Formal Approaches to Socio-economic Analysis - Past and Perspectives

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Abstract

This paper is motivated by the observation that (1) socio economic analysis uses significantly less formalisms than mainstream economics, and (2) that there exist numerous situations in which socio economics could benefit from a more formal analysis. This is particularly the case when institutions play an important role in the system to be investigated.

Starting with a broad conception of a formalism, this paper introduces and discusses five different formal approaches regarding their adequateness for socio economic analysis: The Social Fabric Matrix Approach, the Institutional Analysis and Development Framework, System Dynamics, (Evolutionary) Game Theory, and Agent Based Computational Modelling.

Every formalism entails implicit ontological and epistemological tendencies that have to be reflected on if the formalism should contribute to a better understanding of the system under investigation. The above mentioned formalisms are no exception. Therefore, this paper pays particular attention to these tendencies.

In the end, antagonisms and possible convergences among the formalisms are discussed.

Keywords: Social Economics, Institutional Economics, Methodology, Epistemology, Ontology, System Dynamics, Social Fabric Matrix, (Evolutionary) Game Theory, Agent-Based Computational Economics, Econometrics.

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1 Introduction

> "The tool kit is not as important as the perspective, but it is imperative for giving the perspective meaning in any applied sense."
>
> Hayden (1982, p. 638)

To conduct a socio-economic analysis means to seek understanding of the relationship between the economy and society. The role of social and economic institutions plays a key role in any such attempt and a natural overlap between the schools of social and institutional economics exists.

This is particularly true for the part of institutional economics termed *original* institutional economics (OIE). The other part, the new institutional economics (NIE), puts scarcity and competition at a central stage of analysis, considers markets as a superior way to allocate scarce resources in a society (Ménard and Shirley, 2014, p. 557) and shares the conviction that institutions must be explained with (at best boundedly) rational individuals as the starting point. Only limited attention is given to the question of how their preferences come about (Hodgson, 2004, p. 6). Despite this limited scope, new institutionalists have produced many more formal models than socio economists or original institutionalists.

This paper was motivated by the observation that while formal analysis plays a more prominent role in NIE, it is used quite sparely in the overlapping work of OIE and socio economics. Why is this the case and could a more extensive use of formalisms increase the productivity of social economics as a discipline? Are social economists and original institutionalists against formal arguments *per se*?

A closer inspection shows that at least the latter supposition is wrong. The rejection of many common mainstream formalisms is based on specific and reasonable arguments, e.g the critique of the orthodox *optimization-cum-equilibrium* approach for requiring an excessive and specific reduction of complexity to keep its models tractable. Also, Galbraith (1967), among others, convincingly argued that powerful economic actors make their strategic choices not mainly as a reaction to their environment, but mainly in order to change this environment. Galbraith uses the example of big business corporations to illustrate this point. This form of different motivations and a mutual interdependency of choices and the agent's environment is rarely captured in a formal analysis.

Similarly, a socio economic analysis requires the consideration of values, traditions, habits and the different motives governing the behaviour of economic agents. To consider these aspects adequately in a formalism similar to that of orthodox neoclassical economics (that includes many *implicit* value judgements itself) is impossible.

Another source for the scepticism against formal models stems from Veblen (2011). For Veblen, mathematics "in its pure form" is a logical discipline only. Its results are only assessed regarding their logical consistency or elegance and it deals with logic, rather than the "ephemeral traits acquired by habituation" (Veblen, 2011, p. 489). It is therefore "independent of the detail-discipline of daily life" and "independent of cultural circumstances".

This statement aligns well with Veblen's claim that modern, i.e. evolutionary, sciences can by definition only get to transitional results, as their fundamental postulate is that of continuous change in the real world. And if there is continuous change, all results are time (and probably space) dependent and thus provisional. This perspective is shared by many socio-economists, but is incompatible with the equilibrium approach that underlies the majority of economic models today (Jo, 2011). These models are criticized for neglecting the the cumulative change that has led to the current state of affairs and are not considered to provide valuable insights as they can only be seen as small snapshots within greater societal dynamics. A related critique argues that mathematical models too often create a model world that does not represent anything in the real world, neither whose mechanisms resemble the mechanisms of the real world.

This criticism certainly applies to some mathematical models, but there is no a priori reason to believe that it applies to all. Mäki (2009) developed a framework, the functional decomposition approach to modelling, which, from a realist perspective, helps to scrutinize the extent a model represents the real world. This clearly shows that not all mathematical models constitute what Mäki calls *substitute systems*, i.e. artificial systems that are studied *in place of* the real world, rather than *in order to understand* the real world. [1]

All the formalisms considered in this paper do not fall into the latter category. Neither are they "mathematics in its pure form". They include or require a theoretical framework into which they are embedded and which guides their interpretation: A mathematical function in a model is nothing more than a function. The theory motivating the models helps to interpret this function with respect to the real world. These interpretations have to be rigorous and transparent. If they are not, the criticism of Veblen will apply and the model gets separated from daily life and its institutions (Veblen, 2011, p. 490). But the examples discussed in this paper hint at how one can circumvent these problems through an adequate theoretical framework, as will be illustrated during the exposition of the different formalisms.

This paper discusses some formalisms that I consider to be particularly attractive candidates for socio-economic analysis. Each of them has particular advantages that can enhance socio economic analysis in a particular sense, be it, e.g., an increase of the logical depth of the argument (game theory, system dynamics), the possibility to study phenomena that cannot be subject to verbal analysis (agent based models) or by structuring the overall assessment (SFM and IAD). All of them have to be treated with some care as formalisms always shape the analysis in a certain, often not obvious way. Consequently, I will pay particular attention to the implicit epistemological and ontological tendencies of the formalisms.

At this point it seems to be adequate to define what I mean when using the term "formalism". In a very narrow sense, a formalism denotes any abstract language, such as mathematical or logical formulas, or a computer language. We may call these *formalisms in the narrow sense*. But to limit the term to systems of such expressions seems to be too restrictive for our purpose: A table that is to be completed via verbal words and

[1] I have extended this framework and illustrated its usefulness for the examples of agent-based models and dynamic stochastic general equilibrium models in Gräbner (2015).

then carries a specific message can also be considered a formalism: Its structure carries information and shapes the meaning of the words that have been used to complete it. [2] The working definition we will use for such a *formalism in the broader sense* defines it as a set of abstract or specific objects that are related to each other in a certain way and which can be specified further in the course of analysis. Such a definition captures the central idea of a formalism: A *pre*-defined set of variables and a *pre*-defined set of relations that are then put together and specified by the modeller who makes use of this formalism. The notion of *pre-specification* is key: It carries meaning that has to be reflected on if the formalism is to be used successfully.

The rest of the paper is structured as follows: In the next section I present four formalisms that have already been used successfully in institutionalist theory and that I consider to have particular potential for socio-economic analysis.[3] In section 3 I propose agent-based models as another useful formalism in this sense. As it is not yet well established in current research praxis, I spend some more space on explaining its affinity to social economics. Section 4, after introducing a useful taxonomy for the formalisms, discusses their ontological and epistemological tendencies and elaborates on potential complementarities and antagonisms among them. Section 5 concludes.

2 Established Formal Approaches

2.1 The Social Fabric Matrix

The Social Fabric Matrix Approach (SFM-A) was developed by Hayden (1982) and summarized recently in Hayden (2006a). Since its invention it has been used by institutionalists many times and represents one formalism consistent with OIE methodology. See Fullwiler et al. (2009) for a detailed assessment of this claim and a number of case studies illustrating the substantial usefulness of the approach. As such it seems to be a natural candidate to study institutions within a broader social economic analysis. An SFM is a map that includes all the relevant components of the system under investigation and represents the relations and flows between these components.

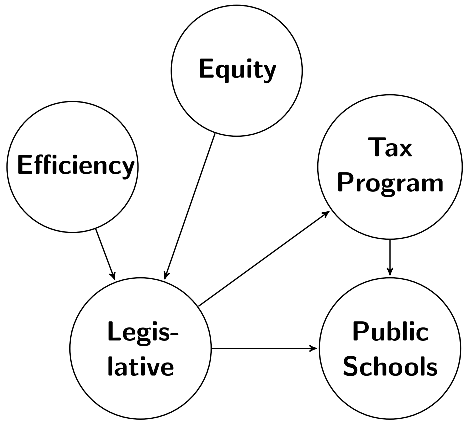
When written in matrix form, the rows and columns represent the different components of the system that the researcher has identified. See figure 1a for an example. The rows contain all the delivering components, the columns, the receiving components and the values in the cells denote either the existence or absence of a direct relation among the components (if only boolean values are allowed) or the strength of the relationship (if the value is some measure for the existent flow). Note, however, that the SFM is

[2] The social fabric matrix and the institutional analysis and development framework are examples of formalisms in this broader sense.

[3] Note that there are other formalisms that have been successfully applied by socio-economists. Yet, it is impossible to consider all of them in this single paper. The selection was made in accordance with my impression about the overall relevance of the formalisms, the degree of controversy associated with their application and with my personal preference. For an overview on other candidates see Radzicki (2003), Lee and Cronin (forthcoming 2015) or the special issue of the *American Journal of Economics & Sociology* (Lee, 2011).

Delivering \ Receiving	Equity	Efficiency	Legislative	Tax Program	Public Schools
Equity			1		
Efficiency			1		
Legislative				1	1
Tax Program					1
Public Schools					

(a) An example for a SFM.



(b) The SFM represented as a directed graph.

Figure 1: An example of an SFM (subset of the original matrix) and a corresponding graph, based on Hoffman and Hayden (2007).

a multidimensional tool, i.e. the relations and flows of the SFM are not necessarily measured by the same unit - this distinguishes it from simple Input-Output matrices.

Thus the matrix gives an overview of all the relevant flows in the system under investigation. But, for many researchers an even more important point, the process of completing the matrix helps one to ask new and relevant questions on the subject matter and to discover components and relationships that would have stayed unconsidered otherwise (Fullwiler et al., 2009, p. 12). The SFM can therefore be considered a heuristic forcing the researcher to think about the whole system in which the concrete problem is embedded into and to identify the relevant variables and relationships of this system. Because there are no pre-completed SFM, the researcher has to build her matrix anew from scratch, which forces her to justify her selection of relevant factors explicitly. The flexibility of the matrix prevents unreflected reference to standards, a common mistake in the application of many formalisms. To the contrary, the matrix stimulates researchers to be explicit about their subjective valuations.

As the matrix can naturally be interpreted as the adjacency matrix of a graph, the matrix shown in figure 1a could also be represented in graph form, see figure 1b. If the matrix was completed using boolean values denoting the existence or the absence of a relation between two components, the result would be a simple digraph. If the values in the cells were a measure for the degree of relation, a weighted digraph would result - although the different weights are not necessarily comparable.

The interpretation of the SFM as an adjacency matrix yields many advantages. In particular, one can use numerous useful graph theoretic concepts to deepen one's understanding of the system under investigation: For the resulting graph, reachability problems can be studied: In the logic of a graph, a reachability problem asks for the existence of a path from node v_1 to node v_2. In the context of the SFM this asks how different components are indirectly interrelated, and, if the graph specification includes weights,

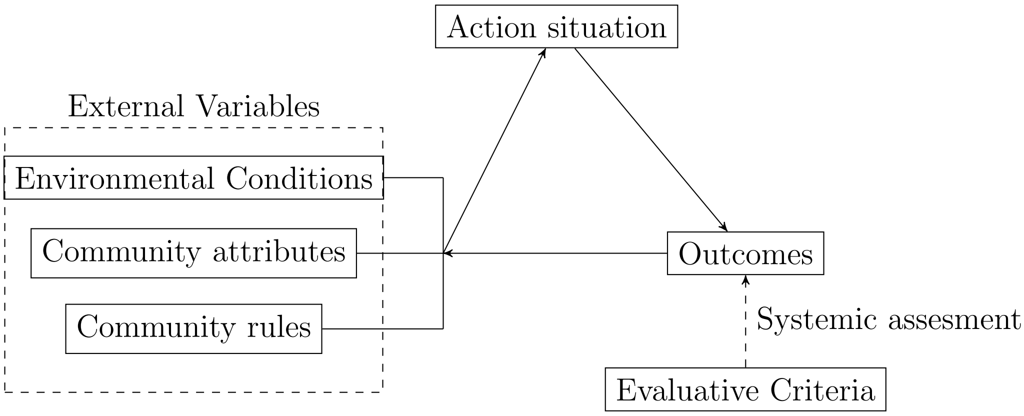


Figure 2: An illustration of the IAD, after by Ostrom (2005, p. 15).

how intense the interrelatedness is. One can also compute the degree distribution or other measures of centrality in order to assess the relative influence of the different components.

The SFM-A is probably the most widely used integrated framework within OIE. It has been developed particularly for institutionalist analysis, and numerous scholars have used it in their analysis.[4] Users stress that the matrix helps to structure research, suggests ever new interesting questions and forces the researcher to take a systemic perspective on the system under investigation (Fullwiler et al., 2009). Furthermore, it does not require any inappropriate reduction of complexity or abstraction from dynamics and is flexible enough to consider many different aspects of the system, reaching from environmental variables over institutions and organizations to the value system and persistent behavioral patterns. Especially when interpreted as a directed graph, it has helped to generate spectacular and policy relevant results, e.g. by considering the contractual structure associated with the construction of a nuclear dump side by the Central Low-Level Radioactive Waste Compact in Nebraska, USA, in collaboration with several big companies. Hayden and Bolduc (2000) were able to reveal the corresponding costs for the public that are, due to the contractual structure and the resulting system of positive feedback loops, much higher than one initially would have expected. As a consequence of these results, the project was abandoned.

2.2 Institutional Analysis and Development Framework

The IAD is a general framework for the study of institutions and their development over time. It was developed mainly by Ostrom (1990)[5] and has been applied in many different occasions. For Ostrom, frameworks are meant to illustrate the elements and relationship required for the analysis at a most general level and thus to structure the following inquiry (Ostrom, 2011, p. 8). The IAD is structured as illustrated in figure 2.

[4]For a corresponding compilation see Hayden (2006a), or consider Tool (2003) and Fullwiler et al. (2009) for a summary of the impact the SFM-A had on public policy.

[5]A more thorough introduction can be found in Ostrom (2005).

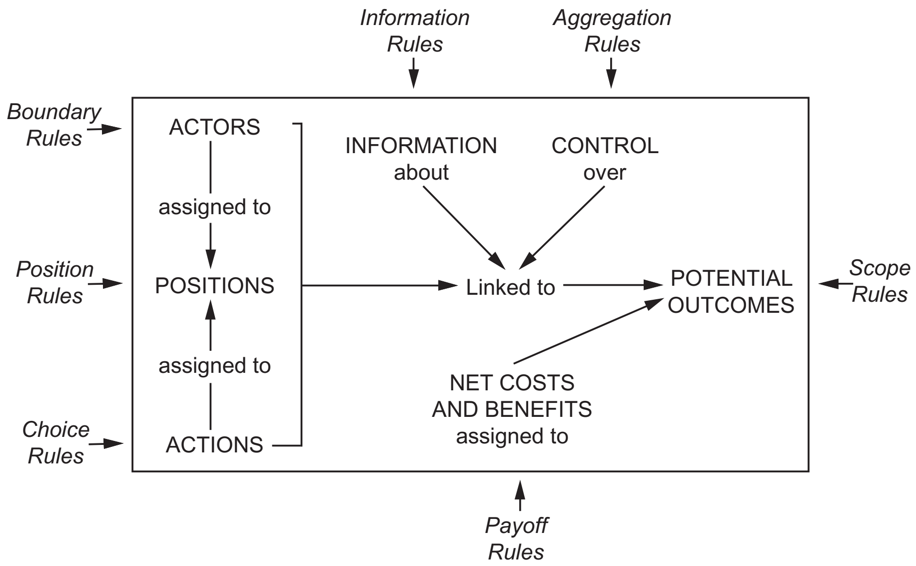


Figure 3: A closer illustration of the action situation, taken from Ostrom (2011, p. 20).

At the center stage of the framework is the *action situation.* This is the arena in which the actors (inter)act and from which the dynamics of the system are triggered. The identification of the action situation is one of the first steps the researcher has to take after the problem at hand has been defined. As illustrated in figure 2, the action situation is embedded into a broader analysis:

The environmental conditions, the attributes[6] of the community and its rules all have significant influence on the action and interaction of the individuals. Sometimes the outcomes from the action situation influence the environmental conditions which then in turn act upon the action situation. The emerging feedback loops can be identified and clarified using the IAD.In the very simplest case, however, one assumes the external variables to be constant and focuses one's analysis on the action situation alone. Figure 3 illustrates how the analysis of the action situation proceeds. Usually one develops a particular model to study the action situation in more detail. For Ostrom, several models can be derived from the same theory, and different theories are compatible with the IAD. It is therefore entirely possible to model the action situation using purely neoclassical models, game theoretic models or any other kind of model (e.g. agent based models, see section 3).

If one treats the variables marked as "external" in figure 2 as exogenous variables, one is concerned only with a model including the seven aspects illustrated in figure 3: The set of actors containing all individuals involved, the set of positions the individuals can occupy (e.g. managers, employees, members of an association, etc.), the set of actions that the individuals can take, the description of the control individuals have on their choices (i.e.

[6]Attributes of a community include, but are not limited to, the level of trust and reciprocity, habits, the value structure or cultural dispositions.

are decisions made in isolation, or do individuals act on the behalf of others?) and the information available to the individuals, the set of potential outcomes of the aggregated individual actions and a description of how these outcomes represent costs or benefits to the individuals. All relevant information has to be gathered before the actual modelling process can begin. Then one makes assumptions about the behaviour of the individuals, their wishes, beliefs, their capacities, and so on. Although the most widely used approach would be to use the conventional neoclassical utility maximizer as a starting point, this is by no means required by the IAD. To the contrary, the questions suggested by the IAD point to a more realistic and socially embedded actor. The experiments of Ostrom et al. (1992) on the mechanisms underlying sustainable self-organization of common goods within communities were motivated by the observation that, if one tries to understand how communities manage their common goods without running into the problems of the "Tragedy of the Commons", the conventional game theoretic individual will not be an adequate candidate for the individuals in the action arena. Therefore, Ostrom refined her model of individuals *within* the broader IAD framework.

In many situations, it does not seem to be adequate to consider the action situation in isolation and to assume the external variables to be exogenous. For a systemic scrutiny of the problem at hand, as it is required in institutionalist pattern models (Wilber and Harrison, 1978; Gräbner, 2014), one models the external variables endogenously. Ostrom (2011) suggests a taxonomy according to which one can incorporate the rules of the community under investigation into the action situation, as illustrated in figure 3. Such a refinement is entirely possible in and suggested by the IAD which could in general be interpreted as a sophisticated *topos* guiding the researcher's thinking, rather than a full-fledged modelling tool.

Another crucial part of the IAD is the very right part of figure 2: The evaluation of the dynamics resulting from the action arena. The evaluation criteria must be specified by the researcher in advance and depending on her theoretical orientation they can include only aggregate and monetary measures, or can be multidimensional, as required for a social economic analysis.

Summarizing, the IAD framework is an extremely general framework that is compatible with many different theoretical directions. It has gained an enormous popularity among scientists and practitioners and is now used in various scientific communities, see Ostrom (2005) or Hodgson (2013b) for compilations of work consistent with a socio-economic viewpoint. These examples show that the value position of the researchers can be made very explicit due to the prominent role attached to evaluative criteria and that cultural habits, beliefs etc. can be included into the analysis of the action situation, allowing a truly systemic perspective on the problem at hand. It is to be noted, though, that the perspective of the IAD is much more focused on individual action than the SFM-A: The action situation is at the centre stage, and the overall dynamics are derived from the arena, even if a continuous feedback between action situation, resulting outcomes and the subsystems of the entire system is possible. This issue will be discussed in more detail in section 4.

2.3 System Dynamics

System dynamics was originally developed by Forrester (1971) and introduced into institutionalist economics by Radzicki (1988), who argued that institutionalist pattern modelling (Wilber and Harrison, 1978) lacks structure, rigour and precision.[7] He hoped to address these shortcomings through the application of system dynamics, i.e. the computerization of the original pattern models (Radzicki, 1988, p. 636). For him, the computational modelling technique of system dynamics represents a computational approach not only broadly consistent with traditional institutionalist pattern modelling. He even goes so far as to state that "the only real difference between the two [system dynamics and institutionalist pattern modelling] is that the building of formal computer models is generally not a part of institutional analysis" (Radzicki, 1988, p. 634). He calls system dynamics and institutionalism two "parallel universes" (Radzicki, 1988, p. 639). Given the aforementioned overlap between institutional and social economics, it is also a natural candidate formalism for social economists.

A system dynamics model is a set of differential equations that is solved numerically. Its vantage point is the claim that individuals in a given system follow goal seeking behaviour (Radzicki, 1988, p. 640) and that the structure of a system, into which these individuals are embedded, is an important driving force of its dynamics (Radzicki, 2009, p. 70). The structure of the system involves its physical structure, organizational structure and the psychological decision making structure. Such an analysis is to be considered a systemic approach as the goal seeking behaviour of the individuals both affects and is influenced by the structure of the system.

The first step when building a system dynamics model is to identify the important variables (or "stocks") of the system under consideration and the dependency structure among the variables (the "flows"). When considering the stocks, one must also pay attention to limiting factors, as most stocks (but not all) face some natural constraint: The number of workers is bounded by the overall population and the area of land is constrained by the size of the region. Such eventual limitations must be specified in the model. The stocks of a system are related to each other via the flows, and the combination of these relations leads to the notion of feedback loops.

In the model building phase or when the model is presented to an audience, one can make use of *causal loop diagramming* in order to illustrate the feedback loops and causal relationship within the model: Stocks, flows and auxiliary variables are drawn as nodes of a directed graph, and the edges between two nodes represent a causal relationship between the stock and flow. The edges are labelled with either a $'+'$ or a $'-'$ depending on whether the relationship is positive or negative. See figure 4 as a simple example.

These loops are then expressed in differential equations that specify the relationships more precisely. Thus the system as a whole becomes a system of (usually highly non-linear) equations that is solved via numerical simulation. The most general formulation of a system dynamics model, given $\boldsymbol{X} = \{X_1, X_2, ..., X_n\}$ as a vector of the stocks, and

[7] A thorough introduction can be found in Sterman (2000).

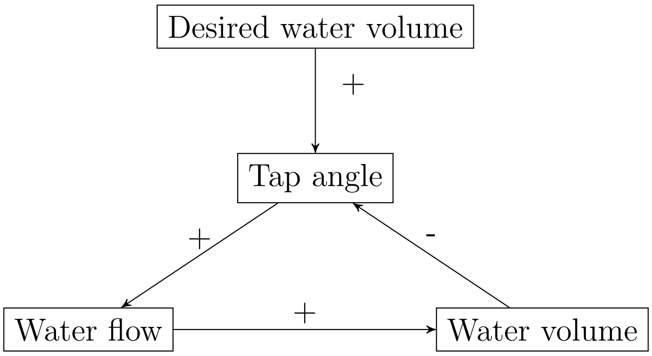


Figure 4: A simple causal loop diagram for a system dynamics model of a bathtub filling situation according to Lane (2008). This diagram assumes that if the water volume rises, one increasingly closes the tap in order to avoid flooding. Note that this is just a simplified illustration of the model and that the strength and direction on the relationships can vary, depending of the overall state of the model.

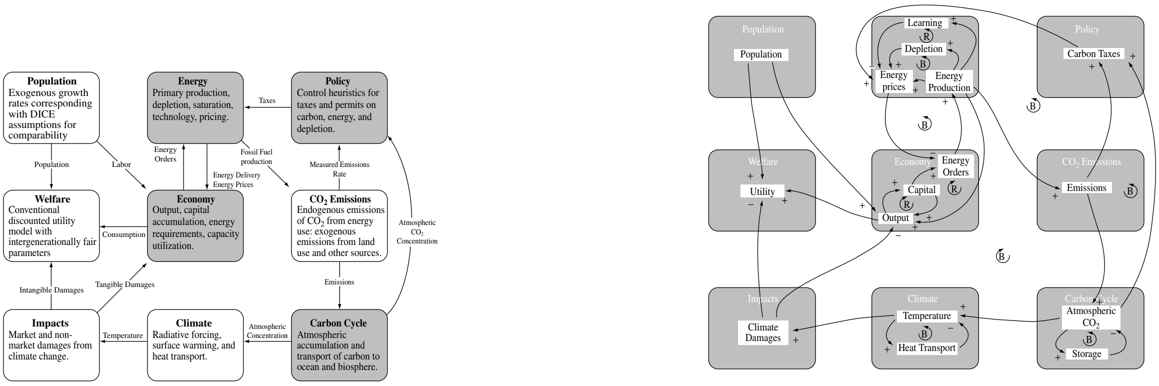
$\boldsymbol{p}$ as a vector containing all constants and the initial conditions, is therefore:

$$\frac{dX_i}{dt} = f_i(\boldsymbol{X}, \boldsymbol{p}), i \in \{1, 2, ..., n\}. \quad (1)$$

Because of the use of differential equations, the system is inherently dynamic and the strength of the feedback loops can vary during the evolution of the model. And as an unambiguous analytic solution is not attempted, there are no general equilibrium assumptions made. For simplicity reasons, a model is often initiated in the equilibrium state. But this is an assumption made for convenience, not for technical necessity (Radzicki, 2010).

The translation of the theoretical model into equations and computer code ensures full transparency and maximum rigor in the model formulation. Note that the researcher continuously improves her knowledge about the system through the modelling process itself, as the obligation to state all relationships explicitly and precisely leads to ever new questions about the system under investigation. Similar to what has been said about the SFM-A, many authors (including the inventor of system dynamics J. Forrester) claim that the building of a system dynamics model and the corresponding learning process is even more valuable than the final model itself (Forrester, 1985; Radzicki, 2009).

Let me provide a quick example that illustrates the general structure of a system dynamics model. While the model description is by no means complete and the interested reader should refer to the original publication, it still gives an idea about the structure of typical system dynamics models. Fiddaman (2002) studies the potential effects of climate policy on the socio economic system and derives some policy advice about how CO_2 emissions can be reduced most efficiently. The structure of the model is illustrated in figure 5 and it becomes clear immediately that the model represents a holistic view on the system under investigation. Furthermore, the author includes boundedly rational



(a) The different sectors of the model.

(b) The causal loop diagram underlying the model.

Figure 5: These diagrams illustrate the strucutre of Fiddaman's model (Fiddaman, 2002).

agents and is able to study the dynamics of the socio-economic systems.[8]

At the end of this section, a caveat is appropriate: SD came under heavy criticism by Hayden (2006b). Hayden argues that the assumptions required by SD are too strong. He argues, *inter alia*, that SD models treat the real world as a closed system and focus on (static) feedback loops rather than on real dynamics caused by the relations between the system itself. There are indeed some critical assumptions within the framework, but to dismiss the approach entirely might be to throw the baby out with the bathwater: There are numerous examples of successful socio economic analysis making use of system dynamics modelling, e.g. Fiddaman (2002), Hayden and Bolduc (2000) and Bassi (2008). None of them claims that the SD model is an exact representation of the real world. As mentioned in the introduction, this is impossible. But the approach allows one to enrich a sound theoretical framework (or an SFM, see later) with a precise analysis of the dynamic relationship among crucial variables. That one has to question the adequateness of the assumptions made in the concrete case is self-evident. But this is true for every analysis.

2.4 Institutional Dynamics and Evolutionary Game Theory

Game theory has a long tradition in many different disciplines of science. It was introduced into economics by the mathematician John von Neumann and the economist Oskar Morgenstein in 1944 . Since then, its importance, also, but not only, in neoclassical economics, has been growing dramatically.[9]

While original game theory is mostly in the tradition of the rational choice paradigm, biologists developed a derivation called *evolutionary* game theory that does not rely on

[8]Note that Fiddaman (2002) has not considered any cultural habits of values explicitly in his model. But these could be added into the model without great difficulty.

[9]For a very good introduction into game theory and evolutionary game theory from an institutionalist perspective see Elsner et al. (2014).

the classical rationality axioms. It analyses how different strategies perform in different environments, under which circumstances they replicate and how they evolve over time.[10]

Several authors point to the potential of (E)GT for socio-economic and institutional economics. These include Field (1994), and more recently Hedoin (2010), Pelligra (2011) and Vilena and Vilena (2004). But there is also a lot of criticism of the application of game theory for a socio-economic analysis of institutions.

I argue that critiques of (E)GT often conflate the exclusive with the heuristic use of game theoretic models: Varoufakis (2008), for example, highlights the usefulness of a very stylized evolutionary game theoretic model to explain how discriminatory institutions emerge and cannot be changed by single individuals alone, but only through a process of collective action. Yet he concludes his paper with a critique of EGT for being agnostic on how such change may work, or on how to criticize the resulting system of exploitation. He, in turn, argues for a historical enquiry of the system under investigation to shed light on these questions. Valid as his remarks on the limitations of EGT may be, one should note that much of his reasoning builds heuristically on game theoretic models and that he makes extensive use of the taxonomy of interactions provided by game theory. When I argue that game theoretic models can be useful for socio-economists I do not say that they should substitute a historical account of the system under investigation or they are able to speak for themselves. Varoufakis (2008) is correct in rejecting such an isolated application of game theory if one wishes to understand societal systems. As all the other formalisms, game theoretic models require a sound theoretical framework that allows a sound interpretation of their mathematical structure and helps to elaborate on the consequences of the model outcomes beyond the scope of the mathematical apparatus. To clarify what this means, I will discuss a best-practice example: Paul D. Bush's *Theory of Institutional Change* and its refinement in a game theoretic framework by Elsner (2012) illustrates how socio-economists can and have made use of game theory to gain additional insights into the emergence and evolution of important institutions.

In his Theory of Institutional Change Bush (1987) established a coherent theoretical device to analyse the value basis for behavioural patterns and the resulting dynamics in the form of progressive and regressive institutional change. Starting from the conception of an institution as patterns of behaviours correlated by socially prescribed values, he builds on the dichotomy of instrumental and ceremonial value systems and develops the distinction between ceremonially and instrumentally warranted patterns (Bush, 1987, p. 1082). Using the idea of ceremonial dominance, he argues convincingly how new technologies introducing new opportunities for instrumental behaviour generally do not lead to institutional progress as the new instrumental behavioural options get encapsulated through ceremonial values with more ceremonial or dialectical behavioural patterns. Progressive institutional progress is possible only if the ceremonial dominance in the society gets reduced by substituting ceremonial values with instrumental ones.

Enlightening as it is, the theory does not explain how ceremonial dominance *emerges*

[10] Strategies are often interpreted as genes, but also as values, behaviour, habits or the like. There exist settings in which the strategies themselves are under ongoing change and players develop new strategies, according to the rules of Darwinian evolution, see e.g. Lindgren (1992).

endogenously in a given society, which could, in principle, also be instrumentally dominated.

Twenty-five years later, Elsner (2012) took up the Theory of Institutional Change and addressed this shortcoming using an *evolutionary-institutional interpretation of game theory* in the Axelrodian framework of the evolution of cooperation. Elsner elaborates further complementarities and equivalences between the two approaches and stresses the similar policy prescriptions derived from the two perspectives (Elsner, 2012, p. 38). He argues that although game theory cannot provide an epistemological basis comparable to that of institutionalism, it can, if embedded into a broader institutionalist process story, add rigour and logical depth into the institutionalist analysis, can allow for a clearer distinction between different types of social rules and institutions, and enhance the institutionalist analysis, e.g. by offering an explanation for the initial emergence of ceremonial dominance in the context of Bush's theory.

The model of Elsner shows that if the application of game theory is not considered a value in itself and authors manage to provide adequate process stories into which they embed their game theoretic analysis, the game theoretical part, in the end, takes the form of a heuristic adding analytic clarity to the analysis. By doing so it enlarges their reach to more complex problem structures, which could not have been understood without the support of such a clarifying heuristic.

3 Agent-Based-Computational Models

3.1 Introduction and Affinity to Social Economics

Agent based computational models (ABMs) are a relatively new trend in the social sciences, although they are already well established in many other research disciplines such as urban planning, ecology, demographics, epidemiology, or logistics.[11]

When building an ABM one starts by programming the fundamental entities of a system as software objects. These objects represent autonomous agents and are able to interact with each other and their software environment. The latter can be programmed either as a software object as well or takes the form of statistical aggregates. In the former case, one could program an object representing an agricultural landscape, which can be exploited by the agents. An example for the latter case would be an aggregated variable representing the overall wealth of the agents. This variable may influence the behaviour of the agents, e.g. if middle-class agents behave differently than low-class agents.

One then studies the systemic and dynamic consequences that result from this configuration by simulating the system and conducts artificial experiments by altering specific aspects and comparing the resulting dynamics. Although the agents usually represent

[11] ABMs have been used in the social sciences since the 1990s, with Epstein and Axtell (1996) and their "Generative Social Science" as a major vantage point. But there were some predecessors in the 60s, particularly in the field of cellular automata theory.

individuals, this is not necessarily the case: depending on the system under investigation, the agents can represent households, groups, organizations, or states.

The interaction among the agents can be entirely random or can be due to the topological structure of the model: One can allocate the agents on a (possibly changing) graph that represents an empirical interaction structure, on a grid on which the agents can make moves, or any other topological structure. This allows to model the agents as socially embedded and interdependent individuals.

Even more importantly, ABMs allows the study of decentralized decision making: There is not necessarily an artificial central planning institution such as for example the Walrasian Auctioneer in most general equilibrium models. Rather, the dynamics of the system modelled are the result of the autonomous interactions of the different agents and illustrate the self-organization a given system is capable of.

As the agents themselves are usually programmed in a computer language, a very flexible specification is possible: The digital objects representing the agents can have several attributes, such as income, saving, health, or a certain disposition. The objects also have functions, according to which these attributes change, and behavioural functions that determine the actions of the agents in certain situations. All these functions can have diverse inputs: The current state of the agent, but also current state of other agents or of the system as a whole. As suggested earlier, this means that, maybe contrary to what the name suggests, ABMs are not necessarily individualistic models: The behaviour of the agents can depend on entities on different ontological levels: An agent can make different decisions depending on the state of the whole system, or on the state of a certain group of agents. One can create a software objects that represent a social institutions and affect the behaviour of the agents. By this, one is able to distinguish very precisely between two different conceptions of institutions: If institutions are nothing more than correlated behaviour that emerges because individuals have a memory and react to each other depending on their experiences with similar situations in the past, there is no causal interaction among different ontological levels and no downward causation in the strict sense. But if an institution is represented by a proper object (which may change over time and whose effect may change depending on the support it gets from the agents) that interacts with the agents, then one can speak of a direct interaction of two ontological levels and thus proper downward effects.[12]

Thus, ABMs allow a very precise study of institutions, rules and networks on a potential meso level of the system and their corresponding relation to the individual agents (Elsner and Heinrich, 2009; Elsner et al., 2014). Also, the agents do not necessarily follow the same stimulus-response pattern the whole time, but can be given the ability to adapt themselves to their environment, learn from past experience and develop new objectives and strategies.

The above said immediately leads to the question of whether one could design an ABM with highly sophisticated artificial intelligence agents that resemble the behaviour of humans and thus guarantees a maximum level of realism. The fact that there is no

[12]Note that the program does not tell you on which ontological level the different software objects belong. This information must be given by the theory underlying the model.

unanimous answer to this question indicates the enormous heterogeneity of different perspectives within the ABM community: Advocates of the so called KISS ('keep it simple, stupid!') paradigm argue that ABMs in general should be kept as simple as possible and one should focus on the rules that are of essential importance for the research question, otherwise the models would themselves become too difficult to understand and it gets impossible to identify the critical mechanisms that yield to the overall dynamics. Proponents of the KIDS ('keep it descriptive, stupid!') paradigm criticize the tendency to reductionism inherent to the KISS approach and argue that agents should be built in line with empirical results from psychology, anthropology and other empirical sciences concerned with human decision making. [13] ABMs are compatible with both world views, and most models take their place in between the two ideal cases. For socio-economists it is important that ABMs allow a certain degree of realism that makes them compatible with different epistemological perspectives, including the realist approach most widely accepted in social economics.

The heterogeneity of existent ABMs has already been mentioned. They represent entirely different economic perspectives with very different underlying epistemologies and ontologies: Some ABMs are considered macro models that want to model an economy as a whole, others model only one particular market or one particular region. Some of the models try to be as realistic as possible, others remain very abstract and illustrate the effects of some mechanisms in isolation. Some ABMs are built for predictive purposes only, while others serve only explanatory reasons. There are ABMs that are built for one particular system, e.g. the model of Geanakoplos et al. (2012) for the housing market in Washington D.C., others are built as generic models that try to illustrate more general properties of systems, e.g. properties that are shared by any housing market in the USA. Also, the mechanisms included into the models are very diverse: Many ABMs were built to study the role of interrelations between agents such as different underlying network structures, others focus on the effects of particular decision heuristics. All this leads to very different epistemologies and ontologies present in the ABM communities.[14] It is clear that only a small subset of all these ABMs are of interest for social economists, but in the future they will (hopefully) increasingly build adequate ABMs themselves.

This seems to be appropriate as ABM can effectively address certain difficulties that social economists face at the moment:

If one considers the economy from a systemic point of view, one has to take the interaction among different ontological levels seriously. This involves the consideration of both aggregation problems and the scrutiny of downward effects. Especially aggregation

[13]If one considers the economic agents to represent the micro level, ABMs are suited for *microcalibration*. This involves a direct test of the adequateness of the agent design. It is common to consult field experts to judge the behavioural assumptions or to exchange the agent with a real human being "playing" the role of the agent in the model and then by comparing how the software and the real human being have behaved. Because the behavioural specification of the agents is done via computer code, there is no upper limit for the complexity of the rules other than accountability considerations. Chen (2012) describes various types of agents including very elaborated artificial intelligence agents.

[14]Unfortunately, most model applications do not reflect explicitly on their epistemological orientation, which makes it difficult to assess the models from a critical perspective.

mechanisms often lead to counter-intuitive results or are difficult to be expressed verbally. Take as an example the role of social networks and self-organization for the functioning of exchange systems: Albin and Foley (1992) have shown that even if one accepts all the usual axioms of the highly stylized Arrow-Debreu economy and only removes the fictitious Walrasian auctioneer in favour of direct interaction among the agents, the market will develop towards an equilibrium, but inequality among the agents will increase. Also, the way the interaction among the agents is structured, i.e. whether their interaction structure is modelled as a ring, a star or another type of network, influences the dynamics. Today, there is a huge amount of empirical evidence about how interaction networks in particular settings look like. These networks can be described with numerous statistical measures, e.g. their degree distribution, their centrality, their clustering coefficient or their density, among others. These statistics can make a huge difference in practice, yet they are very difficult to be described with verbal language. ABMs can help to build a theory of how different network structures affect certain exchange regimes and allow the use of the extensive information we have about real world networks and how their shape affects the aggregation of the individual actions within them.

Furthermore, ABMs help to study the causal effects of different decision procedures such as habit or inertia: As the decision making algorithms can be changed during artificial experiments with the model, we can elaborate how different cognitive procedures affect the system under consideration. Hodgson and Knudsen (2004) have built an ABM that studies the emergence and evolution of a traffic convention. The decision making procedure of their agents involves habituation and they show that habit and habituation can help people to coordinate on a certain traffic convention. They are also able to show that the effect of habit is particularly important and that it has a bigger effect than pure inertia. Such reasoning would have been impossible without the heuristic use of their ABM because verbal language does not provide the necessary exactness and does not allow artificial experiments to reveal the causal relationships. And it is of certain importance for social economists who accentuate the importance to treat human agency in a realistic and adequate manner.[15] Note that this is one reason for the increasing use of ABMs in sociology (Manzo, 2010).

3.2 Empirical Work and Relation to Econometrics

Another huge potential of ABM for socio economists lies in their potential combination with econometrics. Econometric studies abound in social economics, especially because socio economists claim to work on a sound empirical basis and to orient their theory strongly on reality.

But econometric models require quite strict assumptions about the relationship of the variables in the system under consideration and the formalization of the hypothesis

[15] The extensive survey of Chen (2012) shows how different types of agents can be implemented within the ABM framework. The range of possibilities starts with zero-intelligence agents that may not be of primary interest for social economists, but also include elaborate artificial intelligence agents that require a lot of effort to be built. The adequate conception depends on the problem at hand. The important lesson for social economists is that a very detailed description of agency is possible.

to be tested by the researcher. Not only are these assumptions sometimes not met: if they are not, this fault also often remains unconsidered for a long time, because more sophisticated estimation techniques allowing the identification of the problem have not yet been developed. In the (still unresolved) debate about the empirical validity of the Kuznets curve there have been periods in which certain estimation techniques or data sets were used by the majority of the researchers, resulting in general support for the thesis, until later the same techniques and data sets were shown to be inadequate, new methods were applied and the support turned into rejection (Alvarez-Pereira et al., 2015).

Furthermore, econometrics is generally inappropriate for considering aggregation mechanisms: Most of the studies use either exclusively aggregated macro variables (in a macroeconometric framework) or micro-variables (in a microeconometric framework) without considering the important interplay between both (Chen et al., 2012). The systemic analysis attempted by socio economists requires a systemic perspective that explicitly considers the mechanisms between micro- and macro- levels, i.e. aggregation and downward effects. Aggregation represents a particular challenge to econometrics if the system under investigation involves heterogeneous agents (i.e. almost always). Delli Gatti et al. (2007) shows how many standard econometric concepts, including Granger causality, impulse-response functions of structural VARs and cointegration, lose their explanatory power and spurious results emerge as a consequence.

ABM can be helpful to address these shortcomings:

Considering the problem of inadequate estimation techniques as in the case of the Kuznets curve, much confusion stems from the fact that many econometric studies are theoretically *ad hoc*. The underlying models often consider only a single ontological level or are based on static rather than dynamic models. It is therefore often not clear what time horizon has to be considered and which kind of data is adequate for the empirical assessment. We have shown in Alvarez-Pereira et al. (2015) how ABMs can provide the missing formal theory to diminish these problems: Adequately specified they make clear statements about the time horizon to be considered and they help to condense the aggregation effects in the data. In this regard, Chen et al. (2012) suggests to use ABM as a data generating mechanism in order to assess the consistency of the econometric tests: If estimations both for individual parameters and the aggregated data are both consistent, the model has been adequately specified. Without the help of an ABM this consistency remains simply assumed and adverse results emerge.

Lastly, ABM can also help to scrutinize the empirical validity of theories on different levels: As has been argued above, ABMs are subject to micro- or meso-calibration. If a theory gets formalized through an ABM, the resulting model can be tested against the data not only through its overall result, but through the different mechanisms within the model. This facilitates both the construction and the assessment of explanatory theories.

4 Classification and Discussion

In the preceding sections I have presented formalisms that were (or should) seriously be considered by the socio-economic community. I will now compare them regarding their potential fields of application and their ontological and epistemological tendencies. An overview is given in table 1.

4.1 Frameworks, Theories, and Models

During this discussion I build upon Ostrom (2011) and her distinction between frameworks, theories and models: A *framework* represents a general set of variables and certain general relationships among these. It also provides a metatheoretical language with which one can reason about these variables and relations. This language also helps to distinguish and discuss different *theories* which put their focus on different parts of the framework and suggest more specific assumptions that help to analyse the variables, their relations and the system as a whole more precisely. One framework can therefore be compatible with different theories, which then accentuate different parts of the framework and suggests different interpretations. *Models* then involve very specific assumptions about some of the elements of a theory and are used to derive precise predictions or explanations for these variables. Different models can be derived from the same theory and implemented within the same framework. [16] In our context, some preliminary questions immediately arise: Which of the above described formalisms falls into which category, and how does this relate to the relationship among the different formalisms?

The answer is obvious for the IAD: It is the canonical example of a *framework*. The variables and relationships within the IAD can be further specified using different models, and depending on the choice of the models, the overall study gets a more socio-economic, neoclassical or different flavour. The IAD is not bound to a specific theory: There are examples of very orthodox applications of the IAD with very strong assumptions regarding the individuals in the interaction arena and the external variables as purely exogeneous. But there are also examples of studies using the IAD within a systemic analysis of the problem at hand, considering important external variables to be endogenous and to use more realistic models for the action arena. Still, the IAD suggests by its design a certain epistemology and ontology, as discussed here.

The SFM is usually used as a framework: As already mentioned, it helps to structure the ideas of the researchers and to express the different variables and relationships of the system under investigation. The specific relations can then be further studied using different, more specific models. Radzicki (2009) shows this for the case of system dynamics: The SFM provides a general overview, and the relationships are then expressed via differential equations, giving rise to a system dynamic model. But an SFM could also, in theory, be used as a model: If the variables are defined in a very narrow sense, and the matrix represents a very definitive and closed system, the SFM becomes a concrete model. But such cases are rather an exception than a rule. [17]

[16]For Ostrom, examples of theories are *game theory*, *public choice theory*, *transaction cost theory* and the like. I define theory in a broader sense such as the *neoclassical* or *institutionalist* theory, but this is not of crucial importance. I agree that the theory suggests the parts of the framework that are given particular importance.

[17]This shows that a clear-cut distinction between the three ideal types is not always possible. Also, different researchers apply the formalism in a different manner. Still, they may be useful as a general

	SFM	**IAD**	**System Dynamics**	**Game Theory**	**ABM**
Type	Framework (Model)	Framework	Model	Model	Model
Ontological Tendency and Compatibility	Holistic	Individualistic	Holistic	Individualistic	Systemic
Epistemological Tend. and Compatibility	Holistic	Individualistic	Holistic	Individualistic	Systemic
Compatibility	SD, ABM, GT	GT, ABM	SFM	ABM, IAD	SFM, IAD, GT
Remarks	Usually used as an overall frame, but potentially as a general model of one system on its own. Interpretation as a digraph allows a most detailed scrutiny of policy implications.	Extremely flexible, not limited to OIE; a systemic consideration possible if a flexible and dynamic model is used within the action arena. Thus, it is very much dependent on which models are used to enrich the framework.	Can be used for empirical assessment of theories and is a good choice if mainly macro or meso variables are to be considered. Especially useful for creating policy advice.	Requires much interpretational effort and strong embedding into theory	Very flexible tool compatible with many theories and frameworks. Can be used as a complement to econometrics to assess theories on different ontological levels and is very useful to study aggregation problems (esp. upward and downward causation).

Table 1: An overview of the different formalisms.

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For the other three formalisms, the answer is straightforward: ABM, SD, and GT all represent concrete models. All of them require the researcher to make very clear assumptions and to focus on certain relationships suggested by a more general theory. ABMs for example are compatible with different theories and represent a very flexible modelling tool that can be used to model various situations from very different perspectives. But the single ABM is nevertheless a very concrete model with specific assumptions and a concrete aim.

The grouping of the formalism into frameworks and models suggests seeing them as potential complements, rather than strict substitutes: A model might be used within a framework, so the two formalisms may not be mutually exclusive. This might be true in some cases. But the next section shows that all of the formalisms carry implicit epistemological and ontological tendencies that might be incompatible with each other and prevent a fruitful combination.

4.2 Ontological and Epistemological Tendencies

For the ontological and epistemological tendencies I distinguish three ideal cases: systemic, individualist or holist tendencies. The technical design of all the formalisms suggests a certain approach. If this *tendency* is not adequately reflected, it will stay unrecognized, with significant consequences for the outcome and the interpretation of the study.

I speak of an individualist tendency if the model or framework focuses on individual agency to explain the phenomena present at various levels of the system under investigation. The distinction between an ontological and an epistemological individualism is the following: While the individualist ontology suggests the absence of anything such as a "social whole", the individualist epistemology does not deny such a social whole, but it denies the possibility of learning anything about a system by considering this "social whole" directly. All relevant information on the system can be gained by the exclusive study of the individual level. von Mises (1949) advocates an individualist ontology when he argues that "a social collective has no existence and reality outside the individual members' actions." A form of epistemological individualism is articulated by John Hicks when he praises Leon Walras for having understood "that the only economic explanation of a phenomenon is its reference back to individual acts of choice (Hicks, 1934, p. 348).[18]

A holistic tendency means that a model focuses on the relationship among macro-variables, as the societal whole is assumed to transcend its individual members. What happens in the system is the consequence of emergent properties of the system that cannot be explained from the individual level. Again, an epistemological holist would not question individual agency, but argue that individual actions are determined by macro-variables alone. Studying the latter already tells one everything about the former.

taxonomy which facilitates to think about formalisms and their application.

[18] Hodgson (2013a) rightly points to the confusion that is often associated with individualism when he discusses the meaning of methodological individualism. Whether individualism includes the relation among individuals has never been clarified. I think that the constituent element of individualism in any sense is the denial of downward effects on individuals. This is in line with Kapeller (2015 (forthcoming), who identifies this denial with a *simple fallacy of aggregation*.

An ontological holist would go further and deny the existence of individual agency at all. Recent examples of a pure ontological holism are hard to find. Durkheim, with his focus on social facts and his concept of an organic society, is sometimes used as an example. Some also consider Marxism to be an example of ontological holism, although there is an ongoing dispute on this subject.[19]

Systemism can be considered to be the "golden middle" between individualism and holism: Here the whole system is considered to be a composition of different sub-systems that possesses both reducible and non-reducible properties. Individual behaviour both shapes and is influenced by its environment: Both downward and upward effects play a role. For the ontological systemist, there are different ontological levels within the system under investigation and all of them contain relevant mechanisms and properties. Such a *layered ontology* is an essential part of the Darwinian interpretation of institutionalism elaborated by Hodgson and Knudsen (2010). Similarly, according to systemist epistemology one has to study all levels of a system and the corresponding relationships in order to fully understand the system, both as a whole and in its different parts. Such a view has been put forward e.g. by Bunge (2004).

Game Theory Regarding the underlying ontology, game theory is the most rigid formalism: It is certainly rooted in individualist thinking. Still, game theoretic models can be useful for a systemic analysis if they are interpreted adequately. But such an interpretation requires certain effort, as Elsner (2012) has argued extensively. There is a clear epistemological tendency towards individualism as the only endogeneous driving force in the model is the individual, and a compatibility with a systemic epistemology can be achieved only if downward effects are included via the rules of the game. GT is certainly not compatible with either holistic epistemology or ontology.

System Dynamics At the other end of the spectrum we have system dynamics models: Although certain individualistic variables can be included into the models, they mostly work with aggregated variables, and the interaction among the agents on the micro levels is not modelled explicitly. So while SD can be made compatible with a systemic ontology or epistemology, such a specification is not directly suggested by its technical design. In any case, SD is incompatible with both individualistic ontology and epistemology.

Agent Based Models ABMs are somehow in the middle, with a certain tendency towards individualism: Agents are considered to be actors and one of the driving forces behind the dynamics in the system. Nevertheless their behaviour and state can depend on the state of entities on a higher ontological level, e.g. groups or the whole population. As was shown earlier, systemic concepts such as reconstitutive downward causation can be considered in ABMs. Still, there is some tendency towards individualism as the systemic

[19]Some passages of Marx suggest a clear holist ontology, e.g. his statement that "the capitalist functions only as personified capital [...] just as the worker is no more than labour personified." (Marx, 1982, p. 989). But there are also other examples, e.g. the notion that "history is nothing else than persons pursuing their aims." (Marx and Engels, 1956, p. 125).

processes must be actively included into the models, while the upward effects from the micro- to the macro-level are naturally present in any ABM, just due to its technical design.[20]

A danger of ABM is thus that one tunes the behavioural rules of the individuals in such a way that the desired macro behavior gets deduced from the individual actions - such a specification is not necessarily realistic, especially if there is clear evidence for other ontological levels playing a role. Such a failure can be prevented if all the decision making procedures and other mechanisms in the models are made subject of empirical assessment.

Social Fabric Matrix The SFM-A has a holist tendency, as individual decision making is usually not directly included into the matrices. The focus is mostly on aggregated variables and some influential institutions. Thus, the existence of different ontological levels is acknowledged and frequently considered. But the behaviour of different individuals or emergent phenomena triggered by the interaction of heterogeneous individuals are usually not modeled explicitly. It seems therefore fair to say that the SFM-A has a holist tendency, at least concerning its epistemology. But it can successfully be used for a systemic investigation as well, especially if it gets enriched by ABMs to consider aggregation problems and the role of individual agency explicitly.

IAD To the same degree at which the SFM fosters holistic perspectives, the IAD has a tendency to favour individualistic studies. This is due to the focus on the interaction arena. But the character of the study depends in the end very much on the model that is used within the interaction arena. If one models the interaction arena via a game theoretic model and assumes the external variables to be exogenous, one ends up with an individualistic study. If the interaction arena is modeled using a more sophisticated ABM and the external variables and considered endogenously, the resulting study is clearly systemic. The general tendency of the IAD is therefore in the individualist direction, although it certainly allows for systemic accounts if the models for the interaction arena are chosen accordingly. It is not compatible with either holistic epistemology or ontology.

4.3 The Relation among the different formalisms

The above-mentioned shows that the formalisms are not necessarily substitutes. In particular, frameworks are usually accompanied by a model. But not all the models can be fruitfully employed with all frameworks. Their ontological and epistemological orientation must fit together. Furthermore, depending on the question at stake, different models may be the adequate choice. So, while models and frameworks are no substitutes, different models and different frameworks are not always competing with each other directly: SD models are predestined if there are some macro variables of interest that influence each

[20] In fact, theory is required to allocate the different objects of the ABM on different ontological levels. Technically, an agent is as much an object as an institution. That the latter belongs to a different ontological level must be inferred from the underlying theory.

other according to rules that can adequately be expressed via conventional differential equations. As argued extensively by Radzicki (2009), SD models can effectively be used to supplement analysis within a SFM. This combination has lead to very interesting results, e.g. in Hayden and Bolduc (2000). Because SD is an approach focused on aggregate variables and relationships, it is only of limited value within the IAD framework, as it cannot be used intuitively to model the interaction arena which is mainly concerned with the decisions on the micro-level.

ABMs are to be preferred over SD models if either individuals can be expected to be the driving forces of a system or if entities from different ontological levels are expected to interact with each other and aggregation is thus not necessarily straightforward. ABMs are also a good choice if one has more precise information or hypothesis about the heuristics according to which individuals make their behavioural choices: Often, these heuristics can be expressed much easier via algorithms than via conventional equations, and their role for determining the dynamics of the whole system can be explored.

Because they allow a very detailed representation of real world systems and thus allow the explicit consideration of various mechanisms and their interplay, ABMs are very well suited to model the interaction arena within the IAD framework. They might also be useful to complement an SFM, especially if the SFM includes nodes from different ontological levels and a system dynamics model is thus more difficult to implement.

Both SD and ABM can be used to conduct artificial experiments and thus to effectively generate policy advice. Also, both models can be used to complement and qualify econometric assessment of different hypotheses. Again, ABMs are to be preferred if one wishes to assess the role of aggregation and (reconstitutive) downward effects within the system. SD should be used if there are reasonable information about the relation of macro variables, but a specification of mirco mechanisms would involve considerable speculation. Especially if predictions for alternative policy measures are to be derived, this would be a strong argument in favour of SD. [21]

Game theory is a prominent choice if it comes to modelling the interaction arena within the IAD. Numerous examples have proven the effectiveness of this combination from an orthodox viewpoint, although the resulting models can be considered only partial successes if considered from the perspective of socio-economics: As both the IAD and GT have individualist tendencies, their combination will most likely fail to provide an inspiring study of a societal system as a whole.

Also, if considered in combination with the SFM, GT can be very useful to illustrate a relationship between two nodes in a qualitative manner, especially if the two nodes are on the individual and/or the meso level. The embedding into the broader context of the SFM-A effectively addresses the shortcomings of game theory and facilitates a systemic interpretation of the model outcome and the rules of the game. Furthermore, within the broader perspective of the SFM-A, practical policy recommendations can much easier be derived than in the rather abstract GT models alone. If the game becomes too

[21] Scholl (2001) argues for a certain complementarity among SD and ABM: They give insights to the same system from different perspectives. This does not affect the argument that they are not to be used simultaneously together.

complicated to be solved analytically, it can easily be implemented in an ABM framework: Especially GT models involving a topological structure or many heterogeneous agents are solved numerically within an ABM. This is particular attractive for socio-economic analysis as it allows a further relaxation of the otherwise rigid assumptions in game theoretic models.

The last question is whether the SFM and IDA can be fruitfully used together. The only cases in which this could be is if the SFM helps to identify important relationships between the external variables with key variables in the interaction arena of the IAD, or if one uses a very specific SFM within the IAD, either to clarify relevant dynamics within the set of external variables or between external variables and the interaction arena. Both cases are theoretically possible, but practically irrelevant. Even if the possibility exists, there are probably much more intuitive ways to model the corresponding system than to artificially bunch two frameworks together that come from, while not contrary, but different perspectives.

5 Conclusion

This paper has presented different formalisms that can help socio economists in their scrutinies. It is clear that neoclassical theory exaggerates the use of formalisms, but is by no means representative for formalist analysis. All the formalisms discussed in this article can potentially be useful for socio economic analysis, but to achieve this, the formalism must be embedded into a broader theoretical frame: No formalism speaks adequately for itself. All have to be interpreted, and their inherent ontological and epistemological tendencies have to be reflected. This article therefore represents a potential starting point for a more extensive and adequate use of formalisms in this sense. Much can be gained from such an application: Formalist analysis can allow the consideration of questions that have not yet been dealt with (e.g. the role of empirical network structure on societal dynamics) and existing arguments can be made more precise.

To conclude this paper, let us consider the question whether some of the formalisms outlined here can help to bridge socio economic (of heterodox analysis more generally) with more orthodox work. This might particularly be the case for the IAD framework or game theory, as these are also employed by neoclassical economists. Besides the question about how much can be gained from such a dialogue, there should not be too much hope put into the employability of the formalisms discussed in this article: The fact that a certain framework or a way of modelling is compatible with different theories still does not exclude the possibility that the resulting studies are incommensurable: ABMs for example are compatible with a wide range of different theories, including neoclassical theory.[22] But different ABMs might not only yield very different results, they are very different to compare. Their underlying ontologies might be entirely different, the one model might be designed as part of an explanatory exposition, the other model as a self-sufficient device for prediction. While both are models of the same type, they have nothing else in common and can impossibly mutually advancing.

[22]One could argue, for example, that neoclassical DSGE models are nothing else but very specific ABMs.

The more important message of this article, however, is delivered through the exposition of cases where formalisms are essential for further progress in socio economic analysis and the motivation of their reflected and adequate application in the future.

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