System Dynamics Modelling in the Development of Management and Organisational Theory

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Abstract

This paper explores the contribution and the influence of system dynamics in the development of management and organisation theory. It begins with a brief discussion of the contribution of computer modelling and simulation in theory development for the above areas. It then discusses the practice of management theory development from the sociology of science perspective using Bourdieu's concepts of Field and Habitus, as well as Actor-Network Theory, and places the system dynamics methodology in their context by considering the influence that system dynamics scholars can have. The resulting conceptual framework is then demonstrated by presenting two different cases of operations strategy theory development using system dynamics modelling and simulation.

1. Introduction

Compared to other social and humanistic areas of study, the use of modelling and simulation for theory development in management and organisational studies (these terms will be used interchangeably in the article) has been relatively late and limited in scope (Davis, et al., 2007; Harrison, et al., 2007). However, simulation modelling as a theory development instrument, situated between pure deductive and inductive methods, can overcome the limitations of traditional approaches as far as their ability to analyse multiple interdependent processes operating simultaneously is concerned, (Harrison, et al., 2007; Larsen and Lomi, 2002).

Almost in every review article on the use of simulation modelling for management theory development, system dynamics is presented as one the most common simulation modelling approaches/formalisms (Davis, et al., 2007; Harrison, et al., 2007). In practice, in employing SD, or any other simulation approach, the main idea is to introduce experimentation laboratory conditions in social systems research, but seems to be no interest in the context under which the models are developed, i.e. in the "sociology" of simulation-based theory development. Nevertheless, most system dynamics scholars are well aware that system dynamics is more than a modelling formalism, more than another tool for experimentation, more than a different way of representing the same things at different level. It carries a methodology of use with, at least fragments, of a social theory behind its use (Lane, 1999) and "grammar" (Bloomfield, 1986), i.e. a related set of assumptions about its employment and the

way the reality is viewed through its modelling syntax. Viewed within a wider context, these play a decisive role on the process of theory development *per se* (e.g. whether a set of assumptions is considered as given or developed through the modelling process) and on its outcomes.

The aim of this paper is to analyse modes of use of the system dynamics (SD) methodology and its related artefacts within the *practice* of management and organisational theory development for assessing, through the lens of sociology of science, its contribution in the process and content of organisation and management theory. Towards this end, we use Bourdieu's theory of social practice (Bourdieu, 2007), more specifically the notions of *Field* and *Habitus*, to construct a conceptual framework of analysis, in which two cases of using system dynamics to develop theory on organisational issues of the operations strategy process (Slack and Lewis, 2002) are analysed in a self-reflexive manner. The framework is complemented with an Actorr-Network Theory perspective to account for the heterogeneity of the actors (humans and non-humans) involved in such a process. In this way, the contribution of our work lies on the surfacing of the importance of system dynamics as an instrument for management theory development – in addition to its use as a system intervention methodology which prevails in the related studies and literature – and its potential and limitations to influence theory through the incorporation of SD scholars and artefacts in its development process by exposing its abilities and limitations in specific theory development practical social settings.

2. On management theory and system dynamics

In a rather formal way, Campbell (1990) defines theory as a "collection of assertions, both verbal and symbolic, that identifies what variables are important and for what reasons, specifies how they are interrelated and why, and identifies conditions under which they should be related". From a different perspective, DiMaggio (1995) argues that theory is "an account of a social process, with emphasis on empirical tests of the narrative as well as a careful attention to the scope conditions of the account". However, independent of its assumed focus and the emphasis given, most scholars of theory development agree that theory consists of constructs, propositions that link constructs together, logical arguments that explain the propositions using existing widely accepted theories, and assumptions that define the (restricted) area within which the theory is valid (Davis, et al., 2007). The process of theory development is the process by which all four elements are bound together, having in mind possible, or even actually carrying out in parallel, the evaluation of theory by means of either testing the ability to explain variance of a variable or a criterion, or by assessing the richness of the theory and its fit with empirical data, or by testing its fit with empirical data (Bacharach, 1989; Eisenhardt, 1989).

In social sciences in general, and management theory more specifically, we can use the distinction of theories given by Nadel, according to which social theory is *either*
a) a set of linked substantive propositions that tries to introduce something novel, something that we do not know about our social (micro or macro) world. (These propositions require empirical verification or rejection.), *or*
b) a set of instruments, or conceptual frameworks otherwise, that facilitate the construction of real grand theory (Nadel, 1962; Mouzelis, 1995).

These two types of theories correspond to Althousser's Generalities II (theory as an instrument or medium) and Generalities III (theory as a tentative final product), respectively (Althousser, 1982). In this dipole, Parson's theory of social systems is an example of Generalities II, since it can be used as an instrument to develop "final-product" theories, such as, for instance, the theory of the origins of the industrial revolution in England end its effect on the family and labour processes is (Smelser, 1962). In the same manner, system dynamics and its surrounding social theory can be considered as belonging to Generalities II, i.e. it is an instrument that can be employed in different practical settings for developing theory as a teleological product, as well as more specific conceptual frameworks. The models developed and the simulations executed using these models at a latter stage in association with other intellectual constructs and artefacts are used for developing final product theories about organisations, strategies and their relationships with the socioeconomic environment.

David C. Lane has been the System Dynamics scholar with a concern on the social theoretic assumptions surrounding the field (Lane 1999; Lane 2000; Lane 2001a; Lane 2001b). His main interest and analysis is centred on placing system dynamics within the social science controversy of subjectivism/objectivism and the related agency/structure dilemma (Lane 2001a; Lane 2001b). He has used a historical perspective on the employment of system dynamics as an intervention methodology for problematic situations to asses its social substance, and described the gradual transition of objective assumptions about the modelled world and the situation at hand (originated from the functionalism of systems theory) to more subjective modes, i.e. when system dynamics models are used as means for understanding and reflecting on situations and possible interventions. Clearly, one of the reasons of this transition is the use of system dynamics in association with other more interpretevistic methodologies such as the Soft System Methodology (Lane and Oliva, 1998), or as a communicative medium in action research studies (Vennix, 1996). In specific interventions, although the models developed can be thought as theories about how the issue can be represented, they can only be considered as representations of specific situations embedded in specific instances in time, rather than a-historic theories of global validity. After all, the building of such models assumes the existence of theories which are taken as given for assessing the specific situation. These models are different from models built for developing theory, the main difference being the context within which models are built and used.

But social theory is not related to system dynamics exogenously only though its mode of practical employment. System dynamics as a representational formalism has the inherent social assumption that the world consists of, and thus represented as, interconnected feedback loops that result in policies and corrective actions that may have counter-intuitive results. In other words, when these assumptions are taken as granted and emphasised in the analyses, system dynamics, in addition to a modelling technique, can be considered as a theory of behaviour of social systems (Bloomfield, 1986; Lilley, et al., 2004). Taken at the extreme, this may be dangerous as "Claiming to have 'discovered' the route to the source of the mysteries of the social world, system dynamicists place themselves in pole position for the construction of new policies to combat the threats they discover. System dynamics may be viewed as 'a type of social theory … which is explicitly designed for large-scale social engineering'" (Bloomfield, 1986).

In the majority of theory and theory development literature, the underlying assumption has been that theory is a property of disciplines of scientific inquiry, and that it is the output of some sort of "black boxes" instantiated in the form of universities, research institutes, research groups, even researcher's minds. In reality, however, theory development is something that people actually *do*, something that needs to be treated at the micro-level of the individual scientist (the theory developer), research establishment, context of development, as well as the tools of development (artefacts), including simulation models. A treatment at this level will produce insights on how systems dynamics constructs and artefacts are used, transmitted, exchanged, traded etc. among the people that in one way or another participate at the theory development *practice*. The sociology of science is a scientific discipline that deals with these issues from a number of different perspectives, each of which embraces a different sociological paradigm. However, all approaches, with the exception of Bourdieu' s Field-based theory, operate at the micro-sociological level only overlooking the effect of higher level structures on the actions of social agents, such as individual researchers, research groups, etc. (Bourdieu, 2001). In addition, it Actor-Network Theory that provides a framework for understanding the role of technological artefacts – in general, non-humans- in the process of construction of science and scientific facts (Latour, 1987). Following, we briefly visit these streams of thought in the context of SD-modelling-assisted management theory development.

3. *Scientific Fields, Actor-Networks* and the practice of theory development

(Social) practice as an area of inquiry is where the macro level of structures and the micro-level of agency meet and can be treated in holistically. In Bourdieu's thinking which tries to resolve the structure/agency controversy through the mediating role of practice, society and micro social activities, such as the individual activities of academic research in general, and management theory development in particular, can be analysed using the concepts of *Field* and *Habitus*. A Field is an autonomous "system" of (social) positions, structured internally in terms of power relations. Fields can be interconnected and are constructed in accordance with underlying *Nomos* which are fundamental principles of "vision and division" (e.g. academics and practitioners), or organising laws of experience that govern practices and experiences within a field (Bourdieu, 2007). Habitus is the set of dispositions that social agents have as a result of living and acting in particular cultures. There is a two-way relationship between Habitus and Field. The Field is constructed by the social agents that possess the dispositions that define intellectually the Field. On the other hand, the agents that participate in a field incorporate into their Habitus the formal and tacit knowledge that allows them to participate in the constitution of the field. The power and the positions of agents are defined according to the intellectual/symbolic capital that they have managed to accumulate.

Scientific research constitutes a Bourdieuian Field, and specific scientific disciplines also constitute fields at a lower level of analysis (Bourdieu, 2001). The very process of organisational and management theory development and its different facets also constitutes a field which is connected to other fields of communities and organisations (Figure 1). In other words, the process of theory development and the place where it is carried out are structurally embedded which higher level structures from which they inherent properties expressed as particular orientations on the way the research is conducted and its results are deported. When system dynamics is used in the theory

development process, it constitutes a Field with its own culture, structure and social theory assumptions that contributes to the constitution of the organisation and management theory development Field. As individual Fields have specific *discourses* (a discourse as an institutionalized way of thinking, or as Michel Foucault has viewed as "systems of thoughts composed of ideas, attitudes, courses of action, beliefs and practices that systematically construct the subjects and the worlds of which they speak" (Lessa, 2006)), and organisation and management theory development Fields are constituted or influenced by other Fields, according to their structure and Habitus, in some of them system dynamics is the dominant discourse whereas in others plays only a minor role.

Individual "scientific" agents, groups and institutions are defined and establish positions within the field according to the magnitude and specialisation of the capital they possess. At the same time, they define the structure of the Field, which in turn determines the structure of the forces that are exercised on the production of theory, i.e. in the practice of theory-producing scientists. Fields are characterised by internal contradictions and power struggles, in which the power of each agent depends on the differentiating factors that provide him/her with competitive advantage from the magnitude and structure of the different sorts of capital that he/she/it owns. The scientific capital (the word "scientific" with a wide sense of meaning) is a special type of symbolic capital that it is based on knowledge and recognition. The way this capital is distributed determines the structure of the Field, that is, the distribution of power among the different scientific agents. The ownership of a significant quantity of capital (a relatively large quantity of the total capital) results in an advantageous position within the Field and can monitor the entry to the Field, as well as the distribution of "profits"/rewards of the scientific research.
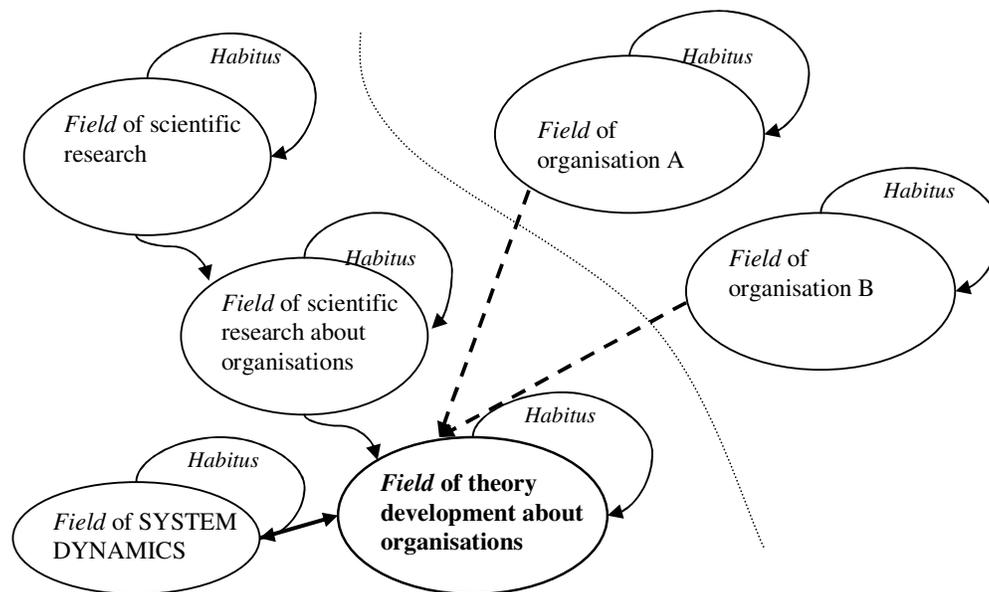

Figure 1. *The Field of organisational and management theory development in the space of Fields*

There is, however, a persisting question as far as social, including management, theories are concerned: Why some theories seem to have greater acceptability and longevity? Why some theories – though not empirically proved in a rigorous way – seem to be more credible than others, and taken for granted more easily than others? By what organisational means do they keep themselves in place and overcome the resistances that would have brought them tumbling down much sooner?

To answer the above questions, as well as the question 'To what extend system dynamics can contribute to the robustness and longevity of a management theory', we turn our analytical lens on the *Actor-Network Theory* (ANT), an approach to sociology in general, and to the sociology of science in particular (Callon, et al., 1986; Law 1986, Latour, 2005). This theory, also know as the sociology of translation, is also concerned with the mechanisms of power. According to ANT, bits and pieces from the social, the technical, the conceptual and the textual are fitted together and '*translated*', i.e. are converted into a set of equally heterogeneous products. Therefore, we can assert that according to ANT management theory is a heterogeneous network, which is the product of translation of the constituent elements of the development process. The network is always in a forming state, i.e. it constitutes the basic element of agency, and in which internally there is no difference and substantiality between, for instance, the SD-proficient modeller (the human agent), the SD simulation model (the technological artefact) and the tabulation and commenting of the results of simulation (the textual).

According to Actor-Network theory, different strategies are responsible for the resistance and durability of networks, as well as for the dominance of some networks over others. One of these strategies is based on the durability of some "materials" that maintain their relational patterns longer than others. So, thoughts don't last long, speech lasts longer, and text even longer, not to mention technological artefacts such as simulation models.

In the following section, we will further clarify and concretise the issues raised in this section by examining two cases of organisational theory development using system dynamics.

4. Facets of the same Field – Two cases of organisation/management theory development using system dynamics

The following two cases are descriptions and analysis based on the author's experiences of the process of organisational theory development in the specific area of operations strategies, employing at some point in the process a system dynamics simulation model. Both cases refer to theory of the *process* (rather than content) of operations strategy, i.e. the aim was to theorise about how operations strategy is developed in different organisational contexts, in either a voluntaristic or deterministic mode. So far, most of the related research has been developed inductively by means of empirical studies that frequently led to the production of normative accounts of how operations strategies should be developed (e.g. Hill, 2000; Platts and Gregory, 1990). In each of the two studies whose presentations follow, the theory-producing micro-Field of the research team is constituted differently and influenced by different Fields. In the first case, the Field is solely derived from

academic research in organisation theory, operations management and system dynamics, whereas in the second, these Fields interact with organizational practice.

According to the discussion of the previous section, the mode of employing system dynamics for theory development with respect to the operations strategy process depends on the position of system dynamics modelling in the structure of the corresponding Field, which in turns influences the way the issues are understood and represented in the system dynamics model. In addition, the modelling process *per se* influences the structure of the Field as agents of system dynamics expertise bring in new symbolic capital from a more formal discipline. Moreover, the position of the simulation model vis-à-vis the other contributing actors determines influences the durability and acceptability of the developed theory. The cases are presented in a somehow neutral way, but are the triggers of the critical discussion that follows.

4.1 System dynamics in management theory development as academic practice

In such as setting, theory development is usually conducted within academic premises (universities or research institutes). A Second Order model is constructed and simulated. In fact, these models are abstract representations based on a plausible reconstruction, or integration, of an underlying theoretical narrative as an aid to the process of theory building (Larsen and Lomi, 2002; Malerba, et al., 2001; Péli, et al., 1994; Sastry, 1995). The narratives are the product of intuition and cognitive frames formed by reading the related literature, discussions with colleagues and practitioners, images from visits to places of work, contact with audiovisual materials, even simulation models. Both formalised and tacit knowledge triggers and forms the basis for the production of new knowledge. The system dynamics simulation model is employed for formulating hypotheses that are not purely linear, i.e. they have feedback loops and for describing parameter evolution with time that is not regular. Clearly, even if the knowledge/power relation of the Field is evenly developed, the system dynamics modelling ability, which relates primarily to tacit knowledge, can be a source of exercising symbolic dominance. Theory building is based on the assumption that the relative issues concern activities and functions which are external to the theory builder's world, and whose exact representation is sought (Lilley, et al., 2004). In this way, the dominant position of SD plays a decisive role on the construction of the issue about which the theory is to be developed. The narrative becomes plausible within the limitations of the language of system dynamics and its underlying social theory of feedback loops, control and search for counter-intuitive behaviours, at a representation level where primarily "systems" and "averages" , not individuals, constitute the basic elements of organisations.

A system dynamics model developed by the author and his colleagues to produce an evolutionary theory of manufacturing/operations strategy process (Adamides and Pomonis, 2008) is an example of such a mode of model use. The whole effort was initiated by a plausible narrative produced by insights from operations management theory and the resource based view of the firm, dynamic accumulation of capabilities in particular. The narrative was integrated on how managers from three operations-related functional units (new product development, production, sourcing and distribution) decide on the development of functional capabilities under interrelated constraints. The modelling was not detailed, and a rich set of assumptions was used for both the definition of the scenarios, i.e. the variation of organisational parameters

of pattern of decision interaction, limits of managerial ability, distribution of incentives and height of vertical hierarchy, as well as of the performance metrics. The inherent system dynamics social theory was in line with the objectives of the theory, i.e. the mechanisms of coordinated capability development, where coordination implied corrective actions to gradually reach the organisation-wide objectives.

Clearly, in this micro-Field, dispositions are developed by the texts and narratives of related theories (evolutionary theory, resource based competition theory, etc.), by the practice of system dynamics, as well as by the general culture and "rules of the game" of scientific research. The value of the system dynamics model and the simulation results (whether they are useful or obsolete) is determined not only by the internal validity tests of the system dynamics methodology, but also by the dominant mental frames of the related scientific community, i.e. how many, and how deep assumptions the community is willing to accept. In our effort, there was no tendency and urgency to accept or "correct" observations that they were not in accordance with previous observations or related theories because the theory developers were not associated with any such intellectual construct neither they belonged to any particular school of thought or group as an organisational entity (Bloomfield, 1985). Obviously, this attitude limits the acceptability of the theory, and makes its testing using empirical methods more difficult.

In this theory development setting, the contribution of system dynamics is to structure the theoretically developed constructs, even in cyclic (feedback) manner, and explore their variability with respect to time. It also provides easy tests for theories, but it may further limit the imagination and improvisation of the theory development process. Moreover, system dynamics contributes to the enrichment of the narrative as concepts are laid out in a 2D space – the space of the model – and additional links are identified. Also to explore the dynamic complexity of the issue, i.e. the interdependent evolution of the constructs and the feedback structures that are formed among them.

4.2 System dynamics in management theory development as academic-organisational practice

In this case, in addition to academics, the theory development process involves practitioners (managers, workers, etc.) and the heterogeneity of the network, from its initial point of formation, is more intense and includes additional actors of the organisational life (memos, forms, logos, etc.) Practitioners are not there to evaluate theoretical constructs but to contribute to their development. This means that the micro-Field of the theory development social process carries the structural properties of both the organisational everyday social life and scientific research Fields. Of particular importance is how these two Fields interact in the management theory development process, i.e. how active is the participation of each of the two communities and what is the power distribution among the two. The whole effort may be initiated by, and be of interest to academics only, with organisational agents passively providing information about their organisation (and not only) lives. Alternatively, in an action research project, practitioners may have a more active role and participate in the development of the constructs and the links among them. In this case, they induce characteristics of their Field (e.g. power structures) into the micro-Field of the specific theory development effort. This, however, is not an unnecessarily undesired fact, as a more rich representation of the organisational reality is induced

into the project. The outcome of such a research effort may be both a theory as a final product, but more frequently, a conceptual framework.

Apparently, in such a research setting, system dynamics plays a supportive role. The model usually acts as an intermediary and is constructed in parallel with the analysis. Modelling supports the participative inquiry for constructs, propositions and assumptions, whereas the information obtained and the narratives constructed help in enriching and refining the model. Hence, in addition to its teleological purpose, that is a meaningful and communicative representation of the theory, the model acts as a driver of the inquiry. Nevertheless, this is an important role, as it mediates the social construction of the issue the theory is going to deal with, performed in the interplay of academics and practitioners.

A model developed by the author and his colleagues (Adamides and Voutsina, 2006) in a theory development effort regarding the interactions in capability developments between the manufacturing/operations and the marketing functions can be considered as a system dynamics contribution in an action research micro-Field. The effort commenced with no previous "grand" assumptions and no assumed objective knowledge of the organisational world and the specific issue. It was the research social process and modelling that drove the consideration of other theories such as prospect theory. There was a clear tendency of the academics to look for counter-intuitive behaviours in the rather simplistic propositions of the practitioners. The outcome of the project that took place in a particular organisation is a theory (the double helix model) that clearly requires further empirical evaluation. In this case the evaluation of the theory has nothing to do with variability, that is, investigation of the outcome of different scenarios, but it only concerns the replication of the same pattern. In this sort of inquiry and theory development, the ability to monitor time in the simulation models acts against the tendency of the participating practitioners to induce a historical (time and context specific) element on the study, i.e. to view things under the perspective of the specific situation, given the dominant position of practitioners, as far as practical knowledge is concerned.

5. Discussion and concluding remarks

There has been a long-standing debate in the field of organization (and management) theory about its nature, as far as its epistemology is concerned. There are scholars arguing that organizational theory is an objective science (Donaldson, 2003), as there are scholars in the support of the views that it is a subjective (Hatch and Yanow, 2003), critical (Willmott, 2003), or post-modern science (Chia, 2003). Each of the four perspectives has different philosophical assumptions and different methodological tools, i.e. different intellectual capital. In a Bourdieuian Field perspective, the four views constitute poles that are competing to dominate the Field and to gain more "profits" of the research outcomes (more academic positions, grants, consulting projects, etc.).

Clearly, simulation modelling, in general, and system dynamics in particular, has been brought into the Field of organisational theory by the supporters of objectivism. As it was indicated above, simulation (and system dynamics) introduces laboratory conditions into social science research. Hence, by introducing a way to represent the objective world and have the ability to "play" with it, these scholars are enriching

their arsenal of methods with a way that provides to their research results natural-science credibility. It is not strange that many "big shots" of the objective-perspective organisation theory rely on simulation to support their theories.

Naturally, system dynamics shares the same background of objectivism, and most scholars and practitioners of system dynamics carry this Habitus. System dynamics was developed by a technocrat, has a positivistic philosophy, originates from a technical field (control systems) and was primarily developed and practiced in a technological environment in the USA, where the natural sciences influence on social science, as far as methodology is concerned (exemplified by the spread of fields such as computational organisational theory), is greater than, for instance, in Europe. So, the use of system dynamics in organisational theory development settings inevitably brings symbolic capital originating from the modernistic tradition that differs from the post-modernistic flavour of modern Europe (Rifkin, 2004), where more pluralistic engagements of system dynamics with more subjective approaches (e.g. Mingers and Gill, 1997), as well as more imaginative interplays of academic and practical worlds are observed. In the latter, of particular importance to the Field is the formation of social capital, i.e. long-standing relations among the partners of theory development efforts, a phenomenon that is observed in Europe in the relations between research groups and public organisations.

In conclusion, we can say that system dynamics through its ability to assist in formulating theories with non-linear hypotheses and to describe behaviours wich are not regular w.r.t. time, introduces a durable actor in the network of organisational theory development, as well as a disposition for objectivism, even if this is not explicitly intended. Its inherent preference for controlled social action and the search for counter-intuitive behaviours should not be taken for granted and should not dominate alternative stances, e.g. the importance of reinforcing loops (Lane, 2008). Nevertheless, theory development Fields with a subjective Habitus can continue to be subjective, critical or post-modern as their intellectual and social capital can neutralise the objectivism of system dynamics. Nevertheless, it is our view that the real contribution of system dynamics to organisational and management theory will be when it establishes its own identity and specialised capital, initially as an integral part of well-defined conceptual frameworks (Generalities II), within the Field, and frees itself from being the Trojan horse of objectivism and the joker card for any combination of methods and tools in post-modern organisational theory development settings.

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