best we can, according to Sugden (2002), make a hypothetical inference according to which what is true for the model could be true for the empirical domain of reference.

[13]The conditions of relevance of the results of the model are also to be assessed in relation to the simplifying assumptions retained (ceteris paribus), which bring into play the relationships between the syntactic form of the model and its interpretation in the conceptual framework. The ideal, as far as explanation is concerned, is to reach the greatest possible level of simplification that is compatible with the validity of the

Let us take the case of modeling using evolutionary game theory. For example, general behavioral strategies that are theoretically evolutionary regarding defense of territory, parental investment in offspring, and so forth can enable modeling of relationships underpinning the behaviors of very different organisms (Woodward 1989, 365-66). But depending on the thematic conceptual frameworks concerned, the explanations will bring into play genetically programmed behavior, or rational behavior, involving cultural factors in the case of human beings. The example of the evolution of cooperation is significant. In the case of an iterated Prisoner's Dilemma game, the confrontation of decision rules in a computer tournament—indicating the probability of defect/cooperation as a function of the history of interactions—showed that the highest average score was obtained by the simplest of all strategies, Tit-for-Tat: one of cooperating on the first move and then doing whatever the other player did on the preceding move. Robert Axelrod and William Hamilton (1981) see in this a justification of the evolution of cooperation in primates as well as the existence of chronic and acute phases in many diseases: it is in a bacterium's interest to cooperate when a carrier is valid, and make the most of its carrier when it is at risk of disappearing. In itself, the competition between the formal rules of action in the framework of the tournament in question offers no explanatory hypothesis. It can only be interpreted in medicine or in evolutionary theory when matched with certain thematic conceptual frameworks associated with these domains.

We are therefore led to support the following Proposition B:

Proposition B: There is explanatory complementarity between the structural generic properties of models and the semantic conditions of interpretation associated with the thematic conceptual research framework.

On this basis, the question of the explanatory role of the structures brought into play by models is twofold. It refers to the generic syntactic structures of the models on one hand, and the structures for action and interaction semantically interpreted in the thematic conceptual frameworks on the other hand.

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proposed explanation. The formal model then enables the syntactic exploration (analytically and/or by simulation) of the properties of the formalization from the point of view under consideration (the causal structure in play). This leads to an assessment of its empirical relevance, internal coherence, and robustness, but not the validity or invalidity of other possible formalizations (other variations of the model/causal structures) for the same conceptual framework (see, for instance, Bulle 2009; Phan and Varenne 2010).

4. The Explanatory Power of Structures and the Multiple-Realizability Argument

To defend their argument that the explanatory power of the bottom-up research strategy of agent-based models is independent of the principles of methodological individualism, Marchionni and Ylikoski take the example of a model developed by Damon Centola, Robb Willer, and Michael Macy (2005).[14] Its subject is the appearance and/or persistence of norms that are socially self-reinforced by conformist behavior, whereas individually they are judged to be unsuitable, wrong, or inappropriate. The authors explore, through simulation, the behaviors of agents interacting in nonhomogeneous networks. They start from a network with a regular local neighborhood and change its structure to create more irregular local or long-range relationships, by applying the "small worlds" (Watts 1999). In the model, there are three types of agents: those who believe in the norm, those who are opposed to it, and those who uphold it in public but are opposed to it in private (the false believers). Beyond a minimum critical threshold of believers in the norm, the latter can be distributed among the population, which is predominantly opposed to it in private, if enough believers are installed locally for the effects of influence to trigger a chain reaction. The establishment of the norm is thus revealed to be strongly dependent on the local effects of information. It does not manage to impose itself (a) when the agents are connected to one another and therefore have good information on the number of supporters of the norm; (b) when there is an insufficient number of supporters of the norm in a local neighborhood; and (c) when long-range relationships (in a "small world" neighborhood) allow the agents to obtain better information on the number of supporters of the norm. In all three cases, the results obtained are broadly linked to the information propagation properties in the network structures used.[15] Marchionni and Ylikoski (2013, §7) conclude that certain explanatory variables of the model are "structural"; in their opinion, "This constitutes a prima facie case against the association of ABS with methodological individualism."

[14]The title "Emperor's Dilemma" is a reference to a tale by Andersen (The Emperor's New Clothes).

[15]Most of the generic properties of this type of network are quite well known (see, for example, Watts 1999).

The objection formulated by the two authors is similar to the multiple-realizability argument, which is reputed to be one of the most common arguments against methodological individualism—here it is a matter of an agent-based model version. This argument is summarized in an interesting way by Daniel Steel (2006, 453), in connection with the associated explanatory theory:

> The central thesis of the multiple-realizability argument is that a single macro-level generalization is sometimes instantiated by several micro-level mechanisms. In such circumstances, the argument concludes, the macro-level relationship is more unified and hence a better explanation. Thus, the holist might claim, when a macro-level relationship is multiply realized, it will be invariant under a broader range of circumstances than any particular micro-mechanism.

On this subject, James Woodward (1989, 365) defends the thesis that in the social sciences, as in biology or in psychology, for example, numerous theoretical approaches depend on the unveiling of "patterns" or specific regularities with a given level of complexity, which can be produced by various causal mechanisms at the lower levels. These significant differences at the lower levels would justify explanatory theories concentrating on common patterns or regularities: "Put crudely, the basic idea is that complex systems can exhibit different levels of organization and that corresponding to these, different levels of explanation are appropriate." From among the examples classically given in the literature, including the game-theoretical explanations of the behavior of various organisms mentioned previously, we can cite the very general type of equilibrium according to which certain systems, regardless of their initial state and the possible trajectories of the elements at the lower levels, lead to the same equilibrium (Pendergraft 2010; Sober 1983)—the explanation would then concern the system's property to produce the equilibrium described—for example, ecological laws confer a major explanatory role on the parameters at population levels (Garfinkel 1991, 53; Pendergraft 2010). These examples reveal two aspects of the question of multiple-realizability, which we differentiate here—(a) various types of elements at lower levels of complexity and/or (b) multiple behaviors or "trajectories" of these elements, or else (a) the explanatory role of the generic structural properties of the formal model and/or (b) the structural character of the explanation produced by the model in a particular thematic conceptual framework.

Against aspect (a) of the argument, we previously defended the lack of explanatory meaning beyond interpretation of the model in a given thematic

conceptual framework: the syntactic properties of models have no explanatory power in themselves.

In the following, we will consider the explanatory role played by the structures brought into play by models once they have been semantically interpreted in thematic conceptual frameworks. The idea that dominates aspect (b) of the multiple-realizability argument is that "lower-level explanations . . . provide more causal information at the expense of explanatory depth" or else that a state X would be produced "even in the absence of the chain of individualistic episodes which brought it about" (Miller 1978, 407). From that point, explanation is referred back to the higher level of complexity involved. To discuss this deduction, we have to first look at what the notions of "causality" and "explanation" here express.

In the following, we defend that the generic structural mechanisms of agent-based models play, in a particular thematic conceptual framework, the role of partial causes (subjected to ceteris paribus conditions).

5. Mechanisms and Counterfactual Causal Explanations

The counterfactual approach, originally proposed by Lewis (1973), and developed today by Woodward in particular, has its roots in Hume. It is based on the notion of the impact of one event on another. Basically, C is said to be a cause of E to the extent that if C had not occurred then E would not have occurred. This conception is, as Woodward defends, more general and closer to the concept of cause than the nomothetic approach, and it better serves the social sciences. On this basis, the explanation of a phenomenon would lie in the exhibition of patterns of counterfactual dependence thanks to the appropriate interventions.[16] Moreover, this conception allows us to understand the explanation's relative worth (by comparison with the binary character of nomothetic explanation): the more the patterns of dependence in play increase in generality, the more the explanation is supposed to deepen.

For their part, the "process theories of causality," developed in particular by Wesley Salmon and Phil Dowe, associate the notion of causality with the idea of production of a specific effect, along a causal line. These theories attempt to overcome the problem of context dependence of counterfactual

[16]An intervention is "an exogenous causal process that changes some variable of interest X in such a way that any change in some second variable Y occurs entirely as the result of the change in X" (Woodward 2000, 199).

patterns based on a form of traceability of the cause–effect relationship. To do so, they assume that at the foundations of the idea of cause, or production of a specific effect, there is the transmission of something, something that persists—for example, conserved quantities, information, or causal influence. As Kitcher (1989, 470) remarks, we would need to "delineate right causal processes and right causal interactions," but the process theories of causality do not allow that, because what they lack is a prior, general form of explanatory structure. By attempting to identify the causal processes at work in an empirical way, or individual causal histories, these theories remain very close to the phenomenal plane. In this respect, they are based on counterfactual arguments:

> instead of viewing Salmon's account as based on his explanations of process and interaction, it might be more revealing to see him as developing a particular kind of counterfactual theory of causation, one that has some extra machinery for avoiding the usual difficulties that beset such proposals. (Kitcher 1989, 472)

By focusing on particular causal histories, process theories do not determine the general factors likely to more deeply account for a given phenomenon. In addition, they cannot be totally detached from contexts, which would assume being able to exhibit all the phenomenological processes at the origin of a phenomenon, regardless of what it might be. This is a generally impossible task. That is why it has to be limited, and we have to settle for partial satisfaction. Hence, the types of justification that we have encountered, and the law or counterfactual cause to which they are ultimately attached. These types of justification allow the explanation to progress and, for this reason, are close to the idea of cause but are nevertheless differentiated from it. On that subject, Emile Meyerson (1908, 83) cites Maxwell declaring that when any phenomenon is susceptible of being described as an example of a general principle applicable to other phenomena, that phenomenon is said to be explained. The laws are true ceteris paribus, in the same way that, ceteris paribus, the same partial cause (or a same causal process) produces the same effect. But Maxwell adds that, on the contrary, when a physical phenomenon is susceptible of being completely described as a modification in the configuration and the movement of a material system, the dynamic explanation of this phenomenon is considered as being complete, because we cannot conceive of a later explanation as necessary, desirable, or possible.

First, the mechanism—that represents, for example, the modification in the configuration and the movement of a material system—leads to a qualitative leap in terms of "explanation." Henry Margenau (1934, 1950, chapter

19) allows us to provide a fundamental reason for this. The notion of "explanation" in the full sense is associated with the exhibition of the "total" cause of a phenomenon and refers, as mentioned previously, to the elimination of ceteris paribus conditions. It is only possible through closure, or isolation, of the studied system. Only an isolated system—as defined in physics—is protected from any external disruptive force, and from any loss or gain of energy. It authorizes the idea of a mandatory sequence from state A of a system to state B. The isolation of a system is thus correlative to its causal nature: an isolated system is a causal system.[17] It allows us to replace open, natural systems with closed, causal systems, thanks to which we can "explain" the observable phenomena by assuming that they preexist in the state of things that precede them. Hence, Proposition C is suggested:

> **Proposition C:** Causality functionally links states of a system conceived of as isolated.

This is why the problematic of causality is reflected, in the sciences, by the construction of isolated systems. In this way, we move, Margenau explains in substance, from effects as changes in ordinary objects to processes in idealized, isolated, or closed systems. Instead of identifying a partial cause—that may be a thing or an event—of a phenomenon in a "total" (open) system, we model the total cause—which is always a stage in a process—of this phenomenon in a "partial" (idealized, closed) system. Another way of expressing the consequence of the above remarks is to say that causality cannot be elicited chiefly from the data of experience—Hume's finding. It is a methodological principle that reflects the coherence that we lend to the natural and human world. This coherence is expressed by constructs and theoretical models. By constructing closed theoretical systems, we free ourselves, on an ideal plane, of situational contexts. The latter have the indirect role of testing hypotheses developed in the conceptual frameworks of research and implemented by way of models.

In this way, we move from more descriptive conceptions to more explanatory conceptions, not only by generalizing but by constructing. This involves qualitatively leaving the phenomenal plane to explore logics that are assumed to be deeper. On this basis, explanation does not admit degrees purely by

[17]"By its definition, a closed or independent physical system is a causal one, because we call it closed when the laws governing its behavior do not involve time" (Margenau 1934, 144, 399).

virtue of its relative generality, that is, the extension of its fields of application. More fundamentally, it admits degrees by virtue of the possibility it offers to deductively account for observable regularities/patterns, or mechanisms based on a lesser level of construction. At a lesser level, the more descriptive theories answer the question of "how" and, by comparison, at a higher level, the more explanatory theories answer the question of "why." But the "why" is only a "how" in disguise: there is no intrinsic difference between concepts of description and explanation. They nevertheless express relative depth of argument (Margenau 1950, 168-69).

In short, the notion of cause reflects our belief in the coherence of nature and is expressed in the most fundamental way by the idea that the state A of an isolated system will always lead to state B, in other words that the cause of state B is state A. We note that, in stochastic models, random factors artificially create various possible states within isolated theoretical systems. The defined causality principle applies, but A and B, respectively, refer to a set of possible states and, therefore, must be interpreted more abstractly: they characterize common patterns of the possible states they refer to.[18]

Consequently, a narrow relationship associates isolation—causality—mechanism. The explanation, whatever its forms may be (law, partial cause, causal process, mechanism), develops as it passes from the "how" to the "why" and, in this respect, through the possibility of deducing a prior description from another, deeper one. The conservation properties, correlative to the isolation of the studied system, allow us to better understand the way the explanation becomes deeper.

On this basis, we defend in the following that the deepening of the explanation by the identification of generative mechanisms assumes that the (causal) theoretical system we construct involves the persistent or transfactual properties of entities acting within the targeted system. In the social sciences, this deepening of the explanation calls upon methodological individualism's framework of interpretation, relying on social actors' rational capacity (in a broad sense). According to this interpretive framework, forces in action in

[18]This use of the defined causality principle in the case of stochastic models tends to fulfill a consistent conception of causality in science. For instance, on the basis of this causality principle—the determination of the state of a system at time t_{o+t} given the state at t_o,—Margenau (1934, 1950) could explain that quantum theory was consistent with the causal character of physical analysis, but necessitated a new conception of the definition of physical states in a more abstract manner (in terms of mathematical functions satisfying certain requirements).

society are governed by the subjective meaning of/the reasons for individual actions.

6. Generative Mechanisms and Methodological Individualism's Framework of Interpretation

The idea of the conservation, and more generally of the persistence of something in time, spans the epistemology of Meyerson, who is currently experiencing renewed interest.[19] Science meets a need to not only act but, above all, to understand. And it is by assuming some identity over time that it can best do this. Actually, what persists is not important; the main thing in the first place is that something persists. This conception of explanation is associated with the idea of a mechanism mentioned above. We will see that it deepens into the idea of a generative mechanism.

To overcome the a priori constantly changing—and in this respect incoherent—aspect of reality,

> I might assume that the elements of things have remained the same, but their arrangement has been modified; from that point, with the same elements, I will be able to make very different sets appear, just as, by using the same letters, you can compose both a tragedy and a comedy (the image is from Aristotle). (Meyerson 1908, 83)

Explanation by persistence over time and the recomposition of the entities brought into play is not intended to be exclusive, but it satisfies a rational demand from the point of view of understanding.[20] The identification of

[19]This is emphasized by Frédéric Fruteau de Laclos (2009).

[20]Unificationist theories, for their part, reduce the explanatory power of theories to their unifying power. They are based on a need for economy of cognitive means—that of deriving the most consequences with as few premises as possible—and are thus interested in deductive activity independently of its meaning. Michael Friedman (1974, 14-15), by illustrating the unificationist theory, also feeds the theory of explanation by the mechanism and, more specifically, by the generative mechanism. He explains that, thanks to the kinetic theory of gases, in the place of the Boyle-Charles law, Graham's law, and its specific heat capacities—we have a more comprehensive single explanatory phenomenon—"that molecules obey the laws of mechanics." Here, we have cognitive economy through the possible deduction of diverse laws based on the behavior of gas molecules. But more fundamentally, it is the interpretation of these laws on the basis of the movement of persistent entities over time—gas molecules—that underpins deeper understanding of the phenomena described by the laws.

persistent factors over time often leads to the substitution of a variation over time, by a variation in space. The need to understand by identification leads, according to the point of view developed here, to the notion of a generative mechanism.

We previously defined the mechanism as an isolated, causal system. The notion of a generative mechanism has been the subject of numerous discussions in the literature, which, due to lack of space, we are unable to revisit. We note, however, that these discussions have as their common ground the idea that the generative mechanism consists of an intellectual representation of the specific combination of factors that "genuinely" generate the phenomenon in question.[21] It has also been advanced that the idea of a generative mechanism is rooted in the differentiation of the theoretical levels of complexity where the explanandum and the explanans are, respectively, located, as emphasized on multidisciplinary grounds, for instance, by Arthur Stinchcombe (1991). The deepening of explanation—involved in the idea of generative mechanism—by recourse to entities located at a lower level of complexity enables us to account for the state B of a system based on a recomposition of the elements of that system which were already present in a previous step A.

In the current philosophy of science literature, forms of persistence over time that serve explanation are defined in particular in terms of "powers" or "capacities" (Groff and Greco 2013). In this respect, Phyllis McKay Illari and Jon Williamson (2011) oppose the "active" approaches such as Machamer, Darden, and Craver's activities approach; Nancy Cartwright's (1989) capacities approach; and Carl Gillett's powers approach, with passive approaches which characterize interaction using laws or some counterfactual notion or other.[22] Causal powers or capacities are dispositional properties of the entities brought into play, and which scientists tend to interpret as real. In this respect, they are not subjected to ceteris paribus conditions: they designate tendencies to produce certain effects in a trans-situational way. In Cartwright's works, they designate causal tendencies which continue to produce their effects, in various situations, by interfering with the course of other factors or processes.

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[21]See Stinchcombe (1991), Bunge (1997), Hedström and Swedberg (1998), and especially Boudon (1998) and Elster (1998) therein; also Goldthorpe (2000), Mayntz (2004), Cherkaoui (2005), Hedström (2005), Berger (2010).

[22]On the contemporary debates surrounding active approaches of causation, see, for example, Mumford (2009); Ellis (2010); Marmodoro (2010); Bird, Brian, and Sankey (2012); and Groff and Greco (2013).

These capacities/powers, by the trans-situational dispositions they cover, meet the quality of persistence over time that constitutes, according to Meyerson, a deepening of explanation and involve, according to the point of view developed here, the notion of a generative mechanism. Active approaches of causation are therefore closely linked to the idea of a generative mechanism. The literature bears witness to this liaison, through the filiation between contemporary theories of causation involving real dispositions or powers, and the works of Harré (1970) and Harré and Madden (1973) who associate the terms "power," "capacity," or "tendency" with the idea of explanation in terms of generative mechanisms, and Roy Bhaskar (1975), who identifies generative mechanisms as "transfactually active mechanisms."[23]

Causality, conceived as a methodological principle necessitating isolated systems, is not only consistent with the active approach to causation—that is, the idea of "trans-situational" causal power—but strengthens on this basis. Whereas the causality principle applies to the representation/description of things, the idea of causal power applies to the things represented. The quality of the explanation produced by the model depends on the quality of the links between the model and the targeted system. The causality principle calls for the construction of isolated systems and, therefore, the quality of the explanation produced by these isolated theoretical systems entails the tendency to isolate the targeted systems. This isolation/independence of targeted systems can only be approximated but it strengthens when explanation refers to factors with transfactual powers/capacities. Our aim is not to discuss the emergent literature on dispositional realism—developed around the idea of causal power—even if the views developed here are consistent with several points debated within this literature, as well as with critical realist conceptions

[23]In the view developed here, generative mechanisms refer to models whereas Bhaskar (1975, 50) as well as Harré and Madden (1973) identify generative mechanisms with the "ways of acting of things," that is, their powers or capacities, so that they involve open systems as well as closed ones: "It is only under closed conditions that there will be a one-to-one relationship between causal law and the sequence of events. And it is normally only in the laboratory that these enduring mechanisms of nature [generative mechanisms], whose operations are described in the statements of causal laws, become actually manifest and empirically accessible to men. But because they endure and continue to act, when stimulated, in their normal way outside those conditions, their use to explain phenomena and resistence to pseudo-falsification in open systems can be rationally justified" (Bhaskar 1975, 46). We note that the point of view developed here does not entail the ontological commitments of Bhaskar's works and other critical realists.

linked to Bhaskar's first works. Nevertheless, our assumptions are methodological and not ontological and contrast on various other fundamental issues with those sustained by certain prominent authors associated with these philosophical currents.[24]

We propose to define, in connection with the dispositional notion of capacity/power, the idea of generative mechanism in the following way (Proposition D):

> **Proposition D:** A generative mechanism explanation is a causal explanation involving the (trans-situational) capacities/powers of the active entities in play.

The generative mechanism marks a step forward regarding explanation, compared with the law, the counterfactual cause, the causal process, and the mechanism that does not match definition (D), from the moment it allows us to deductively account for other forms of causes.

In addition, we can deduce propositions that precede the following condition (Proposition E):

> **Proposition E:** One necessary condition for agent-based models to model generative mechanisms is that the properties of the active entities in play in the conceptual modeling framework are associated, in the thematic conceptual framework, with (trans-situational) capacities/powers.

Advances in the conception of human rationality reveal it to be not only a capacity that is transcultural in its essence, with "reasons" varying according to the auxiliary means for thought that individuals possess (Bulle 2016), but also a general capacity that is not reserved for utilitarian reasoning and includes in its scope even the deepest individual purposes (Boudon [1999] 2001). Individual purposes still appear, in the vast majority of works in the social sciences, to be unconsciously imposed by the social systems in which social actors participate. Works referring to mentalities, dispositions toward, and habitus, for instance, that assume there to be no trans-situational, rational common ground, prevent us from combining explanatory models that are concerned with different domains of social action. The conception of rationality as a trans-situational capacity accounts for the very meaning of

[24]Among them we note the reductionnist interpretation of methodological individualism, especially in Bhaskar (as well as in Margaret Archer, see, for instance, Archer 1998)

interpretive/comprehensive sociology, through the relationship of possible understanding between the observer and the observed. This does not mean that the meaning of/reasons for individual actions might be easily accessible to the observer, or even that the social actor might be fully aware of them, but that ideally, contextual information can render this meaning/these reasons sufficiently clear that the observer might grasp them in an internal way, through his or her own means, such as through empathy. On this subject, the concept of rationality does not play a normative role, but an epistemological one: it enables us to judge the relative relevance of alternative explanations based on the allowed understanding of the meaning of/reasons for individual actions.

Hence, Proposition F is suggested:

Proposition F: The rational (in the broad sense) tendency that underpins the meaning of/reasons for individual actions for methodological individualism represents the type of trans-situational capacity that allows the representation of generative mechanisms in the social sciences.

7. The Explicative Power of Structures and Methodological Individualism

We have seen that the impossibility of tracing back to all of the "causes" of a phenomenon leads to the closure of the "system" and to the mechanism, and from a deeper explanatory point of view, to the generative mechanism. This closure involves a movement of theoretical construction that detaches the postulated causal factors from phenomenal reality. It is a question of, based on models, deriving propositions (assumed to be) true about the causes.[25] The distance taken with regard to the phenomenal plane then explains that we are referring to entities at the lower levels of complexity and to their activities/capacities, but without accounting for the individual causal histories at the practical origin of the observed phenomena. This distance contradicts the multiple-realizability argument opposed to methodological individualism: generality does not involve structures alone. Explanations of the "equilibrium challenge" or of ecological laws are not strictly structural and bring into

[25]This approach to explanation fits in with a propositional approach to representation (Bailer-Jones 2003, 60) according to which models can be expressed in terms of propositions about the empirical world. When a model represents a phenomenon, the model entails propositions that are true with regard to that phenomenon.

play information on the modes of action/interaction of entities at lower levels of complexity.[26] The explicative power of social and relational structures remains partial and only constitutes an intermediate step along the explanatory path.

The description of the generative mechanisms of studied phenomena calls for an understanding of the way the active entities involved act/interact, the scope of which is trans-situational. These active entities are the bearers of the assumed forces in action. In this respect, the transition from a state A to a state B of the system represented by the model relies on the capacities/powers of these active entities. Rationality, in the broad sense of the term, represents the trans-situational capacity of the social actors implemented by methodological individualism: forces in action are supposed to be governed by the subjective meaning of/the reasons for individual actions. This is why the condition that methodological individualism imposes on the explicative power of structures is to act in the form of contextual properties affecting the meaning of/reasons for individual actions (Proposition G).

In this framework, even the case evoked above of Axelrod's experiment on the evolution of cooperation reveals the explanatory power of individual situational perceptions and rationality. As Axelrod (1984, 34-40) explains, a strategy that would have won the first part of the contest by a large margin, if it had been tried, is a variant of Downing's which views Prisoner's Dilemma behavior as problem-solving behavior. The rule is based on an attempt by the player to understand the responses of the other player to his or her choices and to make the choice that will yield the best long-term score based upon this understanding. The second part of the contest revealed that the variants of Downing proposed were dominated by specific programs expressly defined to take advantage of the others. As one of us defended elsewhere (Bulle 2009), this alternative model not only appears to be comparatively successful but may deepen our understanding of the evolution of cooperation: rationality (in the broad sense) may be regarded as a capacity, produced by evolution, with evaluative and strategic potentialities serving cooperation far superior to that produced by the mechanistic Tit-for-Tat rule.

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[26]One example of population ecology involves, for instance, an ecological system composed of foxes and rabbits. Even if one cause of death in the rabbit population is a structural feature of the system, the large fox population, this is only a partial cause: without a certain distribution of rabbit and fox populations, a certain number of rabbit's deaths would not have occurred. Periodic fluctuations in the population levels of the two species are explained on the ground of predation/reproduction logics (Pendergraft 2010).

Relying upon the causal explanatory approach developed by Woodward, Steel (2006, 441) defends that "the generalizations involved in individual level explanations are invariant under a significantly broader range of interventions than their group-level counterparts." This is why Woodward's approach allows us to defend that generalizations at group levels can explain, but that they are less deep than explanations that bring individual levels into play. One consequence, according to Steel, is that even if functional social systems can be multiply realized by individual-level mechanisms, the former offer explanations that are less general than the latter. This is an explanatory advance that Woodward (2000, 220) also attributes to methodological individualism. For example, it is on the basis of hypotheses relative to the behavior of rational economic agents—and not purely macroeconomic relationships—that it is possible to generalize explanations of situations where the conditions concerning information and incentives are different—which would show, he states, that there are no fundamental explanatory relationships between macroeconomic variables.

No doubt the limits Steel sees in the relative generality of the principles of methodological individualism, linked to the problem of the reversibility of preferences, only express the limits of the representations of rationality in question, and not the limits of methodological individualism. This is true as long as a form of identity over time of the social actors' capacities in play remains true, and the evolution of preferences can be incorporated into a more general or deeper approach to rationality. But this persistence over time of capacities satisfies, let us recall, just as much the search for a more essential truth as a cognitive need to understand, which tends to reduce that which evolves to that which remains stable.

We note that the reference to rationality as a trans-situational capacity allowing understanding of the meaning of/reasons for actions for the methodological individualist not only deepens the explanation by virtue of the range of possible "interventions." The explanation is deepened by virtue of the deduction allowed of the various regularities/patterns observed through the valid possibility of "closing" the explanatory system, of detaching it from the different contexts of "intervention," and, also, of combining different models.

A theoretical alternative that is very present in the literature in the social sciences consists of assuming that the explicative power of social/relational structures is exercised by the action of unconscious processes. That is what operators such as "habitus," "socialization," and "dispositions toward" express. However, these operators have no explanatory power comparable with the notion of rationality (in a broad sense) which, as we have seen, is a trans-situational capacity. Explanation deepens once we can deduce the

properties of the systems these same operators describe based on the meaning of/reasons for individual actions. In reality, these operators simply reflect the partial or counterfactual explicative power of the social/relational structures.[27] This is why we put forward Proposition H:

> **Proposition H:** Beyond the explanatory conditions of methodological individualism, the explicative power of social/relational structures refers very generally to partial or counterfactual causes.

8. Conclusion

The purpose of this article was to study the relationships between analytical sociology, which tends to focus on the structural dimension of the explanation offered by the syntactic properties of complex system models, and methodological individualism's generic framework of interpretation that relies on social actors' rational capacity. According to this interpretive framework, forces in action in society are governed by the subjective meaning of/the reasons for individual actions. We have differentiated between two different problems. The first relates to the explanatory power of the generic structural properties of models, and the second to the explanatory power of the social/relational structures in a defined thematic conceptual framework in the social sciences. These two problems are related to the multiple-realization argument, which is associated with unificationist explanatory theories, and opposed to methodological individualism. Our discussion of the first problem mainly led us to formulate Propositions A and B, and our discussion of the second problem, Propositions C to H.

> **Proposition A:** A formal system or model is, from the point of view of the phenomenal world, asemantic; it "speaks" of nothing. It is given its meaning by an interpretation of the entities, properties, and relationships that define it in a thematic conceptual framework.
> **Proposition B:** There is explanatory complementarity between the structural generic properties of models and the semantic conditions of

[27]The process of socialization tends, for example in Talcott Parsons (cf. Parsons [1951] 1964, 203-205), to simply conform the orientations of the individual personalities, defined in terms of motivations, to the requirements of the social system, defined in terms of roles. This type of interpretation of social action puts the accent on structural logics that have no trans-situational range. The causal structure in play is, according to the point of view developed here, only partial.

interpretation associated with the thematic conceptual research framework.
Proposition C: Causality functionally links states of a system conceived as isolated.
Proposition D: A generative mechanism explanation is a causal explanation involving the (trans-situational) capacities/powers of the active entities in play.
Proposition E: One necessary condition for agent-based models to model generative mechanisms is that the properties of the active entities in play in the conceptual modeling framework are associated, in the thematic conceptual framework, with (trans-situational) capacities/powers.
Proposition F: The rational (in the broad sense) tendency that underpins the meaning of/reasons for individual actions for methodological individualism represents the type of trans-situational capacity that allows the representation of generative mechanisms in the social sciences.
Proposition G: For methodological individualism, social/relational structures have an explanatory or causal role in the representation of generative mechanisms only insofar as they affect the subjective meaning of/the reasons for individual actions by the contextual properties they define.
Proposition H: Beyond the explanatory conditions of methodological individualism, the explicative power of social/relational structures refers very generally to partial or counterfactual causes.

From these various propositions, we deduce Propositions I and J:

Proposition I: There is no inherent connection between agent-based models, the mechanism-based structural explanations they can deliver, and methodological individualism. But such a connection is necessary for generative mechanism-based explanatory approaches.
Proposition J: Analytical sociology, focused on the study of mechanism-based structural properties, cannot do without methodological individualism for the representation of generative mechanisms in the social sciences.

In conclusion, for the reasons stated above, the syntactic properties of models have no explanatory power in themselves and the explanatory power proper to social and relational structures is essentially partial—linked to ceteris paribus conditions. Therefore, it is not desirable that formal modeling work in sociology, and that developed around agent-based models in particular, should be liberated from the generic conditions of explanation in the social sciences expressed by methodological individualism (Propositions F and G).

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) received no financial support for the research, authorship, and/or publication of this article.

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