Rerum cognoscere causas: Part I—How do the ideas of system dynamics relate to traditional social theories and the voluntarism/determinism debate?†

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Abstract

This is the first half of a two-part paper which deals with the social theoretic assumptions underlying system dynamics. The motivation is that clarification in this area can help mainstream social scientists to understand how our field relates to their literature, methods and concerns. Part I has two main sections. The aim of the first is to answer the question: How do the ideas of system dynamics relate to traditional social theories? The theoretic assumptions of the field are seldom explicit but rather are implicit in its practice. The range of system dynamics practice is therefore considered and related to a framework—widely used in both operational research (OR) and systems science—that organises the assumptions behind traditional social theoretic paradigms. Distinct and surprisingly varied groupings of practice are identified, making it difficult to place system dynamics in any one paradigm with any certainty. The difficulties of establishing a social theoretic home for system dynamics are exemplified in the second main section. This is done by considering the question: Is system dynamics deterministic? An analysis shows that attempts to relate system dynamics to strict notions of voluntarism or determinism quickly indicate that the field does not fit with either pole of this dichotomous, and strictly paradigmatic, view. Part I therefore concludes that definitively placing system dynamics with respect to traditional social theories is highly problematic. The scene is therefore set for Part II of the paper, which proposes an innovative and potentially fruitful resolution to this problem.

Rerum cognoscere causas (''To know the causes of things'')

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Introduction

System dynamicists claim to ''build models of social systems'' (Forrester 1961). This implies that it is not some natural system or an engineered machine that is modelled. Rather, modelling is directed toward situations in which there are human agents, receiving information and taking decisions in accordance with policies—situations which, without humans, would vanish. Others have tried similar things: sociologists, anthropologists, organisational behaviourists, not to mention economists and political scientists. Such researchers want to know whether system dynamics can do anything for them—but they also want to understand how it relates to their literature, methods and concerns.

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This two-part paper is an exploration of three issues that, in this author's experience, arise when mainstream social scientists seek to understand system dynamics.[1] The three issues all concern aspects of social theory—some assumptions of how human beings behave, how societies hold together and how knowledge about such processes can be acquired. Such assumptions may be explicitly articulated or they may remain as unexamined presuppositions. It is these assumptions that are referred to when speaking of the social theory of a modelling approach. In introducing this paper we therefore deal first with the question of whether it is meaningful to consider system dynamics as having any social theory. We then outline the structure and aims of the two parts of the paper.

''Empirical research without theory is blind''

What possible relevance do the abstractions of social theory have to system dynamics? An external view is afforded by French social theorist Pierre Bourdieu. His warning regarding the perils of ignoring theory is the title of this subsection (from Bourdieu 1988: 774–775).

However, since this is a warning from far outside our field, one might view it as irrelevant. System dynamics deals with sets of differential equations—mathematical entities manipulated in a world of almost Platonic purity. So does it make any sense to speak of its having a social theory? To ask this question is to confuse system dynamics with the mathematics of dynamical systems theory. Though having commonalties, the two are not the same. System dynamics must be seen as a modelling approach that relies on assumptions about how human agents use information, how one can go about collecting empirical data to construct models, how groups of people can develop confidence in such models, and how those models can be used in a social context to address some issue. This combination of mathematical core, scientific stance on the applicability of models and craft skills relating to the ways of making such models useful constitutes the system dynamics method. With this richer view, it becomes clear that system dynamics extends into areas of concern normally associated with the social sciences and their underlying social theories.

An internal view presses home the point; ''System dynamics needs a broader and deeper debate about its underlying philosophy, the contrast with alternative philosophies, the nature of knowledge, the role of subjective and observational information, and the criteria for judging validity'' (Forrester 1980b: 15). Such philosophical/theoretical issues are indeed of relevance to our field.

System dynamics is not unusual in this respect since all modelling approaches may be related to a social theory. Some systems approaches have clearly articulated social theoretic assumptions. The clearest example is ''soft systems methodology'', or SSM (Checkland 1981). This is explicitly

based on subjectivism and Checkland illustrated this by taking a framework for social theories and locating SSM in the appropriate region of it. As part of a comparison of system dynamics with various problem structuring methods, the present author considered such assumptions and was able to locate some additional ''soft'' OR methods (see Figure 1). However, when it came to system dynamics he could only state that, ''the placement ... is a current research interest'' (Lane 1994: 127).

The reason for this is that the system dynamics literature has barely articulated its social theory. This is reflected in the comment that: ''The present [system dynamics] paradigm is not sharply defined'' (Forrester 1985: 1). Getting a sharper definition requires work. Furthermore, debating issues relating to system dynamics at this level may seem alien to most practitioners. But clarifying the social theory of system dynamics makes explicit its deepest working assumptions. This makes possible comparison with other theories in the social sciences in a manner likely to generate interest. Practice may also be enhanced by comparison with other approaches that share the same basic assumptions (Lane 1994), such research contributing to the debates on choice of method (Jackson and Keys 1984; Flood and Jackson 1991; Watson 1992; Mingers and Brocklesby 1997) and the mixing of methods in theoretically coherent ways (Bennett 1990; Mingers and Gill, 1997; Lane and Oliva 1998). These are all arguments for dealing with social theoretic issues in order to

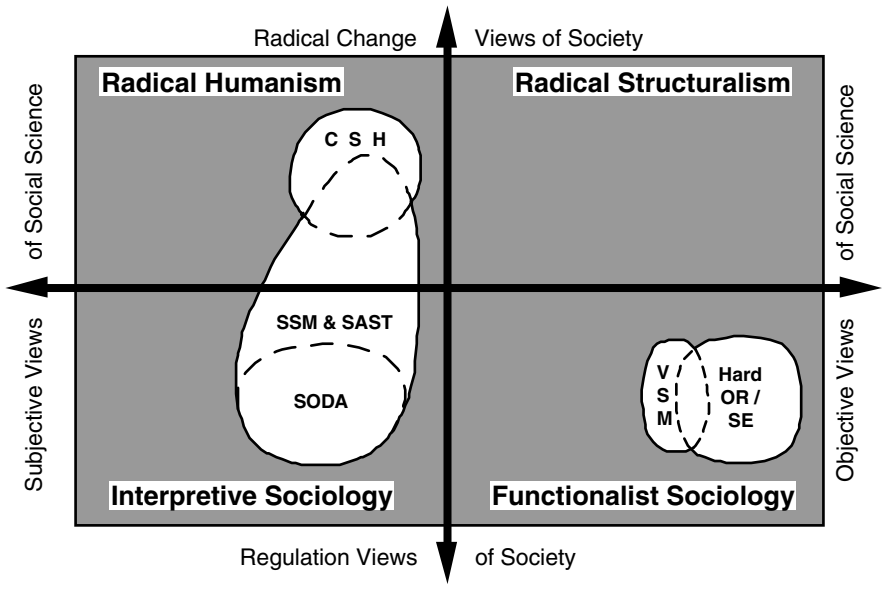

Fig. 1. Simplified version of a framework for social theories showing the placement of various systems and OR modelling approaches. Key to abbreviations: SE systems engineering; SSM soft systems methodology; VSM viable systems model; SODA strategic options development and analysis; SAST strategic assumptions surfacing and testing; and CSH critical systems heuristics. Redrawn from figures in Checkland (1981) and Lane (1994), reproduced by permission of John Wiley & Sons Limited

relate better to the management science and systems science fields. But the arguments extend further, as described below.

The structure and aims of this paper

This two-part paper deals with three issues that arise when the sensibilities of mainstream social scientists are directed towards system dynamics. The issues and their treatment may be described as follows.

The first issue concerns the social theoretic assumptions underlying system dynamics. We use a framework—widely used in both OR and systems science—that organises the traditional positions on social theory. The aim is to answer the question: How do the ideas of system dynamics relate to traditional social theories?

The second issue concerns a specific aspect of the social theory of the field. System dynamics is widely misreported as conceptualising the social world in a purely mechanistic way. The view is broadly refuted by answering the question: Is system dynamics deterministic?

These two issues are treated in this present Part I of the paper and a specific conclusion is drawn: traditional, paradigm-based analysis does not offer a sound theoretical home for system dynamics. This suggests that an exploration of an important and innovative debate in contemporary social science might offer theories more appropriate to our field. The scene is therefore set for Part II.

Part II will open with a treatment of the third and final issue dealt with in this paper. Perhaps system dynamics relates best to those theories that seek to integrate thinking based on the actions of individual human agents with thinking that emphasises structural constraints. The question being considered is: The agency/structure debate—opportunity for system dynamics?

Taken together, these three questions are of general significance for system dynamicists. However, their primary justification is the need to clarify them in a way that is meaningful for social scientists so that they are drawn towards system dynamics. Therefore, Part II closes by drawing together all of the previous analysis in the form of four suggestions for clarifying and innovating the social theory of system dynamics. The goal is to help mainstream social scientists to understand how our field relates to their literature, methods and concerns. Across its two parts, the over-arching aim of this paper is therefore to use social theory to enable system dynamics to be extended further into the social sciences.

How does system dynamics relate to traditional social theories?

To illustrate the explicit subjectivism of SSM, Checkland (1981) used a framework for social theories (Burrell and Morgan 1979). In a comparison

of system dynamics with various problem structuring methods, this author located other 'soft' OR methods using the same framework (Lane 1994). The results are reproduced in Figure 1. It is the same framework of Burrell and Morgan that is used in this section to support an initial examination of the social theoretic roots of system dynamics. The arguments for this decision are twofold. First, the framework offers a clear paradigmatic representation of a very wide range of traditional social theories. Related to this, the second reason is that this framework has been utilised elsewhere within systems science (Checkland 1981; Jackson 1993) and in other disciplines (e.g. Hirschheim and Klein 1989; Jackson and Carter 1991). Its use therefore promises to support helpful comparison between system dynamics and other approaches.

This section proceeds as follows. First, the framework is described. Then clear placements of existing system dynamics practice are identified. The possible existence of 'subjective' approaches is then outlined. Finally, some candidate conclusions are discussed.

A traditional framework for analysing social theory

Burrell and Morgan (1979) conceptualised a wide range of social theories as being located within four paradigms, generated by two axes (Figure 2). The horizontal axis concerns assumptions about the nature of social science, whether its approach should be ''objective'' or ''subjective''. These two definitions contain four strands of assumptions. Ontological assumptions

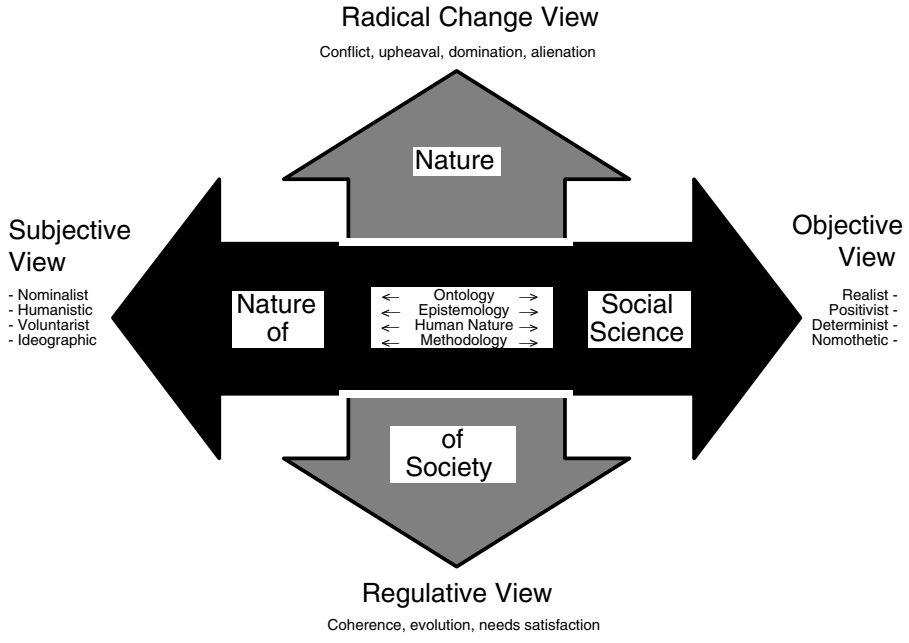

Fig. 2. Illustration of the two axes at the core of Burrell and Morgan's framework

concern the nature of the phenomena being studied. The realist view takes the social world as having a quite separate existence from individual humans and their appreciation of it, whilst the nominalist position views the social world purely as a product of human description, consciousness and action. Epistemological issues concern the type of knowledge that can be obtained. The positivist view is that causal laws perceivable by an objective observer may be deduced, whilst the humanistic stance sees knowledge as being concerned with the significance and meaning that humans ascribe to their actions, these being drawn out via the textual interpretation that is hermeneutical analysis.[2] The human nature strand concerns the model of humans and their relationship with their environment. The deterministic view has people responding in an almost mechanistic way, functioning as products of an environment that forms both the situations they encounter and the conditioning they imbibe, whilst the voluntarist approach ascribes a much more creative, free-will approach to humans, treating them as agents able to create their environment by their thoughts and actions. Finally, phenomena may be investigated using two different processes, or methodologies. Nomotheticism promotes the measurement of general concepts, whilst ideographic approaches aim to access the unique insights and interpretations that individuals have of the world.[3]

The vertical axis in Figure 2 expresses variations in assumptions about the nature of society. 'Regulation' concerns theories that emphasise the essential cohesiveness of society, seeking to understand the maintenance of the status quo and describe processes of needs satisfaction. In contrast, ''Radical Change'' concerns theories describing societal conflict, the use of power to dominate and states of alienation. The word ''radical'' is important. The regulative approaches certainly do not imply stability; evolutionary change theories are included here, as are various disequilibrium and morphogenetic theories and some forms of conflict.[4] In contrast, radical change theories deal with structural conflicts throughout society, with the aim of motivating wholesale upheaval in the broadest terms possible.

Using these axes, Burrell and Morgan (1979) concluded that the social theories then existing could be seen to lie in one of four paradigms. The descriptions of these follow directly from the above account of the axes but their respective accounts of the social world may be (greatly) summarised as follows. The most important is ''Functionalist Sociology''; in this paradigm the social world exists outside of humans and so can be observed and the structural laws that sustain it uncovered. Within ''Interpretive Sociology'' the social world is what agents interpret it to be. ''Radical Structuralism'' views the social world as a prison of structural economic forces. Finally, in ''Radical Humanism'' the social world is a psychological prison of economic alienation. Various schools of social theory can be located in one of these four paradigms (Figure 3). There are differences of emphasis between the various constituent schools. However, each of the four paradigms has distinctive theoretical assumptions that are in

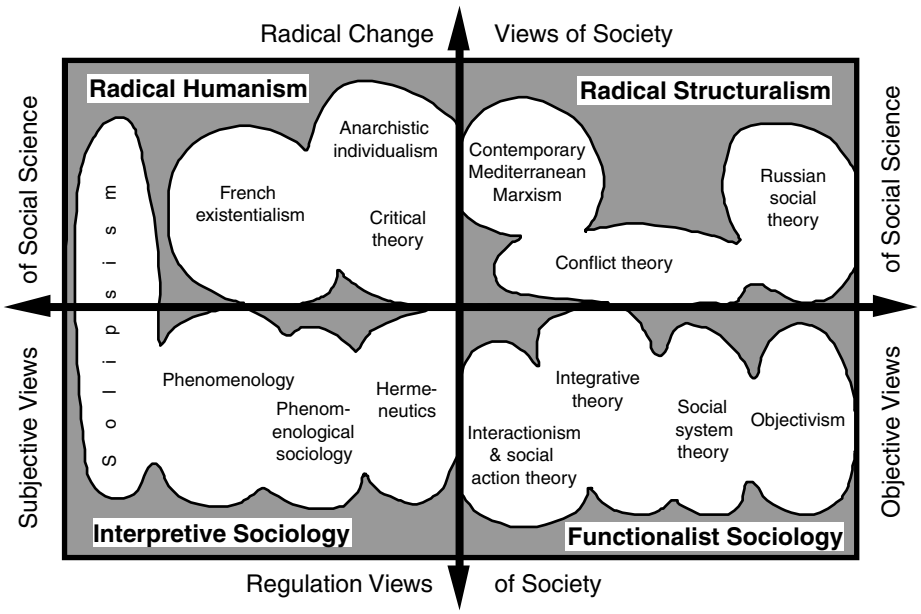

Fig. 3. Framework proposing four paradigms (bold) for the analysis of social theory and the constituent schools of the paradigms. Figure redrawn from Burrell and Morgan (1979), reproduced by permission of Gibson Burrell and Gareth Morgan

sharp opposition to those of the other three. In this model the paradigms are therefore incommensurable.

Inferring social theory from existing practice

System dynamics has no explicit social theory. Its social theoretic assumptions must therefore be inferred from the literature of the field and from actual practice. Pursuing this analysis we first obtain groupings of existing system dynamics practice (see Figure 4).

INITIAL SYSTEM DYNAMICS PRACTICE

This grouping contains the practices that began with the appearance of Forrester's core ideas (Forrester 1958, 1961). The location of this grouping—Initial SD—is crucial to the argument that follows. Forrester's proposal is partially a form of ''Social system theory''. With a positivistic and servo-mechanistic view of the social world, and a realist and seemingly determinist stance, the aim is to understand how behaviour arises from social structure by mapping out physical or material flows. However, there are also some quite different aspects of the ideas and these are central in establishing Initial SD away from the objectivist extreme. In social theory terms, Initial SD has more in common with Burrell and Morgan's ''Integrative theory'' school than with ''Social system theory''. For example, models treat information as a carrier of meaning, which is subject to perception and interpretation by the actors in the system.

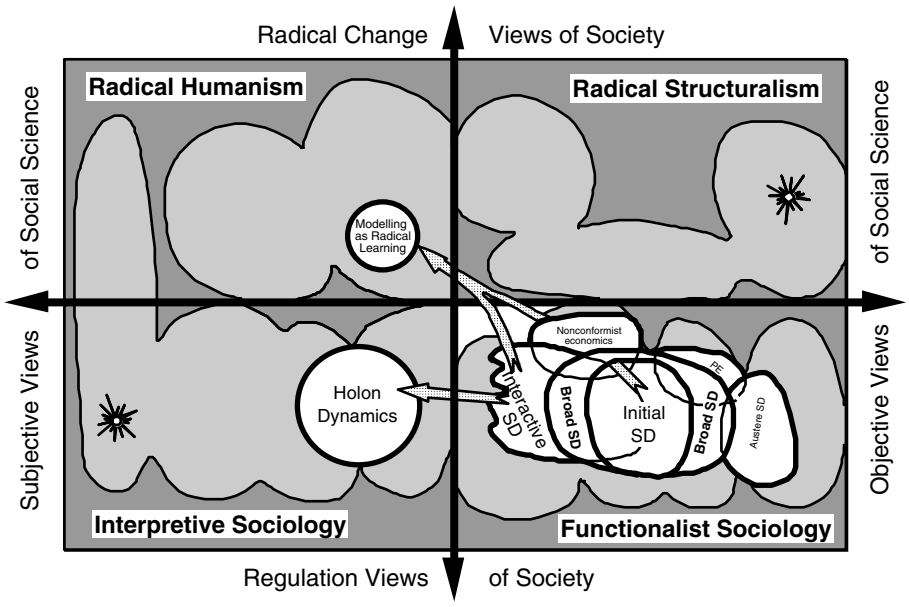

Fig. 4. Analysis of the social theories of system dynamics practice. The regions (and ''flashes'') of practice are located in schools with which their implicit operating assumptions seem consistent. ''Policy Engineering'' is shown as PE. The two circular regions denote embryonic or speculative forms of practice.

Also, subjective mental models are used as sources of judgemental data, both to supplement objective data and to extend the range of concepts included in a model. Finally, importance is attached to the personal experience of building and experimenting with models, so that ''confidence'' in them is obtained and qualitative ''insights'' into effective policy levers are gained. These ideas, clearly present at the creation of the field, indicate an embryonic inclination towards a much more interactionist stance.

Broad system dynamics practice

After perhaps a decade of the field's life, a division may be observed, centered upon more or less objective interpretations of the notion that validation of a model was best seen as a process of creating ''confidence'' in that model. The more objective interpretation saw confidence as created by rigorous science and therefore emphasised positivistic means (e.g. the refutationism view in Bell and Bell 1980) in order to produce results that were tenable. The alternative interpretation saw confidence as arising from social conversations, the emphasis being on ways of bringing modelling closer to users (Meadows 1980).

This urge to combine both technical and less objective elements in model validation is plain in other contributions (Forrester and Senge 1980; Richardson and Pugh 1981). Forrester himself reflected a broad range of interpretations of the core ideas of system dynamics (Forrester 1980b), though some discomfort

over this may be read into his call for more work on the paradigm of the field (Forrester 1985).

The less objective strands of system dynamics—present in Forrester's thinking and increasingly developed in Broad SD—attracted criticism from practitioners rooted implicitly in the heart of ''Social system theory''. For example, the field was accused of being too reliant on judgemental and subjective data and on failing to create generalisable theories (Ansoff and Slevin 1968; Nordhaus 1973; Zellner 1980). Convincing defences were offered to these criticisms, in which Forrester—as well as correcting more technical errors—argued that both the validity of models and the importance of the resulting theory had to be seen in reference to a particular managerial situation or case study (Forrester 1968a; 1980a; Forrester, Low and Mass 1974). However, it is important to note that Forrester argued only for an easing of absolutist notions of objectivity and for a more catholic view of what constituted empirical data. This is not subjectivism in the Burrell and Morgan sense but rather an orientation to somewhat less objective schools of thought.

Although more specialised views have emerged (see below), these overlap with the Broad SD region. It is therefore this region—recently delineated by Sterman (2000)—that may be proposed as the enduring heartland of system dynamics.

Interactive system dynamics practice

This grouping encompasses group decision support modelling and the promotion of organisational learning. The focus is on creating a shared interpretation of a problem via personal involvement in modelling. The modelling provides both a language and a process of group interaction. The aim of creating group understanding and the belief in the importance of the feedback relationship between actors and environment has points in common with the school of ''Interactionism and social action theory''. Contributors to this region include Sterman (1988), Morecroft (1988), Senge (1990b), Vennix (1996), Lane (1992), Richardson and Andersen (1995) and Warren (1999).

The placement of this grouping is indicated by the theoretical work of Barlas and Carpenter (1990). Their social conversation view of model validation, based on Quine's relativism, is a significant weakening of positivist epistemology. However, a model is still ''a theory about how a system actually works'' (Barlas and Carpenter 1990: 149), so that ontologically they preserve a realist view. So, for all of its interest in group understanding and judgmental data, the ''Social system theory'' roots of system dynamics are still clearly present. Although the uncertain boundary of this region indicates that this point merits further debate, for this author the positioning is clear. This form of system dynamics has moved significantly across and away from any Vienna Circle-style objectivist extreme. But few system dynamicists would acknowledge the subjectivist position that social reality is only an intersubjective social construct. Because there remains

a strong realist strand in the field's thinking, even this form of system dynamics is nonetheless located in the ''Functionalist sociology'' paradigm.

NONCONFORMIST ECONOMICS

Also located towards integrative theory are the proposed usages of system dynamics in institutional and evolutionary economics (Radzicki 1990; Radzicki and Sterman 1994).

POLICY ENGINEERING

Emerging primarily from the work of Lyneis (1980), this is a retreat into the ''redoubt'' of ''Social system theory''. It involves the application of system dynamics by expert consultants as a traditional simulation approach. Other examples are Forrester (1989) and Levin, Hirsch and Roberts (1975).

AUSTERE SYSTEM DYNAMICS PRACTICE

These practices emphasis more determinist, positivist and objectivist approaches. These include: microworld validation, in which emphasis is placed on quantitative data to test for behaviour modification (Bakken, Gould and Kim 1992); and behavioural decision-making work (Sterman 1989; Kleinmuntz 1993).

''FLASHES'' OF PRACTICE

Some very different practices are observable, not as established fields, more as sudden ''flashes''. Wolpert's atheoretical paper (1992) derives from a solipsistic extreme. In contrast, the work of Ryzhenkov (1989, 1990), with its emphasis on treating the economic system as a system of imprisonment, has a clear linkage with Russian social theory.

Identifying subjective approaches: ''Agency Dynamics''

Most of the practice described so far has been located in the functionalist paradigm. In the main, this seems appropriate. However, it may be possible to debate the point. There are nuances and interpretations of ideas that might lead one to wonder whether the core ideas of system dynamics might reach out into other paradigms, as indicated in Figure 4. In this subsection, two rather speculative forms of practice are described. Partly, they are potential forms of practice, inspired by subjective social theories, but there are also reasons for considering whether the core ideas of system dynamics also fit, to some extent, with such ideas. Hence, we might debate whether such practices exist at present, albeit in embryonic form.

Subjective approaches can be grasped in system dynamics terms via the concept of the ''confidence'' that users have in a model. Confidence results from: agreeing an issue focus; believing in the mental models articulated to produce

a model; and internalising model insights. These three are social phenomena, involving subjective perspectives on issue focus, the attachment of meaning to mental models and a personal, experiential approach to learning. This opens up the possibility of practices grounded in the two subjective paradigms. The emphasis therefore moves from objective social systems operating according to general, invariant laws to a concentration on how groups of humans act as agents, agents who create their world by processes of description and the creation of shared meaning. Both of these new regions are therefore examples of ''Agency Dynamics''.

REGULATIVE AGENCY DYNAMICS: ''HOLON DYNAMICS''

This is a form of practice grounded in the interpretivist paradigm. Whilst 'systems' are thought to exist in the world, ''holons'' are seen as ways of making sense of the world (Checkland 1988; Lane and Oliva 1998). So, in Holon Dynamics, models are purely nominalist representations, devices that help human agents create their social world. Positivism is inappropriate and there are no general concepts to measure; modelling is accepted as a personal experience, which can only be understood in its full richness (for examples, see Eden and Jones 1980; Lane 1997).

Does such practice exist? There are three candidates whose work seems to have been moving in this direction. Senge's ideas appear nominalist and voluntarist (Senge 1990a, 1990b), though the lack of espoused social theory makes any placement problematic. However, Senge can be seen to have been toying with interpretivism. Vennix (1996) explicitly sees the goal of group model building as the creation of intersubjective meaning. He could be seen as an interpretivist. Finally, interpretivism is weakly declared by Lane (1992) and described explicitly in Lane and Oliva (1998). This form of system dynamics resembles SSM in some important ways.[5]

RADICAL CHANGE AGENCY DYNAMICS: ''MODELLING AS RADICAL LEARNING''

Are the mental models that are articulated those of alienated prisoners? Do microworlds free people or more effectively convey a management ideology? Issues concerning power, ideology and coercion addressed in the radical humanist paradigm are relevant for system dynamics and this form of Agency Dynamics therefore engages with them. Such practice would involve the use of system dynamics modelling to further open debate in groups.

Although system dynamics is proposed as an ''anti-authoritarian'' tool in Forrester (1965), much theoretical work would be needed to change it from this faint glimmer into a clearly developed radical humanist approach. However, the attempt would offer a challenge to fashionable ''empowerment'' platitudes.

Three competing conclusions from this analysis

When the spread of groupings in Figure 4 is surveyed, different, indeed competing, conclusions come to mind.

Merely a recraftable method

One possible conclusion is that system dynamics is merely a method that simply does not relate to issues at the social theoretic level. This view is provoked by the range of groupings and the degree of uncertainty (indicated above) regarding some of the placements. The argument runs as follows.

Modelling approaches consist of tools, techniques, method and social theory (Eden 1990). Forrester's assumptions generate a collection of modelling approaches and craft skills, which together constitute the system dynamics method. These assumptions do not operate at the level of social theory; they only appear to do so. In fact, the assumptions of system dynamics are contradicted, or hedged with uncertainty in other parts of the literature, and are capable of quite different interpretations. This allows them to be viewed as fitting in with various social theories.

This conclusion is not the same as the suggestion that system dynamics breaks through paradigm incommensurability in social theoretic terms (Cavaleri 1992). In this case the incommensurability of the traditional paradigms was violated without any account of how this might be accomplished. In contrast, our first conclusion here is simply that system dynamics is a rootless creature, merrily adapting itself to circumstance and probing whatever phenomena and issues seem interesting—whilst keeping its head well below the parapet and making no assumptions that commit the field to any social theory.

Clarity and security in functionalist sociology

A second conclusion is that system dynamics is grounded in functionalist sociology. This is arguably the paradigm within which most practice took place and so it is reasonable to deduce that Forrester and his successors were implicitly using this set of social theoretic assumptions. This conclusion simply makes that stance explicit. The embryonic practices within other paradigms would then be rejected as distracting errors. Note that the spread of practice within this paradigm is not a cause for concern but arose from reasonable developments of Forrester's ideas. It further extends system dynamics into other social theoretic schools and so improved practice.

The implication is therefore that system dynamics offers a practical, relevant and empirically based approach, which operates with a mixture of ideas from social system theory and integrative theory, and even interactionism. As such, it has shown itself as having much to offer sociology (Hanneman 1988) and organisational theory (Sastry 1997).

Perhaps not explicable in traditional social theoretic terms

As discussed further in the suggestions section of Part II, both of these conclusions have disadvantages. Perhaps the rather thin account of system dynamics implied by the first conclusion explains a recent tendency to reach for the second. However, an alternative is to take more account of the uncertainty

of some of the locations of practice in Figure 4. One might ask: Do the four strands of the horizontal axis (see Figure 2) bundle together too many attributes or offer false dichotomies, so that they cannot discriminate the features of the field? Despite its use elsewhere, one might then be moved to ask: Is the traditional framework simply not capable of explaining system dynamics?

In the following section these questions are taken up. As an example of the problems of locating system dynamics within a rigid, paradigmatic framework, it is shown that the determinist/voluntarist strand is utterly inappropriate for describing the field's assumptions.

Is system dynamics deterministic?

To exemplify the difficulty of critiquing system dynamics in traditional social theoretic terms, this section shows that the field does not sit at either of the two extremes of the ''human nature'' strand of the Burrell and Morgan framework (1979).

The criticism and its importance

System dynamics is frequently misjudged as being an approach that conceptualises the social world as a machine (Keys 1988; Jackson and Keys 1984; Jackson 1994; Flood and Jackson 1991). Various terms are employed to make the point but the essential criticism is that system dynamics is ''deterministic''. The determinism criticism can be interpreted in two ways: that system dynamics offers a ''grand theory'' of the type now considered crude by social scientists; and that the field takes an extremist dehumanising view of the extent of structural control on human agency. These criticisms of system dynamics are widely known within the systems science movement. Yet they are, essentially, false. The following two subsections therefore respond to these ''determinism'' criticisms.

Crude appeal to grand theory?

The word ''determinism'' is used to describe the position that cause and effect are related by laws that exist outside of human subjectivity, together forming a timeless grand theory (Morrow and Brown 1994). The pursuit of grand theory via causal laws is based on the Humean tradition that scientific explanation involves relating phenomena to be explained to other phenomena via such causal laws (Frankfort-Nachmias and Nachmias 1992). This principle of causality is a central concept in natural science (Popper 1982).

This form of the determinism criticism is therefore that system dynamics posits a grand theory about the existence of objective causal laws in social systems. It has been observed that an assumption of the field is that ''well-defined laws govern behaviour'' (Flood and Jackson 1991: 33) and that

''Forrester talks about fundamental laws of nature and the social sciences'' (Bloomfield 1982: 13).

System dynamics has a ranges of ''theories'' that appear deterministic in this sense. For example, models are said to be causal theories and Forrester lays out *Principles of Systems* (Forrester 1968b). There is also the grand claim that underlying models is, ''a set of principles..., incomplete as they may be, that I believe do represent the actual nature of physical and social reality'' (Forrester 1994: 250).

Like Beer's laws on the viability of systems (Beer 1981), it would indeed appear that the theories of system dynamics propose universal laws. This issue is complex and so the following is an attempt to begin the process of clarifying the claims that system dynamics makes in the context of social theoretic disputes over these issues.[6]

On the nature of the 'theories' in system dynamics

Positivists in social science ''attempt to frame their causal explanations in terms of universal statements... universal propositions'' (Denzin 1978: 130). This thinking underlies structural functionalism and social system theory (see Figure 3), these approaches ''hav[ing] been motivated by the belief that there is a single theory... that could be used... to analyze all societies throughout history'' (Ritzer 1996: 257). This approach was dominant in 1950s and 1960s sociology—when system dynamics was being crafted. However, there have emerged major criticisms of this Parsonian approach, its disfavour and decline being partially due to the wholesale rejection of grand theory (Mills 1959; Ritzer 1996).

System dynamics offers ''theories'' at three different levels. At the highest level is the claim that the time evolutionary behaviour of social systems is explainable in terms of feedback loops and state variables. This is crudely put, but the important point is the nature of this claim: this is not a grand content theory. There are no specific variables or conceptual categories. For example, it is not suggested that ''socialisation'' or ''class stratification'' are meaningful concepts necessary to explain the evolution of all societies. In contrast, this grand claim of system dynamics is a structural theory—it makes a grand methodological claim about how certain types of phenomena might be explained.

Moving down to the next theory, we find the principle of how the concepts of feedback loop and stock should be used to construct models (Forrester 1968b). This is not a grand theory. This is a representation theory, or scheme, proposing a way of implementing the above grand methodological theory.

A more specific theory is that inquiry methods based on system dynamics can assist in understanding social phenomena (including business decision making). This theory rests on the idea that unassisted, humans cannot infer the behaviour of systems represented in the above fashion in a way which is

logically consistent; computers are needed to deduce the behaviour. This is an empirical claim. As such, it is well supported by data (Sterman 1994).

With this clarification it is clear that none of the above ''theories'' proposes an invariant causal law and that there is no crude grand (content) theory. The only universal law/theory on offer is a grand methodological, or structural theory, associated with a representation scheme. This position can still be criticised, but it does not attract the determinism-related criticisms attached to grand theory in the sense of Parsons and Mills.

Treatment of causality in system dynamics

Can causal links in models be an adequate tool for treating human behaviour? Behind the criticisms from Flood and Jackson quoted earlier is the question of whether actions are governed by such (micro) laws of causality.

Social theorists differ widely in their view of causality in social systems. It is generally accepted that the practical establishment of laws and theories is much more difficult in social science (Bailey 1987). Some theorists have attempted to amend and reframe the theory of causality, whilst others argue that the concept should be extirpated from social inquiry (Giddens 1976; Phillips 1987; Lincoln and Guba 1985). For example, Phillips states baldly that the causal laws of natural science are not to be found in social science and that, if explaining human actions is the aim, then an understanding of individuals requires hermeneutical interpretation (Phillips 1987).

The debate may be loosely characterised as an argument over the respective importance of these two forms of ''explanation'': *Erklären* and *Verstehen* (Morrow and Brown, 1994; Ritzer 1996). Natural scientific explanation is *Erklären*—the objective establishment of invariant, general laws of causal explanation. *Verstehen* requires the hermeneutical process of interpreting the subjective meaning that individual humans attach to their actions; the resulting insights are very specific and are never generalised into causal laws.

Within such a range of views, where do the causal models of system dynamics fit in? It is accepted that the type of explanation that it is appropriate to use in social science—the balance between *Erklären* and *Verstehen*—varies with the detail of the phenomena studied. For example, Phillips observes that with groups, enduring patterns may be observable and limited prediction possible (Phillips 1987).[7] Similarly von Bertalanffy is aware of the contrast between ''molecular'' and ''molar'' (best thought of as ''macro'', or ''mass'') approaches but asserts that, ''for mass behaviour, systems laws would apply'' (von Bertalanffy 1962: 76). The appropriateness of using causal laws can therefore be judged in the context of the aggregation of system dynamics models. System dynamics is concerned with aggregate social phenomena, not individual meaningful actions. There is a crucial difference between causality in the cybernetics of Beer (which treats events, actions and individual stimuli and decisions) and in system dynamics (which treats the causes of aggregate

patterns of behaviour) (Richardson 1991). Forrester is very clear that when constructing a model; ''We are not the psychologist delving into the nature and sources of human motivation'' (Forrester 1961: 96).

Having clarified somewhat the currency of the debate, it becomes clear that, when Beer employs causality, he is appealing to notions of grand theory and rejecting *Verstehen*. However, system dynamics does not involve the view that individual human decisions are explainable solely by causal laws, that subjective explanations of the *Verstehen* type are irrelevant. The field is simply not operating at a level of detail low enough for it to be accused of adopting such a crude stance.

POSITION CLARIFIED, BUT CASE OPEN

Two arguments have been made. First, system dynamics should not be criticised as propounding a crude grand (content) theory because what it advances is a (grand) structural theory. Second, the modelling of causal laws, which transcend human subjectivity, is a reasonable position because of the level of aggregation of models.

A suitable note on which to end is that the grand structural theory of system dynamics, along with the theories of logical deduction and representation, stand or fall as a coherent research program (Lakatos 1974). They should be considered in terms of the plausibility of its grand structural claim and its empirical success in providing explanations for novel phenomena. The various ''theories'' of system dynamics form the ''hard core'' of the field and the healthy flow of applications indicates that the research programme is a progressive one. It is on those terms that any of the theories and laws of system dynamics should be judged.

Complete structural control of human agency?

The second interpretation of determinism is that human agency is completely controlled by system structure. This view relegates humans to mere cogs in a machine, passive responders without autonomy, the stance underlying the ''behaviourist'' work of B. F. Skinner in the school of ''Objectivism'' (Figure 3). This position is best viewed as an extreme point on a scale labelled ''extent of human autonomy'', or ''human nature'' in Burrell and Morgan's (1979) schema. Determinism is the zero point of the scale. At the other end would be the voluntaristic, free-will view that ''Individual decision making is unaffected by context and consequences of the system in which it takes place'' (Bowen 1994: 88).

This form of the determinism accusation is made by Jackson; ''there is an apparent contradiction between deterministic ideas of systems governed in particular ways and voluntaristic ideas of our ability to do something about systems'' (Jackson 1994: 220).

FORRESTER'S POSITION

Forrester certainly asserts that, ''decisions are not entirely 'free will' but are strongly conditioned by the environment'' (Forrester 1961: 17). He also refers to ''man as a captive of his systems'' (Forrester 1980b). A superficial conclusion is that Forrester is offering a version of Skinner's behaviourism. However, with just a little work, a more subtle argument appears. In discussing the policies represented in a model, he does say that, ''people's reactions are a consequence of the changes of the system within which they are embedded'' (p.16). Crucially, he then offers an extended quotation which supports the notion that the environment that controls human decision making is *itself* made by human decisions.

RESPONSE—BOWEN'S ANALYSIS

The counter argument is twofold: that human decisions are only partly determined by system structure and that, since the purpose of modelling is to make such influences explicit, the system may be recrafted advantageously. These issues have been addressed with care by Bowen (1994) and so only a brief recapitulation is needed here. Bowen rejects the notion that system dynamics is deterministic but instead adopts a mid-point on the scale of human autonomy. By using system dynamics, ''individuals can design and affect the redesign of the social and managerial systems that impose on them... [therefore] individuals... retain—at least in part—the ability to make autonomous decisions'' (Bowen 1994: 87–88). Bowen concludes that the field is clearly distinct from the ideas of Skinner.

POSITION CLEAR, CASE CLOSED

Accusations that system dynamics takes an extreme view of human autonomy have more to do with the limited knowledge of some commentators than with the actual assumptions of the field. In fact, neither the deterministic nor the free-will extremes express the position of system dynamics: perhaps some new way must be found of expressing the stance of the field? However, it is very clear that system dynamics sits well with the view that ''Sociology... needs to embrace free will no more than determinism'' (Durkheim 1895: 141).

Interim findings and the task ahead

Part I of this paper produces two findings. First, system dynamics is difficult to place in terms of traditional social theories. Second, system dynamics challenges the dichotomy of the determinism/voluntarism debate. The second point begins to explain the first: if system dynamics does

have a social theoretic home, then it must be different from the traditional ones considered so far. In Part II a resolution is offered to these problems. Some recent social theories seek to integrate the ''agency'' and ''structure'' paradigms that have traditionally been employed. A description is given of these and what was once proposed as ''a bold conjecture'' (Lane 1999: 521) is advanced as a firm thesis: that the implicit social theory of system dynamics is consistent with such integrative theories. Additionally, some suggestions are made for building on such social theoretic work to improve communication between system dynamicists and mainstream social scientists.

In short, whilst Part I of the paper raises many problems, it prepares the way for Part II, which aims ''to know the causes of things'' by offering some answers.

Notes

1. Earlier versions of these papers have appeared as LSEOR Working Paper OR.98.26 and as two papers in the CD-based proceedings of the 2000 International System Dynamics Conference held in Bergen.
2. Burrell and Morgan label their epistemological strand ''anti-positivist''/ ''positivist''. This seems an unhappy choice since it defines the subjective end in a negative way. The more confident term ''humanistic'' is used here for alternative epistemologies (see Phillips 1987).
3. ''Nomothetic'' derives from the Greek words *nomos* (law) and *thesis* (placing). This describes processes by which general rules are established. In contrast, an ideograph is a representation that merely suggests a unique insight. It is formed by the words *idea* (an idea) and *graphein* (to write).
4. Conflict between commercial enterprises is one example. Competition is deemed to have invigorating consequences for the market and hence has an integrating and stabilising effect for society as a whole.
5. This point may be emphasised by comparing the position of 'Holon Dynamics' in Figure 4 with the placement on the same framework of SSM and of other problem-structuring methods of 'soft' OR, as shown in Figure 1.
6. A more extensive treatment of this and other aspects of the determinism criticism may be found in Lane (2000).
7. Phillips uses the example of students filling up a lecture theatre. The individual choices of seat would be unpredictable, though hermeneutic interpretation might allow a researcher to understand the reasons why a particular student chose his/her seat. However, for a large number of students, seat-filling appears to take place in a pattern that is invariant in many ways and which can be used to make predictions at an aggregate level with a wide range of audiences (Phillips, 1987: 111–112).

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