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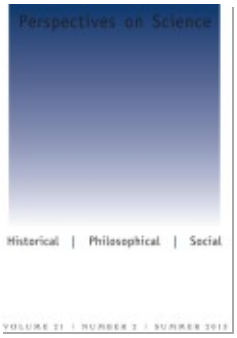

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Modeling Practices in the Social and Human Sciences. An Interdisciplinary Exchange

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The study of scientific models has become an active and important focus in history and philosophy of science, and to a lesser extent in sociology of science. Such attention acknowledges that models are central to scientific practice and that they are distinct from both theory and data, but there is a growing realization that modeling practices differ between and within disciplines. This special issue uses this realization to extend the discussion on models into new areas and different uses in the human and social sciences.

1. Introduction

Philosophers of science studying scientific practice often consider it a methodological requirement that their conceptualization of "model" closely connects with the understanding and use of models by practicing scientists. Occasionally, this connection has been explicitly made (Hutten 1954, Suppes 1961, Morgan and Morrison 1999, Bailer-Jones 2002, Lehtinen and Kuorikoski 2007, Kuorikoski 2007, Morgan 2012a). These studies have been dominated by a focus on the—relatively similar forms of—mathematical models in physics and economics. Yet it has become increasingly evident that the way models are conceptualized is very different in

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some other sciences, where philosophers' accounts of models' characteristics and functions might have to begin again. For example, comparisons of the mathematical models of economics and physics with the model organisms of biology show how the latter offer very different resources (experimental ones rather than mathematical), and different kinds of reasoning (by analogy rather than deduction). And, if such biological organisms are taken to be the exemplar, then new comparisons with the social and human sciences arise (see Creager et al., 2007).

In this special issue, in keeping with recent shifts of attention in science studies and in commentaries on scientific models, we stress the importance of the practical experiences of modeling within the sciences as a way to understand the philosophical issues. But we turn our focus toward those disciplinary fields where modeling has become increasingly important, yet is still neglected by those in the history and philosophy of science communities. These fields include some which are traditionally labeled "humanities" where we nevertheless find strongly evidence-based and concept-based ways of thinking: theology, archaeology, and anthropology. In these fields, we can find modeling used to make sense of the subject domain and to investigate the terrains of those worlds just as in the more usually studied natural and social sciences. In other words, we find modeling as a scientific approach to the study of humanity and society associated with fields that are often not seen as sciences at all.

The structure of this special issue is designed to provide insight into the styles of models and modeling in a variety of fields that span the human and social sciences. Five papers are provided by expert practitioners in: bible studies, psychology, architecture and energy usage, archaeology, and anthropology. Each one is attended by a commentary from a philosopher of science who has specialist knowledge of modeling in another of the human/social science fields such as economics, epidemiology and sociology. These combinations of papers and commentaries enable us to look at disciplines where modeling is often not accepted (such as theology), or where modeling is subject to keen internal inter-disciplinary argument (such as energy usage), and to make comparisons with other fields where it is more dominant (such as economics). We also asked our philosophers of science to respond from a more general philosophical perspective in their commentaries, yet found that our specialist practitioners were equally keen to take on board some of the generic work from philosophers of science in analyzing their own fields' experience with models.

Our volume of practitioner accounts and philosophical reflections on them serve three purposes. First, to point out some differences between received wisdom in philosophy and actual modeling practices in these fields, which suggest that modeling offers "intermediate services" to the scien-

tist. Second, to stress the divergence in function and style between different modeling practices. Third, to identify elements of the "vernacular" that seem specific to modeling practices across these human and social science disciplines, in spite of their many divergences.

2. Intermediate Services

The most common characterization of models found in current philosophical discussions—based remember on physics and economics—considers models as representations that are highly idealized. This often amounts to the admission that scientific claims based on models are inexact or approximate. Yet at the same time, their ubiquity in science puzzles philosophers to ask questions about how models serve the "ultimate" goals of science: how can they explain phenomena, how can they predict future events, how can they help determine policy interventions, and most puzzling of all, how can they lead to true scientific knowledge?

In contrast to these philosophical preconceptions, the papers of this collection stress functions which might be thought of as "intermediate." While Morgan and Morrison (1999) framed an account of models as instruments of investigation that "mediated" between other elements in scientific activity: between theory and data, pure science and policy aims, and so forth, the accounts given here reveal something different, but largely complementary. Models in these accounts also serve as instruments, but ones that offer a variety of *intermediate services,* in the sense that they contribute to intermediate objectives that one needs to achieve on the way to those ultimate goals of science. While the modelers and their work presented here may hope ultimately to reach those "ultimate" goals of science, they often set their sights on more immediate objectives, constructing and using their models accordingly.

This would be primarily a sociologically interesting fact, were it not for the observation that most modeling endeavors never get to the final stage in which the "ultimate" goals are reached, so that the intermediate services that models provide contribute to those goals only indirectly. Thus, most models never constitute full explanations, predictions or true representations. Rather, as intermediate elements, they provide "insights," "understanding," "heuristics," "new perspectives," "platforms for further discussions," or "coherent stories" for research to continue. In the process, the models themselves are developed in different ways, find new unexpected uses, become communication or instruction devices, get shelved in the library of a discipline, or are changed beyond recognition.

If this is so, it would be wrong to assess modeling success solely (or at all?) against the "ultimate" goals. Rather, we suggest, philosophers of science should pay more attention to these "intermediate service" functions

of models, analyze how the use of models can provide such services, and how those intermediate elements fit together. They need to ask in what ways scientists learn from models, even if this learning does not amount to explanation, prediction, control, or truth. We project that philosophers of science will find no convenient answers here, as it is quickly evident that while models may function in various different ways to provide such intermediate services, the examples discussed in this volume show that they do not perform those services in any uniform way, or at least in any way that is easily framed. Little reflection is needed to see that this is what one might expect. Models have sometimes been referred to primarily as tools or instruments and at other times primarily as representations. Tools come in various guises and can be used to perform many varied tasks. Representations come in many forms, represent many different things, and may do so in many different ways. And though of course models may both be representations and tools at the same time, neither such labels nor roles place much constraint on the way that models function.

3. Intermediate Services of Models

The five main papers included in this issue were written by practicing modelers in anthropology, psychology, bible studies, archaeology, and energy usage. All of these papers report on the *functions* of models. In this section, we outline the main aim of each of these papers, and the model functions they report. We also discuss the respective commentators' main take on these papers. This allows us to exemplify the different intermediate services provided by modeling as practiced in these fields. Our analysis also sets the scene for investigating unusual or common features of modeling in the human and social sciences, a matter we discuss in the last section of this introduction.

The main aim of Dwight Read's paper is to show how modeling helps anthropologists understand kin structures in different societies. Read distinguishes data models from theoretical models. In the specific field of study, data models are the representation of kin patterns extracted from actual kinship terminologies used in different communities ("kin term maps"). A theory model is a representation of patterns derived from a kinship theory. This theory is a hypothesis about how members of a society compute kinship terms ("generative logic"). On the one hand, it is interpreted realistically: it is supposed to represent how competent members really compute kinship terms. On the other hand, it is subject to many idealizations, e.g. about individuals' competence, absence of performance errors, information availability, etc.

Under these idealized conditions, the generative logic produces patterns that are then compared to a data model. Read argues that a theoreti-

cal model is explanatory if it is *isomorphic* to a data model. At first sight, Read's account seems to fit in with the conventional *deductive-nomological* (D-N) account of explanation: the explanadum (i.e. the pattern represented in the data model) is derived from a law and initial conditions. This conventional perspective attributes no independent functions to models, as a theoretical model is only an implementation of a theory, and a data model only a description of some pattern found in the data. However, as Caterina Marchionni points out in her commentary, such a reading neglects the hypothetical nature of theory, and the inferential function of theoretical models. Such a theory does not contain true regularities, but rather a consistent set of possible rules for kinship terminology formation. What sort of kinship pattern these rules produce is investigated by constructing a theoretical model. This theoretical model thus functions as a tool for inferring which structure a set of generative rules produces—even if we cannot be sure whether these rules are the correct ones, and thus cannot use the model to explain the observed patterns. Read's case thus stresses the *descriptive* and *inferential* services of models.

Read's case also points to an interesting feature of how models may carry normative functions for the subjects of the social and human sciences. In this anthropological study, "theory" is taken to offer an explanation of the kinship relations if the theory model is isomorphic to the data model: a conventional account. But the kinship terms are normative within the society, so that a data model is also the "theory model" for the community at issue (rather as rational economic man can be taken as a role model for behavior). The combination of idealized theory model and normative data model are used by the scientists to investigate and understand the variations in kinship structures across societies.

Jari-Erik Nurmi describes his modeling practices in developmental and personality psychology. He pays particular attention to the way models relate to background theory on the one hand and empirical observations on the other. His analysis proposes a distinction between theory and models, rather close to the more conventional distinction between theoretical models and empirical models. Their relationship is hierarchical, in that theory is more abstract than models, but their interaction is mutual: models are derived from theories, but models transmit "fit" with empirical data to theory. This analysis, as Nurmi himself confirms, is similar to the hierarchical semantic account of models in Suppes (1962).

As Till Grüne-Yanoff's commentary concludes, Nurmi's analysis of his own cases stresses the theory's role as the prime agent of development for his investigation. Theories function as "heuristic tools", expressing paradigms, traditions, and the accumulation of past evidence; they are used to direct research especially through shaping the model. Models in contrast

express observations and data; they are used to design experiments that can test hypotheses. It is through this process of integration in the theory (i.e. the theoretical model) that Nurmi commences a new research endeavor, with significant effects for how measurement proceeds, how data are collected, how the functional form is specified and how it is estimated. The heuristic use of theories, and their non-conventional definition, means that models play the dominant role in expressing accounts of the problem at an intermediate level.

Petri Luomanen also discusses the heuristic use of models, albeit in the rather different context of bible studies. He compares and contrasts two different modeling approaches to the formation of early church movements: the rational choice approach proposed by Rodney Stark and others, and the heuristic approach of the Context Group (to which Luomanen counts himself). Both traditions are highly controversial in bible studies, often fraught with accusations of "positivism" or "determinism." This applies in particular to the rational choice approach. It proposes highly abstract theoretical models which supposedly represent the formal structure of the sect-church progress. Concrete historical events are seen as instances of this structure, governed by the principles captured in the theoretical model.

In contrast, the heuristic modeling approach proposed by the Context Group seeks to defuse accusations of "positivism" or "determinism" by stressing the roles of models as tools for trying out ideas and help in working out new perspectives. As Luomanen rightly notes, however, usefulness in evoking new perspectives is not a sufficient reason to accept a model, since patently undesirable approaches (involving, e.g., anachronism and ethnocentrism) also serve such heuristic functions. So how, Luomanen asks, can one defend modeling in bible studies without running afoul of either charges of "determinism" or methodological arbitrariness?

As Diego Rios points out in his commentary on Luomanen, this is not only a question relevant for bible scholars. The disagreement over the functions of models in bible studies between the rational choice and the heuristic approaches mirrors the broader disagreement between a more traditional account of the epistemic role of modeling as dependent on theory, and serving ultimate ends like explanation and prediction, versus the view that models are autonomous from both theory and data, primarily serving intermediate ends.

Luomanen answers his question by offering models as flexible schemas that provide the materials to argue with and which offer frames for historical narratives as a way of "testing out" accounts. These are not considered representations of true core structure, nor are they deduced from such. Instead, the model offers a schema that provides possible exemplars and tax-

onomies. Charges of "positivism" or "determinism" are thus deflected. However, this does not lead to methodological arbitrariness. Luomanen argues that there is a connection between model and real-world target: at least, the model schema should raise the issue of resemblance. Furthermore this issue should ultimately be resolved based on additional evidence, so that enough correspondence between model and historical data can be established. A critical evaluation of models under the heuristic account is thus maintained.

Graeme Earl discusses computational archaeological models and their development. Their primary function is to visualize—to recreate visually, in digital representations, the living spaces of past times. It may come as a surprise to the reader how many different purposes visualization can have. Models may provide "Euclidian windows" but also offer virtual cameras or mimic human vision of modeled spaces, offering virtual sensory and emotive experiences of archaeological materials.

Crucially, these modeled spaces and materials are themselves open to scrutiny. Contrary perhaps to expectation, many computational archaeological models are not intended to represent—in full and finished form—buildings, spaces or practices of the past. Rather, they often represent available information about past buildings, consciously stressing the gaps in evidence. Or they might present hypothetical living-scapes, which when taken with ethnographic data, generate hypotheses about past human and social experience. Or they might make explicit an archaeologist's vision of a space, offering a sensory and emotive experience that excavation plans or individual exhibits could not convey.

Consequently, these models provide intermediate services for the archaeologist. They are designed to stimulate thoughts and questions, rather than to stand in for any real past. As Mary Morgan writes in her commentary, they are the sites in which archaeological "interpretations" are creatively tested and retested. They also function to create shared understanding—within the field by making explicit a researcher's vision; and outside the research community by communicating to the layperson. This of course does not exclude the use of models as media for the representation of archaeological research results; but Earl's paper nicely illustrates some intermediate services that many philosophers of science might be unfamiliar with. Crucially, as Morgan argues in her commentary, these intermediate functions cannot be neatly separated from the ultimate ones by a separation of context of discovery from context of justification: rather, it is the continuous process of discovery that constitutes the higher goal of understanding, and hence offers justification for the use of models.

David Shipworth starts his paper with a criticism of the dominant type of home energy usage models. Specifically, these models do not sufficiently

account for occupant behavior influences on home energy usage, and instead focus on "hard" aspects like building properties and heating technology. Shipworth uses recent philosophy of science accounts of modeling (especially by Boumans 1999 and Winsberg 2009) in order to explain these deficiencies. Energy models are downward (i.e. largely derived from theoretical equations from physical sciences), motley (combining inputs of all quality and types into outputs of homogenous and indeterminate quality and type) and autonomous (i.e. the most sensitive variable of the deterministic model, average internal temperature, is adjusted so that the model output fits aggregate energy use data). Because of these features, energy models are open to influence from a dominant "folk ontology," one which favors technological and physical factors over human and social ones.

In contrast to this dominant "vernacular" of energy modeling, Shipworth proposes the use of Bayesian networks. These models are designed to draw together all the elements that determine energy usage inside homes from many different disciplines each with different traditions of modeling. This makes them "motley" in content, but not in quality. To the contrary: because these models are relatively theory agnostic, they include only those factors that are considered relevant for empirical reasons.

Furthermore, these models are portrayed as "neutral" for sociological reasons: they have to draw together diverse forms of knowledge, and disciplinary contributors each having a dominant folk ontology. Their main usage thus lies in thinking through scenarios of what is possible and—by the way that they draw elements together—challenging the dominant folk ontology of different fields. As Erika Mansnerus points out in her commentary, Shipworth's discussion offers an argument for how interdisciplinarity can have not only institutional but epistemic effects.

The accounts here in the volume have primarily focused on the way models are used, that is, they have mostly concentrated on their roles or functions and the services they offer. It seems quite natural then to adopt the account in philosophy of science that treats models as tools or instruments. And, as we should expect from considering the nature of tools, there is no one way to fashion a tool, there is no one design of instruments, there is no one way in which all tools or instruments are used. Rather, different tasks often require different tools fashioned in different ways; yet the same task may be fulfilled by different kinds of tools, and one tool may be used for a number of tasks. Just so with models. Indeed, the huge variety of things that are counted as models in the fields described in this volume strongly supports the primary characterization of models as tools. And if, as in this volume, social scientists focus on what they do with models, an instrument-based account is almost inevitable.

Though we suggest that this is their primary characterization, that does not mean that we eschew the notion of models as representations entirely. Morgan and Morrison (1999) already argued that we should understand models as autonomous instruments of investigation that function as mediators just because one of their generic characteristics is that models carry various kinds of representing qualities. A similar argument is relevant here. If models provide intermediate services, it may well be that they do so because—to those working in these human/social scientific field—they count as representations. These scientists work with their models without going into great philosophical worries about how they represent, or what it means to represent. For some modelers, that notion invokes resemblance (such as archaeology), for others (as in biblical studies) it might more naturally imply only denotation (see R. I. G. Hughes 1997 and Goodman 1968). In other cases, it is more fruitful to focus on the activity—on representing—to understand what is involved. The two different ways of characterizing kin relations that generate the theoretical and data models in Read's paper show two ways in which representing happens and which allow a back-and-forth discussion of kin structures. The process of representing the formation of cults and sects in early Christianity in schemas (as described by Luomanen) not only describes scholarly views on the history of those events, but offers insights into the current debates about those events. As we have seen in this volume, models represent in many different forms, and at many different levels, and the processes or actions of representing are equally varied.

So, as in the earlier Morgan and Morrison (1999) account of models as autonomous mediators, the account here suggests that the qualities of models that makes them instruments, and also represent in some way, can be complementary. The archaeological and anthropological ones do so in very obvious ways, those of psychology and biblical studies less clearly. Yet because models are tools directed at specific problems within a discipline, the primary focus we see in the field is on their use as *tools* rather than as *representations.*

4. The 'Vernacular' in Modeling

What then do we find especially unusual about models and modeling in the fields represented in this volume? The examples and practices suggest the importance of the "vernacular" for modeling in the human social sciences because human and social scientists have connections with their subject matters rather different from those of the natural sciences. These are sciences about people and society and those scientists who make models are people who are also members of those societies. Human and social sciences are sciences of ourselves. This is sometimes seen as a problem, as in

commentaries about the problem of separating out the "commonsense" or "folk ontology" of the subjects from the objective scientific ontology, or at least (as in Shipworth's paper) in freeing a modeling project from a dominant and biasing folk ontology from a particular field in the interdisciplinary context. We prefer to emphasize that the "vernacular"—the everyday local knowledge in content and form that a human brings to the problem by being a member of that social space—also plays various positive roles in modeling in these sciences.

Models and modeling have a complex interaction with such vernacular elements which deserves and needs to be taken seriously. We see this in the kin modeling problem—the data model is built upon the vernacular: the socially accepted conventions and norms that tell a member of a society which kin relations are recognized and important and which are not in their (or another) society. These are not pre-theoretical nor folk beliefs, they are the data of society—the vernacular that the data model aims to capture. In the problem of modeling energy requirements for houses, it seems self-evident to start from the view that a house is the standard unit and that energy usage is standard. Yet here the vernacular is present not in this simplistic assumption but rather in the emphasis that energy usage needs to be connected to people in the house and with what they do. This emphasis on the vernacular points to where modeling needs to go in concrete terms, away from simplistic abstractions that fail to provide good intermediate services in measurement and in prediction. In the case of modeling psychological development, it was important to realize that motivation was not an inner need but a relation between inner motive and objectives present in reality. This conceptualization built on the vernacular of adolescents, and contrasted the vernacular of 11- and 18-year olds.

Such vernacular knowledge can be tremendously useful in advancing models from idealized, simplified and abstract to useful and usable objects for a variety of purposes. But it can also be dangerous. The vernacular needs to be confronted because there is no reason to assume that the scientists' local vernacular knowledge is *to some extent* general, and therefore useful, when it may turn out to be idiosyncratic and personal to his or her own circumstances and so potentially misleading. The vernacular needs challenging and testing, just as any other assumption used in model making and model using, but it is not—in itself—a symbol of suspect or prescientific knowledge, as it might be in some natural sciences, to be dismissed out of hand. For example, the vernacular belief that the sun rises every day in our world has a different category status from the vernacular claim that society has a system of regular punishment for unacceptable behavior it labels crimes. While the first comes from a construction based on

personal observation without connection to scientific knowledge, the second comes from our observation of the society we live in where that locally constructed knowledge is likely to overlap with the scientific. The vernacular ought to be articulated and proved generic so that it can be assessed and used effectively, but it may remain tacit and individually personal.

The vernacular not only operates as a source of knowledge, but a touchstone for assessing modeling projects. For the human and social scientist, the vernacular knowledge that they carry around offers an immediate way to gauge surprise from using the model (see Morgan 2005, Grüne-Yanoff 2009). The vernacular is the base line, and anything that the model can be used to teach the scientist (in the many different functions and services that we have found in this field) can be compared with it. If the explorations with the model create a feeling of surprise, then something new has come out of the modeling work. This might be an artifact of the modeling, but could be new knowledge about the theories used, or about the data used, or about the way the model works, or about the relevance of one of the particular assumptions. Of course surprise can happen just as well with models in the natural sciences for models in any field have the potential to be learning tools that extend existing discipline-based knowledge. Yet the human and social scientist modelers have the advantage that the vernacular serves as a second kind of local human and social knowledge that operates in addition to their scientific knowledge and field experience. It may be down-played as something like "common-sense knowledge" but that does not make it less useful.

A second (and perhaps related) characteristic particularly germane to these human and social scientific activities of modeling is the manner in which models take inputs from the domain and crank the materials in such a way that we no longer recognize the bits while others create recognizable elements in their models. Models—as we see from these papers—work like epistemic sausage machines (as Shipworth suggests in this volume): scientists feed stuff into them, and get stuff out of them. Pushing the metaphor further, sometimes the output material is so finely minced that the object model that comes out of the process has been turned into something in which the original inputs cannot be recognized. For example, energy usage modeling takes in things in the vernacular form that we might recognize—such as temperatures in our house, a list of our household appliances, our family size and so forth, and turns them into numbers which undergo so much mincing, scrambling and reassembling that they emerge in the model looking unlike anything we can recognize and make sense of unless we are a social scientist in that field, for example as an equation with probabilities attached. In contrast, other kinds of modeling specialize in maintaining, or recreating, something recognizable from the

original inputs so that the raw materials are still evident. For example floor layouts found on archaeological sites remain recognizable when the recreated simulation building appears on top of them. Furthermore, archaeological modelers seem to be anxious to preserve this recognizability, as it carries important information about the different epistemic qualities of the model ingredients. We can find the same contrast in the ways that observations from the human/social scientific space are recorded and reported. Morgan (2012b) labels this *chorizo* vs. *bratwurst* reporting. In *chorizo* reporting, some elements of the raw evidential ingredients are still recognizable (as in the ethnographies of anthropology), whereas in other fields, or simply for other questions and topics in the same field, evidence is taken in and reported in terms which have already been turned into social scientific representations where no original bits can be recognized (as in the aggregate national income accounts of economics).

This *chorizo* vs. *bratwurst* quality might be thought to offer another way of thinking about representational qualities and the vernacular in the context of models. For example it might be thought that *bratwurst* represents already conceptualized materials and *chorizo* vernacular evidential ones, that *bratwurst* provides a theory model and *chorizo* a data model. But this could be seriously misleading when comparing models. Think again about those archaeological models discussed by Earl—by some very complicated processes, inputs such as details of some ancient structures are entered, chewed up by the computer program, reassembled and a virtual building is created. This is a *bratwurst* machine creating something like *chorizo.* The outcome looks like something that might have existed, but not because it is an architect's maquette, built out of plaster or wood, oriented to a certain direction and shaped with entrances as found on an existing site, but because—on purpose—the digitized model is made to look like something with familiar elements that we people might have seen. Both scientists, and the scientific argument in this field, require a vernacular representation to make their investigations viable. Other fields, with other disciplinary requirements, prefer the non-vernacular in their model representations and produce only bratwurst models as a matter of disciplinary practice.

5. Conclusion

The papers of this special issue reflect on modeling practices in the social sciences and humanities. We explicitly focused on those disciplines that philosophers of science commonly neglect. Unsurprisingly, these reflections by practitioners and philosophers of science revealed many different forms and functions of scientific models in these disciplines. However, we

drew two conclusions that go beyond these specific cases, and which might be of interest for a wider audience.

First, modeling practices must often be assessed with respect to their success in providing "intermediate services," rather than with respect to ultimate scientific goals like explanation, prediction, and control. This is obvious for disciplines where the link between model and phenomena is as tenuous as in bible studies or archaeology. But we believe that this is also a relevant concern in the more established modeling sciences like physics, biology or economics, and that important lessons for those sciences can be learned from the reflections presented here.

Second, we identified the vernacular as playing a special role in social science and humanities modeling practices. While in the natural sciences, vernacular knowledge in the form of "folk physics" or "folk biology" is often a problem that needs to be overcome, vernaculars in the social realm are important sources of information that need to be harnessed and explored for scientific purposes. Models, as many of the papers in this volume show, are an excellent tool for engaging with and analyzing these vernaculars. They make vernacular information explicit, and allow underlying assumptions and hidden implications to be explored. Models also offer sites for negotiating between different vernaculars, e.g. those of different disciplines. Finally, models help qualify existing vernaculars, for example showing something to be possible which is commonly held to be impossible. These characteristic relationships between vernaculars and modeling practices thus appear specific to the social sciences and humanities, and distinguishes them from modeling practices in the natural sciences.

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