SYSTEM DYNAMICS AND PHILOSOPHY
A Constructivist and Expressivist Approach[1]

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Abstract

Theoretical reflections about System Dynamics (SD) have usually been grounded in the developments of what can be called "general philosophy of science". In our paper, a philosophical approach more sensitive to the peculiarities of SD is proposed that is closely linked to the recent constructivist proposal of John Searle and to the expressivist theses of Robert Brandom. We will focus on three very important conceptual problems concerning the validation of SD models –the ontological problem of realism with respect to the structures postulated by SD models, the epistemological problem of the explanatory power of SD models, and the methodological charge of merely producing a kind of "patchwork" when building of SD models--, arguing that by combining the constructivist and expressivist philosophical perspectives of those authors in a certain way would offer a better understanding of scientific and technical activities such as SD modelling.

Key Words

System Dynamics Modelling, Social Systems, Philosophy of Science, Searle's Construction of Social Reality, Brandom's expressivism, Validation of System Dynamics Models.

Computer modelling of social systems using System Dynamics (SD) is a field that is continuously expanding, both theoretically and practically. There are many theoretical analyses that try to find a philosophical foundation for SD modelling. But the rule has been to look for such a foundation in the developments of what can be called "general philosophy of science". In our paper, we will suggest different sources of insight, based on the philosophy of action and the philosophy of logic. General philosophy of science will be contrasted with philosophies of special sciences, the latter being far more powerful and relevant to confronting the conceptual problems that have arisen in SD modelling.

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Following the opportunist tone suggested by philosophies of special sciences, we will introduce two contemporary philosophical perspectives: John Searle's constructivist proposal on the constitution of social reality, and Robert Brandom's expressivist theses on logical truth. Our aim will be to argue that a certain combination of these perspectives would offer a new starting point in the efforts to get a better understanding of scientific and technical activities such as SD modelling.

We will focus on three very important conceptual problems concerning the validation of SD models: 1) the ontological problem of realism with respect to the structures postulated in SD models, 2) the epistemological problem of the explanatory power of SD simulation models, and 3) the methodological charge of merely producing a, let us say, "patchwork" when building SD models. The lavel "ontological" would make reference to the ways reality itself could be, "epistemological" would make reference to how our knowledge claims could be justified, and "methodological" would make reference to the procedures employed to arrive to such knowledge claims. The validation of SD models would involve all these aspects. Discussing them, we argue for the new philosophical approach offered.

It is important to emphasize from the beginning that we will be referring exclusively to the SD modelling of complex social systems. More concretely, we will be referring to economical, political, urban, industrial, etc., social systems which contain many institutional features. We could say that through the explicit process of SD modelling we can find what we have put into those highly artificial systems. And as will become clear in what follows, our approach would lose much of its force and relevance if we focus on the modelling of other more "natural" systems.

1. SD, the general philosophy of science and other philosophical sources.

There have been numerous analyses of SD modelling which try to find some kind of philosophical foundation for this process, although it has been the rule to look for such a foundation in the developments of the general philosophy of science[2]. Sometimes, for instance, it has been suggested that certain varieties of moderate realisms such as that of Popper's falsationism, or critical rationalism, could fit SD procedures[3]. Other times, it has been maintained that a certain practical relativism, or a contextualist and pragmatist philosophy of science along the lines of Kuhn, would offer an adequate framework for the justification of the claims of SD models[4]. We ourselves, some years ago, tried to show in several papers[5] that some more recent epistemological proposals, such as the "internal realism" of Hilary Putnam, were in a better position to deal with many of the conceptual problems involved in SD modelling.

[2] See, for instance, Barlas, Y. (1996), Forrester, J. & P. Senge (1980), and Homer (1996 and 1997)
[3] See, for instance, Bell & Bell (1980), and Bell & Senge (1980).
[4] See Barlas & Carpenter (1990). For a pragmatist perspective close to Peirce, see Barton (1999).
[5] Vázquez M., M. Liz & J. Aracil (1995); Vázquez M., M. Liz & J. Aracil (1996); and Liz M., J. Aracil & M. Vázquez (1996).

We do not want to criticize the merits of those approaches here. In particular, we would maintain the relevance of Putnam's position as an important "third way" between realism and relativism. Something close to Putnam's "internal realism" would fit many of the features of SD, especially 1) the important role mental models play in it and 2) how some important kinds of justification, explanation and understanding are possible in spite of the plurality of alternative SD models with respect to any system. Nevertheless, these sorts of highly general philosophical perspectives are too unspecific and therefore their relevance to SD is very limited. In other words, we would like to have something more. The question would be: Can philosophy offer something more? We think that the answer is yes.

Let us focus on philosophy of science. What can philosophy of science offer to the reflective analysis of SD modelling? In a broad sense, these philosophical reflections can follow any of the following lines:

1. General philosophy of science
2. Philosophies of the special sciences
3. Social and cultural studies of science

Let us consider each of them in greater detail. On the one hand, as we have suggested, general philosophy of science (option 1) is too unspecific and therefore limited. Moreover, recent developments in that field of philosophy are revealing: they are quite repetitive, giving a sensation of blockage or stagnation.

On the other hand, social and cultural studies of science (option 3) are often extremely relativist, and they would put in serious trouble any process of validation. According to these approaches, the only epistemological rule for scientific development would be "anything goes", and the only relevant value would be practical success. In the end, these approaches would entail the rejection of any philosophy of science and epistemology. Moreover, they would entail the rejection of any philosophical reflection at all.

What about philosophies of the special sciences (option 2)? The first thing that needs to be said is that philosophies of the special sciences are not general philosophies of science applied to a certain scientific or technical discipline. Philosophies of the special sciences get their own way with a variety of recourses coming from conceptual frameworks more akin to their own topics. This is what has happened recently with philosophical areas such as the philosophy of mathematics, the philosophy of logic, the philosophy of biology, the philosophy of psychology, the philosophy of economics, etc. These areas do not repeat principles and norms obtained from a general philosophy of science. All philosophies of the special sciences are to a large extent quite autonomous and opportunistic.

This would be a very important fact about the evolution of recent philosophy of science. And it would also open the door for new kinds of philosophical reflections about SD modelling. Beyond the mere application of a certain general philosophy of science, and beyond what can be found in the so called social and cultural studies of science, there might be other philosophical ways to get a deep reflective understanding

of SD. In this case we would have to be as autonomous and opportunistic as any other special philosophy of science.

Indeed, there are multiple and complex relationships between SD and philosophy. We are working under the hypothesis that some sort of philosophy of science is relevant for SD, and we are trying to find the most adequate way in which this is so. But SD would also be relevant for the philosophy of science and other related philosophical areas, a very important fact to keep in mind. SD modelling is a perfect example of the scientific and technological use of computer simulation models in order to increase our knowledge and control. Because of this, getting an adequate and deep reflective understanding of SD would also have important consequences beyond the field of SD. It will improve how we make the philosophy of science and, in the long term, it will also improve how we make science and technology.

2. Systems and models

We are arguing that there is a need to find a reflective, philosophical understanding of SD not exclusively centred on the conceptual frameworks offered by a certain general philosophy of science. In order to find some clues, we are also suggesting that we must be much more sensitive to SD procedures themselves. With this in mind, let us examine some of the features involved both in the social systems that are intended to be modelled through SD and also in the SD modelling of those systems.

2.1. The social systems modelled

The more prominent feature that should be noted is that both the social systems modelled through SD and the SD modelling of those systems involve intentional actions displayed in the causal network of the physical world. However, the sense in which those intentional actions are present is very different in each case.

In the case of the social systems typically modelled through SD, intentional actions show the following three characteristics:

1. They have a powerful constructive efficacy beyond physical reality.
2. Typically, that constructive efficacy is only implicit.
3. Typically, the realities construed in that way have a high objective value.

Intentional actions are constructive forces that give shape and structure to all sorts of objective realities beyond the reality of physical phenomena[6]. The world around us is a world full of such realities beyond the physical. Generally, the construction of such realities is not explicit, but only implicit. But, realities construed in this way are objective in the sense that there are usually facts that can prove or disprove the truth of the claims referred to by those realities. These claims are not irreducibly arbitrary or a mere question of taste.

[6] In a broad sense of "physical" that would include chemical and biological phenomena. Intentional actions would construe a "second" nature out of the "first" nature of physical-chemical-biological phenomena.

The social systems construed through our intentional actions can be very complex and of a great variety. For instance, they can be economical, political, urban or industrial. And the complex structures involved in them are to a large extent completely objective. They are objective even though they are full of normative ingredients derived from the conventions and compromises implicitly adopted in our intentional actions. The source of those structures is the subjectivity of our intentional actions. But the result is perfectly objective. Beyond the physical world, our intentional actions are able to build a very complex world of social and institutional facts.

The three characteristics of intentional actions we are examining are present in all the social systems that are typically modelled by SD and the conceptual structure of those characteristics would be an important part of a proper topic of a philosophy of action. Hence, if we try to go beyond a general philosophy of science, in order to get a better reflective understanding of SD, that philosophical area would be very important.

2.2. The SD modelling of those systems

Now, let us turn to the case of the SD modelling of those social systems. Intentional actions would also be present here. However, in this case they would display other characteristics such as:

1. The aim of those intentional actions is to enable a rational process of decision making concerning some problems within the modelled system.
2. Typically, the decisions adopted through that process are taken explicitly
3. Typically, the rationality behind those processes has to do with the satisfaction of certain subjective parameters.

A SD model is a sort of tool helping to answer explicit questions about the modelled system. Generally, SD models are built when we have some practical problems of control in a certain system and we need to rely on expert knowledge. SD models have become very useful in helping to solve problems of control in complex social systems when we do not have enough theoretical knowledge at our disposal.

SD models allow us to detect the dynamical consequences of our actions in the modelled system. Through the manipulation of the SD simulation model, we can have a kind of "virtual" experience of the results of our actions in the system that is being modelled. In that respect, SD models would offer an open set of conditionals in the following form:

If X (and certain conditions C are satisfied), then Y

Where *X* would be a certain action directed toward the relevant variables of the system in order to bring about *Y* as result, if the conditions C are satisfied, in the system modelled. Now, let us suppose that conditions C are in fact satisfied. We would then have an important kind of conditional statements with actions as antecedents and certain

states of the modelled system, the states resulting from those actions, as consequents. We can call them "action-result" conditionals.[7]

In relation to those action-result conditionals, there are three main kinds of why-questions that a SD model would help to answer:

> Question 1: Why do *X*?
> Answer 1: Because we value *Y*, and *If X, then Y*.
>
> Question 2: Why value *X*?
> Answer 2: Because we value *Y*, and *If X, then Y*
>
> Question 3: Why assume the action-result conditional *If X, then Y*.
> Answer 3: Because, according to our SD model, that conditional would reflect some objective relationship involved in the modelled system.

Question 1 is an "agentive" question about why to do something. And answer 1 is constituted by a certain valuation and a certain action-result conditional. Question 2 is an "evaluative" question about why to value something that we can do. And answer 2 consists again in the same valuation and in the same action-result conditional. What is remarkable here is that we have the same *explanans* for two very different *explananda*. Exactly the same valuation and the same action-result conditional would help to explain why to do something, i.e. question 1, and why to value that action, i.e. question 2.

Let us go to question 3. Question 3 is a "justificatory" question. It asks what is the validation of the action-result conditional statement, which is part of the *explanans* both of answers 1 and 2. In other words, answer 3 plays a crucial supporting role in answers 1 and 2. Both answers obtain epistemic support from answer 3. Answer 3 provides validation to certain conditional statements able to orientate action and to transmit value. The hybrid action-result conditional *If X, then Y* would be able to do that in the sense that if we value something *Y*, then we have to both do *X* and value *X*. An important aspect of valuing something is to try doing certain things and to value them. Action-result conditionals could tell us what these things are. The antecedents of these conditionals would make the things we have to do and to value explicit, if we value certain things.

Answer 3 claims that those action-result conditionals are validated when, according to our SD model, they are able to reflect objective relationships involved in the modelled system. As stated earlier, by "objective" we mean something that is not an arbitrary question of taste. We do not mean that they do not depend on our subjectivity. There is a crucial difference between these two things.

[7] The background for those action-result conditionals would be the whole net of equations of the model together with certain initial conditions. Even if the modelled system were our own practices of making decisions on the actions to take in certain conditions, the SD model would offer an open set of such action-result conditionals.

Many times, we assume that our SD models have a highly objective value in the sense that what is obtained from them is not an arbitrary matter of taste. The question is: do we also have to assume the existence of objective relationships in the modelled system which are not dependent on, or related to in one way or another, the intentions, beliefs, desires, etc., of the agents involved in that system? It would seem that the answer to the last question has to be negative.

There is a very important sense in which what we explicitly find in a SD model of a social system is no more than what we have implicitly put, through our intentional actions, into the modelled social system. Hence, the validation of the action-result conditionals cannot come from an objective reality that does not include the intentional life of the agents involved in the social systems modelled. This is a very important feature of the justification or validation of SD models.

The problem is how to understand that feature. Curiously, that problem would be very similar to another problem of epistemic justification or validation concerning logical laws. Let us consider the logical laws of a conditional form. When we look for an epistemic justification or validation of conditional logical laws, we are trying to find some objective relationships between the antecedents and the consequents of those laws. As before, by "objective" we mean something that is not an arbitrary matter of taste. The crucial point is once again the following: do we also have to assume in reality itself the existence of objective relationships which are not dependent on, or related with, in a way or another, the intentions, beliefs, desires, etc., of the subjects involved?[8]

Beyond the application of a certain general philosophy of science, we were looking for other different sources of reflective philosophical insight for SD. The analysis of some of the ingredients involved both in the modelled social systems and in the SD modelling of those systems has brought us very close to the philosophy of action and of the philosophy of logic. On the one hand, we have found implicit constructions of an objective reality beyond the physical world. On the other hand, we have found explicit decision making processes based on certain action-result conditionals which need a validation that is quite similar to the justification demanded for logical truths. Following these ways, in the next two sections we will introduce a couple of very relevant recent approaches in the philosophy of action and the philosophy of logic: John Searle's constructivist proposal regarding social reality and Robert Brandom's expressivist theses concerning the justification of logical truths.

3. The constructivist proposal of John Searle.

John Searle is a very well known contemporary American analytical philosopher. Until the 80's, the majority of Searle's work was devoted to systematizing and clarifying the Speech Act Theory, one of the most important approaches in the

[8] There is a direct analogy between what we have called action-result conditionals and logical laws. In what follows, it will become clear that we are not claiming that action-result conditionals based on SD models should have the status of logical laws. However, the analogy can also be sustained in relation to how we establish both kinds of statements. The decisive feature is always some peculiar constancy maintained through variations in discursive practices (in the case of logical laws) or in our actions (in the case of the action-result conditionals).

fields of Linguistic and Pragmatics, and the most direct alternative to Chomsky formalism[9]. Since the 80's, Searle has become increasingly interested in aspects of the philosophy of mind. His rejection of the identification of minds with computer programs has provoked some of the more important discussions in that field in the last decades[10]. From 1995, however, Searle has become more and more interested in certain problems of social ontology and his ideas have again been very thought provoking and stimulating[11].

We will focus on three points of Searle's constructivist proposal: 1) the mechanisms that construct social reality; 2) the objective/subjective distinction; and 3) the implicit and unconscious nature of that construction.

According to Searle, our intentionality is an irreducible biological feature, and both social phenomena and language are manifestations of our intentionality. Social reality is a result of collective intentionality. The bearers of collective intentionality are always individual subjects, but collective intentionality necessarily involves other subjects, apart from oneself, as agents of the actions[12]. Hence, collective intentionality can exist without the need to postulate collective subjects. In other words, we can simultaneously maintain "methodological individualism" and take into account collective intentionality as the basis of social phenomena. Social phenomena are not merely an aggregate of individual intentions and actions. Social phenomena display collective intentionality. But it is possible to give sense to the notion of collective intentionality without being engaged in the existence of collective subjects.

Collective intentionality is enough for the existence of social phenomena. However, social phenomena include much non-human behaviour. What is peculiar about human beings is that we inhabit a world full of social institutions. Searle analyses in detail two basic kinds of mechanisms used to construct social institutions:

1) Assignment of functions
2) Constitutive rules

The kinds of functions that are important here are those that we impose on reality. They have to do with our uses or practices. Some objects have attributed functions that they are not able to perform only by virtue of their physical composition. The function of a one dollar bill, for instance, is a clear example of this. Other very important examples include the functions of representing, symbolizing, etc., or, more

[9] Following the seminal work of Austin (1962), John Searle develops in depth his peculiar version of the theory mainly in Searle (1969 and 1979). Other relevant works include Searle (1962, 1964, 1965, 1968, 1975, and 1978). For more information about this period of Searle's work, see Burkhardt (1990), Fotion (2000), Hirstein (2001) and Lepore & van Gulick (eds.) (1991).

[10] The most influential argument for such an identification can be found in Turing (1950). The most important works here are Searle (1980, 1983, 1985, 1992, and 1997). About the evolution of the discussion, see Preston and Bishop (eds.) (2002).

[11] Searle (1995) is the main work about these new problems. Other references include Searle (1999, 2001, and 2004). See also Grewendorf & Meggle (eds.) (2002), Koepsell (ed.) (2003), Koepsell & Moss (eds.) (2003), Smith (ed.) (2003), and Schmitt (ed.) (2003).

[12] In collective intentions, inside each individual agent there are intentional contents like "we desire …", we want to do ...", "we will do …", etc.

generally, of meaning something. In all of these cases, the function requires that we accept that certain objects have a special status[13].

Now, let us clarify the notion of constitutive rules. Searle insists that institutional facts only exist in relation to systems of constitutive rules. Regulative rules give structure to practices that already exist, whereas constitutive rules make certain practices possible. That is, they are practices that did not exist without the rules. Chess, for instance, is constituted by the rules of chess. The formal structure of a constitutive rule is always the following:

In context *c*, something *x* counts as *y*.

The function of "to count as" would be an attributed function that *x* cannot realize only in virtue of its physical composition. It needs the collective intentionality of accepting that, given an appropriate context *c*, something *x* has the required status to count as *y*. Things like money, stamps, credit cards, rituals, conventions, etc., are what they are thanks to certain systems of constitutive rules.

Along with social phenomena, Searle considers language as an irreducible manifestation of our intentionality. Moreover, language is one of our more important social institutions. Thanks to the functions enabled by language and to the constitutive rules of language, we are able to construe all kinds of institutional phenomena.

A very important case in which language is able to create institutional facts would be that of declarative speech acts: marriages, baptisms, war and peace declarations, resignations, legal sentences, contracts, certifications, etc. Here, some institutional facts linked to our linguistic practices make the creation of other institutional facts possible. We could say that our social world is full of things that we do with words.[14]

All institutional and social reality is supported by our intentionality, which in turn is a brute, irreducible feature of our brains. Our "second" nature is a product derived from our "first" nature. Brute facts of physics, chemistry and biology are fundamental. But, beyond them, there are also social and institutional facts like marriages, wars, money, artificial objects, science, culture, economic relations or political systems. These phenomena exist because they are generated or construed by our intentionality, one brute and irreducible fact of biology. In that sense, those phenomena would be ontologically subjective. They depend on our subjectivity. They are construed by us. However, social and institutional phenomena would be epistemologically objective in the sense that what we can say about them is not a mere matter of arbitrary opinion, taste or preference.

The objective/subjective distinction has two very different meanings, one of them ontological and the other one epistemological. Brute facts of physics, chemistry and biology are epistemologically objective and ontologically objective. Social and

[13] Sometimes, Searle uses the expression "functions of status". Other times, they are called "agentive functions", in contrast with the non-agentive ones which would be discovered through certain theoretical and explanatory contexts (for instance, the heart's function of circulating blood).

[14] *How to do things with words* is the title of Austin's (1962) seminal book on the Speech Act Theory.

institutional facts are epistemologically objective but ontologically subjective. Sometimes, Searle also says that whereas brute facts of physics, chemistry and biology are intrinsic features of the world, social and institutional facts are relative to the observers. All features relative to the observers are ontologically subjective, but some of them are epistemologically objective.

In a recursive way, collective intentionality, the assignment of functions and constitutive rules make it possible to construct the social and institutional world in which we live. But, and this is a very important point, that construction is rarely explicit. Usually, the intentional processes of construction of the social world are only implicit and unconscious. We do not need to be conscious of the ways in which social and institutional systems are construed. We only need to be equipped with certain capacities, skills, abilities and dispositions. This what Searle calls the "Background".

The Background operates exactly in the same sense in which we do not need to explicitly know the constitutive rules of our natural languages. Indeed, we know how to speak the languages we are able to speak. But that knowledge constitutes our implicit mastery of those languages[15]. With the construction of the social and institutional worlds we could say that there is also a kind of implicit mastery. Typically, we do not construe them explicitly, but only implicitly.

4. Robert Brandom's expressivist theses

The philosophical perspective of Robert Brandom, another prominent American analytical philosopher working today, is no less ambitious than Searle's. Brandom offers many relevant and powerful insights on profound issues concerning philosophy of language, philosophy of mind, epistemology, metaphysics and logic[16]. In particular, he explains the nature of meaning and the structure of the conceptual in new and fascinating ways. In addition, the same could be said of the importance of pragmatic norms in thought and action. As we are going to see, those topics entail certain theses about the problem of the epistemic justification or validation of logical truths that are of great interest for us.

In this section, we will focus on three points of Brandom's perspective: 1) his views on meaning, 2) his expressivist theory of logic, and 3) the idea of a form of rationality based on the process of making what is implicit in what we do conceptually explicit.

Brandom's views on meaning or semantic content, both in thought and language, is pragmatist, inferentialist and contextualist. Meaning is defined in terms of the use of symbols, and the relevant uses are defined in terms of inferential practices in a public, social context. According to Brandom, representational features like reference, truth conditions, etc., applied to mental contents, the semantic contents of our thoughts, depend on the representational features of the linguistic contents present in our public

[15] For more information, see Searle (1983).
[16] Brandom (1994) and Brandom (2000) constitute the main references for his perspective. More recently, he has elaborated his views in a more historical perspective, taking into account the philosophical tradition from Descartes to the present, in Brandom (2002).

languages. And these representational features of our public languages are derived from the public inferential uses of certain symbols according to the normative constraints of a certain social context. In other words, all meaning and semantical content are grounded in normative pragmatic compromises concerning the inferential use of certain linguistic items in a social context.[17]

The relevant normative features are those that can make some asserted symbols count as a reason for or against other claims. Hence, the semantic contents of assertions are taken as basic, and they are defined by the inferential roles involved in our linguistic ability of giving and asking for reasons concerning those assertions. All the representational features of languages and minds would be derived from that inferential ability. Things like logic, in a broad sense, have the expressive role of making explicit the normativity present in the inferential relations implicit in that inferential ability.

Brandom's approach is completely opposed to what has been the current representationalist paradigm. Representationalism would consider features such as reference or truth conditions applied to mental contents or to linguistic contents as primitive. According to Brandom, the representational paradigm has been ubiquitous in Western philosophy ever since the Enlightenment, and it is not easy to imagine other alternatives. One opposed line of thought, however, is present in Romanticism. As opposed to the Enlightenment image of the mind as a "mirror", Romanticism proposed the image of a "lamp". Mental activity is understood not as a passive representation, but as an active revelation, full of creativity and experimental intervention. The basic picture used by Herder, for instance, is the process by which "inner" becomes "outer" when a feeling is expressed by a gesture. In more complex cases, our attitudes are expressed in all sorts of actions, including verbal behaviours.

Brandom proposes analysing some of these complex cases of expression as a matter of making explicit, in a conceptually articulated way, what is implicit in our practices. To make explicit is to turn something we initially only "do" into something we can conceptually "say". It is a process of converting a "knowing-how" into a "knowing-that", and this entails conceptualization. Now, once concepts are applied, we can make assertions on what is only implicit in our practices. These assertions are the sort of things that can enter as premises or consequences in our inferences and reasonings. This would open the door for a reflective understanding and a rational revision of our practices and their normative components.

Brandom's approach has powerful implications for the philosophy of logic. And we will focus on that point because it has important implications for us as well. The standard way of understanding logic is as giving us access to very peculiar kinds of ideal truths: logical truths. From the expressivist perspective offered by Brandom, logic could be understood in a very different way. Logic could be seen as a set of expressive recourses for "saying" something about what we "do" when we make inferences. Logic would make something that is implicit explicit in our discursive inferential practices. Logical vocabulary serves to make that know-how explicit. The use of logical

[17] The main inspiration of Brandom's approach is the type of pragmatism and "linguistic nominalism" defended by Wilfrid Sellars in the 50's. About that, see the edition of Sellar's essay "Empiricism and the Philosophy of Mind", Sellars (1997), introduced by Richard Rorty and commented by Brandom himself.

vocabulary would allow us to explicitly say what we implicitly do when we apply certain concepts or when we infer some claims from other ones.

In order to illustrate that expressivist perspective, we can quote an example presented by Brandom himself[18]:

> "In applying the concept *lion* to Leo, I implicitly commit myself to the applicability of the concept *mammal* to him. If my language is expressively rich enough to contain *conditionals*, I can say that *if* Leo is a lion, *then* Leo is a mammal. (And if the language is expressively rich enough to include quantificational operators, I can say that if *anything* is a lion, then it is a mammal.) That Cleo is a cephalopod is good (indeed, decisive) evidence that she is not a lion. If my language is expressively rich enough to contain *negation*, I can make that implicit inferential component articulating the content of the concept *lion* explicit by saying that *if* Cleo is a cephalopod, then Cleo is *not* a mammal.
>
> By saying things like this, by using *logical* vocabulary, I can make explicit the implicit inferential commitments that articulate the content of the concepts I apply in making ordinary explicit claims".

Logical vocabulary allows us to make explicit the implicit inferential commitments, and entitlements, that articulate our speech acts and our thoughts. And this would be the only source of epistemic justification or validation of logical truths. Logic would not be describing any ideal realm of "logical truths". In Brandom's own words[19],

> "Logic is not properly understood as the study of a distinctive kind of *formal* inference. It is rather the study of the inferential roles of vocabulary playing a distinctive *expressive* role: codifying in explicit form the inferences that are implicit in the use of ordinary, nonlogical vocabulary. Making explicit the inferential roles of the logical vocabulary then can take the form of presenting patterns of inference involving them that are formally valid in the sense that they are invariant under substitution of nonlogical for nonlogical vocabulary. But that task is subsidiary and instrumental only. The task of logic is in the first instance to help us *say* something about the conceptual contents expressed by the use of nonlogical vocabulary, not to *prove* something about the conceptual contents expressed by the use of logical vocabulary […] Logic is accordingly not a cannon or standard of right reasoning. It can help us make explicit (and hence available for criticism and transformation) the inferential commitments that govern the use of all our vocabulary, and hence articulate the contents of all our concepts".

The last statement is especially important. Through the process of making conceptually explicit what is implicit in our inferential doings, we get an important kind of conceptual self-consciousness. Furthermore, we are then placed in a position to

[18] Brandom (2000:19-20).
[19] Brandom (2000:30).

rationally change and improve our inferential practical mastery. Brandom calls this kind of reflective rationality "expressive rationality".

5. **Three conceptual problems**

We have presented two recent philosophical perspectives: Searle's constructivist perspective on social reality and Brandom's expressivist perspective on the pragmatic justification or validation of logical truths. Perhaps Searle's perspective is not a complete philosophical account of everything that is involved in the social world, and perhaps Brandom's falls short of being an adequate account of logical normativity, but despite these questions, they offer important insights. Moreover, a certain combination of their perspectives could be very useful for us in the effort to get a reflective conceptual understanding of SD modelling.

We will try to show that by briefly analysing three crucial problems involved in the validation of SD models: 1) the ontological problem of realism concerning SD models, 2) the epistemological problem of the explanatory value of SD models, and 3) the methodological charge of merely creating a sort of "patchwork".

5.1. The ontological problem of realism concerning SD models.

Our first problem can be introduced through a direct question: in what sense can the structures postulated by SD models be assumed to exist objectively in reality?

Here, we are faced with something that philosophers would call an "ontological problem of realism". And worries about the danger of a lack of realism are very frequent in the literature of SD[20]. Moreover, sometimes the instrumental value of SD models is emphasized in a way that tries to face this problem by explicitly embracing some kind of irrealism. However, even though we accept that SD models have an unquestionable instrumental value, we cannot avoid this ontological problem of realism. To be practically effective in decision making processes the SD model must capture those aspects that, from the points of view of the users of the SD model, are able to connect with their purposes with sufficient fidelity[21]. So, even though SD models are built to look for a solution to practical decision making problems, with no other theoretical interest, we could ask the following ontological question: in what sense can the structures postulated by SD models be assumed to exist objectively in reality? In what sense could they be said to be "real"?[22]

Now, using the constructivist and expressivist perspectives of Searle and Brandom presented above, we can offer a highly plausible answer to this problem. In many cases, it woud be completely adequate to pretend that the structures postulated by SD models represent or describe something objectively real in the modelled systems. SD models would make explicit something that is implicit in the social world. That social world is construed by us. We give it structure and reality. Therefore, the

[20] Some important references are Barlas (1996), Barlas & Carpenter (1990), Bell & Senge (1980), and Forrester & Senge (1980).
[21] About that, see Forrester (1961) and Sterman (2000).
[22] A recent discussion of that question is offered in Mingers (2004 and 2006).

structures we make explicit in the SD models, trying to explore their dynamic consequences, can be as real as any of our intentional constructions. They can have exactly the same kind of reality than any product of our intentional actions.

The two meanings of objectivity that are distinguished by Searle are especially appropriate for dealing with our problem on a conceptual level. Many times, the structures explicitly postulated by SD models are those that implicitly give form to the modelled social systems; and they are epistemologically objective. And there are facts about the matter that can prove or disprove the truth of our claims over the real systems modelled. Hence, our claims are not an arbitrary matter of taste or subjective preference. However, those structures are not ontologically objective but ontologically subjective. They depend on us. We construe them through our collective intentionality, by assigning functions and creating systems of constitutive rules. Even implicitly and unconsciously, we are the source of their ontological reality.

Furthermore, the subjective ontological nature of those structures offer a very simple explanation of why they cannot be easily reducible to more basic or primitive facts described by theories not including the subjects involved in the social systems modelled. The reality of those social structures depends on the intentionality of the subjects involved in them. Hence, their reduction to something ontologically objective would have to entail the ontological reduction of the subjective to something objective.[23]

5.2. The epistemological problem of the explanatory value of SD models.

The second problem we want to discuss is epistemological, having to do with the validation of our knowledge claims: how can SD models have some explanatory value? Assuming that causal explanations have a clear explanatory value and that SD explanations are very often expressed in causal terms, that question could be formulated in the following way: in what sense are SD explanations genuine causal explanations?

Together with the worries about irrealism concerning SD models, there are also many discussions and analyses about the use of causal language in SD modelling[24]. In fact, both problems affect all disciplines in the social sciences. Here, causal language is always suspected of being illegitimate. It is said that at best causal terms have only a metaphorical or rhetorical meaning.

Again, by combining Searle's constructivism and Brandom's expressivism, we think that a plausible answer could be given to this epistemological problem. Applying mathematical and computer tools to certain expert knowledge, SD models are able to make explicit the structures implicit in the social system modelled. Also, they are especially able to make explicit the dynamic consequences of these structures. Explanations based on this explicit knowledge reveal what is only implicit in the actions of the agents involved in the modelled systems. They identify some of the implicit causal relations built into the social realities the agents have intentionally construed.

[23] According to Searle's views, this would be impossible.
[24] See, for instance, Coyle (1996), Olaya (2004), Richarson (1996), and Sterman (2000).

From this point of view, SD explanations are no more that a further step in the process of making explicit something that is implicit.

SD explanations are quite similar to the explanations given when we ask what somebody did. Explaining what somebody did makes explicit relevant features of what was implicit in her doing it. Similarly, SD explanations consist in formulating relevant explicit consequences obtained from the explicit structural and dynamic knowledge offered by the SD model which, in turn, is built from what is implicit in the social systems modelled. What is implicit, that which is intended to be extracted from certain expert knowledge, are the intentional structures that the agents involved in the social systems impose on brute physical reality. These structures and their dynamic consequences are real. They are real thanks to the intentional actions of the agents, guided by a certain collective intentionality able to attribute and recognize functions and able to accept systems of constitutive rules. That reality is epistemically objective and ontologically subjective. And SD explanations make it explicit.

Causal relations are included in the modelled social systems from the onset. Without them, these systems would not exist at all. These relations are made explicit by SD causal explanations. Because of this, the most important component of SD causal explanations is the relation between the implicit and the explicit, especially with respect to the dynamic consequences of the structures imposed by the subjects in the social systems modelled. SD causal explanations try to make them as explicit possible in order to improve rational decision making processes.

5.3. The methodological charge of merely creating a sort of "patchwork".

Our last problem is methodological. How can SD models help to elaborate deep and well founded theories about the social phenomena modelled? In particular, what would be the theoretical role of the generic structures used in the construction of SD models?

This is a crucial problem for the methodology of SD. Sometimes it is said that SD modelling creates a curious opportunistic "patchwork", without any theoretical orientation[25]. This accusation would be especially relevant in relation to the process in which expert knowledge is incorporated into the generic structures thematised in SD literature.[26]

Brandom's expressivist perspective is particularly well suited to deal with this problem. We could make a revealing and powerful analogy between Brandom's treatment of logical structures and the way that generic structures in SD modelling are usually employed. According to Brandom, logical relations expressed in our languages make explicit the sorts of inferences we are implicitly committed to in our discursive practices. Logical relations say something about what we do when we are engaged in discursive practices. From that pragmatic basis, we can understand logical truths as those logical relations able of maintaining a quite peculiar constancy. Claiming that

[25] An extensive discussion of this question can be found in Sterman (1991). See also Greene (1994).
[26] The importance and peculiar character to those generic structures is one of the main points made in Senge (1990)'s book. See also Wolstenholme (2003 and 2004).

something has the status of a logical truth is to be committed to the discursive fact that, maintaining certain words constant, we can substitute the other words any way we want. The words that we can maintain constant become logical constants; the other words become nonlogical vocabulary.

Hence, logical truths serve to identify certain inferential constants in our discursive practices. At this point, we could apply Brandom's approach to the methodological problem we are discussing. Exactly in the same way in which we can say that logical truths serve to identify certain constants in our inferential discursive practices, we could say that generic structures in SD serve to identify other sorts of constants in our social practices. We would obtain a kind of expressivist conception of the generic structures of SD, analogous with Brandom's expressivist conception of logical truths.

It is important to note that from the perspective we are proposing, the lack of a previously defined theoretical orientation is not a defect but a virtue of SD modelling; in the same sense that the lack of a previously defined theoretical orientation is not a defect but a virtue in the discovery of logical truths. In the latter case, a previously adopted theoretical orientation could introduce important mistakes in the evaluation of our inferential practices, and in a similar sense a previously adopted theoretical orientation in the building of SD models of social systems could introduce important mistakes in the evaluation of the social practices from which social systems are built.

Something very similar can be said of the use of the same SD generic structures in different contexts (modelling very different social situations). They are generic, very basic structures simply because they can be used that way, with a different particular content in each case. They reflect or express something that is implicitly present in our actions. Exactly in the same sense in which logical truths would reflect or express something that is implicitly present in our discursive practices.

Of course, the normative force of SD generic structures is very different from the normative force of something like logic. Anyway, in both cases we have some necessities and possibilities far beyond the necessities and possibilities found in the natural worlds of physics, chemistry and biology. Additionally, in both cases the source of such "second" nature normativity would be the intentionality displayed in our actions. Moreover, in both cases we get a very special kind of conceptual self-consciousness by means of which we can rationally improve our practices.

6. A constructivist and expressivist philosophy for SD

The reflective effort of getting a better understanding of SD modelling of social systems faces many problems. We have identified and discussed three important problems and we have tried to show that a certain combination of the philosophical perspectives opened by Searle's constructivism and Brandom's expressivism would offer conceptual recourses that appear adequate to deal with them.

The basic idea is that in SD modelling of social systems we explicitly obtain what we implicitly put into the social systems modelled. The social systems modelled

are implicitly construed by us and SD modelling makes their structure and dynamic consequences explicit in order to achieve a better self-conscious, rational position in decision making processes.

Furthermore, from the new constructivist and expressivist approach suggested, the interrelations of mental models, social systems and SD models, a classical topic in SD reflections, can be understood in a very simple and clarifying way:

1. Social systems are real systems intentionally construed in an implicit way out of the mental models of the agents involved in them. Social systems are real systems that are epistemologically objective but ontologically subjective.

2. Using certain mathematical and informational tools, and certain expert knowledge, SD models try to make explicit the structures and dynamic consequences implicitly present in social systems.

3. Mental models enriched by SD models get a special kind of self-conscious conceptual qualification in order to rationally improve the relevant decision making processes that inspire the building of SD models.

Social systems are real systems about which objective knowledge is possible. However, their reality has a subjective ontological source. We construe them[27]. SD models make explicit some of those constructive components and their dynamic consequences. In this process of making something implicit in our actions conceptually explicit, SD modelling needs the help of some expert knowledge. Mathematical and computational tools would also be crucial because they constitute the expressive recourses able to make constructive components and dynamic consequences conceptually explicit. Without those recourses, we could not make explicit these constructive components and dynamic consequences. This is very important.

No less important is the fact that what is conceptually explicit in SD models must intimately interact with mental models in order to improve the processes of decision making. Those decisions have to become part of the constructive components and dynamic consequences of the social systems in which the subjects are involved. Those decisions are part of their practices as agents. In addition, SD models are not useful unless they are finally integrated with the implicit forces that construe the social systems modelled[28].

[27] Very recently, Lane (2000, 2001a, and 2001b) defended a perspective quite similar to the mixture of epistemological objectivity and ontological subjectivity we can find in Searle's constructivism. It is remarkable that Lane sees in that combination one of the more peculiar features of the SD approach.

[28] The process of model testing and mutual improvement of mental models and SD models is highly repetitive, and discrepancies between them, and between them and available data, stimulate improvement in each. See Forrester (1961) and Sterman (2000 and 2002). More in particular, see Homer (1996 and 1997).

7. Conclusion and open questions.

Now, let us summarize some of our main results. Trying to find some sort of reflective understanding for SD modelling of social systems, we suggested that instead of merely applying general philosophy of science we should employ perspectives that are more sensitive to the peculiarities of SD modelling. The analysis of some of the features present in the social systems modelled and in the SD modelling of those systems leads us to the fields of the philosophy of action and of the philosophy of logic. On the one hand, social systems entail the implicit construction of objective realities through our intentions and actions. On the other hand, SD modelling of those social systems is built with the aim of rationally improving explicit decision making processes based on certain action-result conditionals which need validation, in a sense quite similar to the epistemic justification applied to logical truths. In order to follow this analysis, we introduced two recent philosophical approaches: John Searle's constructivist perspective on the constitution of social reality, and Robert Brandom's expressivist theses on the justification or validation of logical truths. According to Searle, social and institutional phenomena are construed through the recursive iteration of three basic mechanisms: collective intentionality, the assignment of functions and systems of constitutive rules. These phenomena are epistemologically objective but ontologically subjective and, in general, we only construe them implicitly. According to Brandom, logic does not describe or represent any ideal realm. It has an expressive role linked to what is implicit in our inferential practices. Logical vocabulary serves to make explicit what is only implicit in our inferential commitments, and logical truths express some invariances present in them. The justification or validation of logic is pragmatic, but not simply based on mere success. Through the process of making explicit what is implicit in our actions, we get a very important kind of conceptual self-consciousness able to rationally improve our inferential practices. We have argued that a certain combination of the perspectives of Searle and Brandom could be very useful to achieve a reflective understanding of SD modelling. We applied their constructivist and expressivist views in the discussion of three crucial problems concerning the validation of SD models: the ontological problem of realism with respect to the structures postulated in SD models, the epistemological problem of the explanatory value of SD models, and the methodological charge of merely producing a kind of "patchwork". Finally, we generalized that constructivist and expressivist approach analyzing the interrelations between mental models, social systems and SD models.

Beyond SD modelling of social systems, our approach has interesting consequences for two fields. Firstly, it is relevant to other scientific and technological disciplines devoted to the analysis of any sort of system that, like social systems, are at least in part intentionally construed by us. Secondly, and because SD modelling is a paradigmatic case of the scientific and technological use of computer simulation models in order to increase our knowledge and control, our approach is also relevant in relation to other developments in science and technology involving the use of simulation models as a way of making explicit what is only implicit in certain actions and in certain expert knowledge[29].

[29] For some authors, computer simulation would entail a completely new way of doing and understanding science and technology. See Axelrod (1997) and Winsberg (2003).

There are also many open questions. We will very briefly touch on three particularly important ones. The first one concerns constructivism. The construction of social phenomena has limits. It can be constrained by a variety of factors, but mainly, it can be constrained in three ways: 1) by psychological or subjective facts entailing limits to our constructive powers, 2) by objective facts in the reality outside the subjects, generally having to do with complexity, and 3) by the interrelations among those subjective and objective facts[30]. With all of this in mind, perhaps it would be better to speak of a "bounded" constructivism, in analogy with the familiar idea of a bounded rationality. It would be very important to analyse that bounded constructivism in precise terms.

The second question has to do both with constructivism and with expressivism. Imagination has a role both in the construction of social phenomena and in the expressive move of saying explicitly what is implicit in our actions. Moreover, sometimes that role can be crucial; for instance, when we are faced with some kind of constraint or bounding in the construction of social phenomena. It would be also crucial in the decision making processes founded in the explicit structural and dynamic knowledge obtained from the SD models. Again, it is very important to analyse the role of imagination in these cases.

The third open question has to do with the application of the proposed combination of constructivism and expressivism to other problems that arise in SD. There is one topic worthy of special consideration: the strong tendency to view SD as a methodology focusing on learning processes in complex social systems[31]. When SD is considered from that perspective none of the usual philosophical approaches offer much help. What is needed seems to be an approach sensitive to the fact that social systems are constructed by us and, also, sensitive to a certain, let us say, "Socratic" conception of learning as a move from what is implicit in our actions to what we are able to make conceptually explicit. Both things are at the core of our proposal.

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[30] About the crucial implications of that point for SD, see Sterman (2000: chap.1) and Sterman (2005). Sterman's analysis focuses on the fact that, very often, complexity hinders evidence and our ability to discover the delayed and distal impacts of our interventions, generating unintended side effects.

[31] See, for instance, the recent work of Sterman (2005).

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