Models and truth
The functional decomposition approach

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1 Introduction

Science is often said to aim at truth. And much of science is heavily dependent on the construction and use of theoretical models. But the notion of model has an uneasy relationship with that of truth.

Not so long ago, many philosophers held the view that theoretical models are different from theories in that they are not accompanied by any ontological commitments or presumptions of truth, whereas theories are (e.g Achinstein 1964). More recently, some have thought that models are not truth-valued at all, but truth-valued claims can be made about similarity relations between models and real systems (e.g. Giere 1988). Others suggest that models are instruments that can be used for attaining truths, for example that models are false means for true theories (e.g. Wimsatt 2007). At the same time, philosophers and others keep talking about models being 'correct' and 'incorrect', 'accurate' and 'inaccurate' or getting facts 'right' or 'wrong'. Among practicing scientists, one can find both the notion of a 'true model' and the idea that 'it is in the nature of models that they are false'. There seems to be enough variety of views and confusion around them to invite a little bit of further investigation (see also Mäki 1992, 1994, 2004, 2006, 2009a, b, c).

Different conceptions of the model-truth relationship involve different ideas of what models are and what truth is, as well as how the two are related. Views of how they are related range broadly, including the following. Models are not truth valued, but they are useful vehicles for generating true claims about the world. Models are not truth valued, but truth-valued claims can be made about how they relate to the world. Models are truth valued, but always inescapably false about the immensely rich and complex real world. Models are truth valued, and possibly true.

Some of this variety of views may appear in one writer. Consider William Wimsatt's case for "False Models as Means to Truer Theories" (Wimsatt 2007, 94-132). Wimsatt implies that models are truth valued: they are false. He also seems to imply that the difference between model and theory is a matter of their relative truth content: less (or none) in model, more in theory. He says models can be false in many ways, by being "oversimplified, approximate, incomplete, and in other ways false" such as getting the interactions of variables wrong, the variables not denoting real entities, being phenomenological, and failing to predict the data. And he characterizes these ways as "errors" in models (100-102). By contrast, I don't take all those various ways as ways of models being false. And I think that in the practice of modelling, some important falsehoods in models are often not errors at all, but rather deliberately adopted strategic falsehoods.

Wimsatt next lists (104-105) twelve ways in which false models may be useful (but now no more useful in helping get to "truer *theories*" but rather just truer or otherwise more realistic *models* or measurements). Some of these ways involve moving from thin, simple, and incomplete models to thicker, more complex and more complete models – that is, from false to more truthful in his vocabulary. This is a rather popular idea that appears in the notion of getting closer to truth by "concretization" by authors such as Nowak (1980) and Cartwright (1989). This is another manifestation of the "Perfect Model Model" (Teller 2001) according to which a perfect and possibly true model is a precise photographic replica of its target. By contrast, I have disputed this by suggesting that the simplest and thinnest model versions employing strategic false idealizations may be true.

In what follows, I will give examples of the sorts of step that can be taken towards spelling out the intuition that, after all, good models might be true. Along the way, I provide an outline of my account of models as ontologically and pragmatically constrained representations. And I emphasize the importance of examining models as functionally composed systems in which different components play different roles and only some components serve as relevant truth bearers. This disputes the standard approach that proceeds by simply counting true and false elements in models in their entirety and concludes that models are false since they contain so many false elements. I call my alternative the functional decomposition approach.

2. Models as representations

Like many others, I take models to be representations. I have found it useful to dissect the idea of representation a little further by thinking of it as having two aspects: the representative aspect and the resemblance aspect. Models as representatives stand for some target systems. They represent their targets by serving as surrogate systems that are of direct interest in scientific inquiries. A representative may or may not resemble its target. Resemblance is an additional relationship between the surrogate system and the target system. In order for the model as a representative to do its job as a surrogate system that provides an epistemic gateway to the target, the two systems must resemble one another. If they do, one may hope to (indirectly) acquire information about the target system by (directly) examining the properties and behaviour of the surrogate system. Provided resemblance is ensured, models can be examined in place of their targets without sacrificing the quest for knowledge about real systems. But as I'll explain in a moment, actually achieved resemblance is not required for representation to be in place. Nor does resemblance need to be detailed and comprehensive.

Dividing representation into these two aspects enables having a rather rich and synthetic account of models. For example, it helps incorporate both pragmatic and realist ingredients in the account. The representative aspect brings out the intentionality, creativity and contextuality of models. Models are created by modellers to serve their interests in certain situations. The modellers' goals and contexts provide the *pragmatic constraints* on models. So my account has a strong pragmatic dimension. But it also has a strong realist dimension. The resemblance aspect highlights the involuntary character of representation: models are, or at least many of them should be, constrained by the characteristics of their targets. This imposes an *ontological constraint* on modelling. But even requirements of resemblance are pragmatically constrained, as we will see. There are more nuances in the account. A formulation goes like this:

[A] Agent *A* uses object *M* (the model) as a representative of target system *R* for purpose *P*; addressing audience *E*; at least potentially prompting genuine issues of resemblance between *M* and *R* to arise; describing *M* and drawing inferences about *M* and *R* in terms of one or more model descriptions *D*; and applies commentary *C* to identify the above elements and to align them with one another.

Three distinctive characteristics of this account deserve attention. I join those, such as Giere, who have emphasized the importance of purposes and intentionality in the notion of model as representation. The relationship so conceived has the form: *A* uses *M* to represent *R* for purpose P (Giere 2006, 60). So for an object to represent at all, an agent's intentionality is required. Furthermore, one and the same model object can be used for a number of different purposes, and this makes a difference for how well it functions as a representation. One way in which my account extends this idea is to incorporate the notion of *audience* as part of the pragmatics of representation. Models are built and examined so as to meet and shape audience expectations. The audience-dependence of modelling is one manifestation of the collective nature of scientific work. Models are constructed and used so that they enable communication, convey information, promote agreement, and help persuade others to revise their belief intensities. Just as other purposes, meeting and shaping audience expectations make a difference for how a model fairs in representing.

The second novelty in [A] is that it is put in terms of *at least potentially prompting genuine issues of resemblance to arise* – while other accounts may make no separate reference to resemblance or may require actually achieved successful resemblance. That there be an issue of resemblance that is being raised or that can be raised – and perhaps even settled – makes room for a variety of models at different stages of their epistemic trajectories, from highly conjectural and speculative to highly secure and warranted. The range of 'representational models' becomes thereby extended. By requiring that the issue be 'genuine' I mean to put forth two ideas. First, genuine issues are about non-utopian resemblances: *M* or its modifications should have the capacity to resemble *R* so that successful resemblance does not appear as an unattainable utopian goal, but should instead lie within the horizon of our cognitive possibilities. Second, genuine issues are not about just any of the numerous arbitrary ways in which *M* and *R* do (or do not) and might (or might not) resemble one another, but rather about specific respects and degrees of resemblance that meet the pragmatic constraints. This will play an important role when dealing with the issue of truth.

The third novelty in [A] is the incorporation of what I call *commentary*. A model commentary *C* has a crucial role to play in turning a model object *M* into a representation. Model objects are mute and passive, they are unable to do the representing by themselves. For this, an active agent is required to use a model object for representing some facets of the target so as to serve some purposes and to communicate all this to some relevant audiences. Use must involve talk. The agent must speak on behalf of the mute model object. This must be done in a way that aligns the model object with the other components of representation. Model commentary is an activity of the modelling agent that seeks to identify the relevant components of representation and to coordinate model objects with the model descriptions, purposes, audiences and issues of resemblance involved in representation. Model commentary also plays a crucial role in dealing with the issue of truth.

Model commentary *C* is needed for the task of coordination since *model description D* is not sufficient for this – while *D* is necessary for *C*, since one must describe what one comments. Here I consider a class of models that can be conceived as imagined objects or systems. Model descriptions are necessary for such models, for them to come about and to play their roles in scientific inquiry. What is merely imagined must be described by concrete means, such as material objects, mathematical equations, diagrams, visual images, graphs, verbal accounts, and so on. One and the same model can be described variously, using different concrete devices. These devices are used in constructing models, characterizing their properties, and reasoning about them.

Reasoning or inference takes place among model descriptions *D*. Some inferences lead to conclusions about the imagined model world *M*: about what properties the model has, about what happens in the model. Other inferences lead to conclusions about the real target system *R*. These latter conclusions are hypothetical if genuine issues of resemblance can be raised, and they become increasingly warranted the more reliably those issues get settled in favour of actual resemblance. It makes no sense to make such inferences in case no genuine issues of resemblance can be broached. So on this account, a model permits inferences about the target if it is representational in the sense of [A]. By contrast, Suarez (2004) suggests that a model is representational provided it enables inferences about the target. My account reverses this relationship: inferential capacity depends on representational capacity. From an epistemic point of view, however, the two interact: to determine whether a model has representational capacity, one needs to exercise a lot of inference. There is no inference-independent way to find out about whether a model succeeds in representing.

A model description does just what the term suggests: it describes a model. But it does not say what in model *M* is relevant for what purpose and audience, and what facts about target *R* it is supposed to highlight in a given context of model use. This is where the idea of functional decomposition becomes acute. And this is where model commentary *C* is called for its services.

3. Models and truth

Account [A] of models as ontologically and pragmatically constrained representations offers numerous opportunities for linking models with truth. These various possible lines are based on isolating different components of [A] and exploiting them in truth ascription. Model commentary plays a crucial role in pointing out the relevant components and their roles in determining the truth-value of a model.

One possibility is to focus on the *pragmatic* components of model representation, namely purpose *P* and audience *E*. The strategy is to adopt a suitable pragmatic concept of truth and to ascribe the respective pragmatic property to models. Account [A] makes two such pragmatic properties available, namely usefulness in relation to a purpose, and persuasiveness in relation to an audience. The respective concepts of truth then are *truth as usefulness* in serving a purpose, and *truth as persuasiveness* in conforming to and shaping the beliefs of an audience. Truth ascription is a matter of ascribing such pragmatic properties to models. A model is true if it succeeds in serving a purpose such as contributing to the attainment of a policy goal; or if the audience addressed finds the model persuasive enough to accept it. In each case, further requirements should be imposed on usefulness or persuasiveness for these to qualify as definitive of truth (such as sustained long-run usefulness and persuasiveness as an outcome of a rhetorical conversation observing some ethical principles).

Even though I take models to be pragmatically constrained representations, I prefer not to adopt a pragmatic concept of truth, thus the above is not my way of getting truth into models. There are a couple of intuitions that I am not prepared to sacrifice. An agent A can successfully use a false model M to impress an audience E. And A can successfully use a false model M to serve some other purpose P, such as prediction within some range of reliability. I take these intuitions to suggest that truth is independent of persuasiveness and usefulness (while these can be included among the fallible criteria of truth).

Both of these options – truth as usefulness and as persuasiveness – are based on picking out distinct components -- P and E -- in the composite act of representation as relevant to the model's truth. Note, however, that both tend to treat models in an indiscriminate manner, thus model object M itself is not decomposed. Truth is ascribed to models as wholes, not to some limited parts of them. The view I am pursuing here, on the other hand, takes a decompositional approach to M as well, not only to the composite act of representation.

So I take two steps away from the pragmatic view of the truth of models. First, we should not begin with focusing on the M-P or the M-E relations as key to models possibly being true. We should rather start first with isolating the M-R relation from the pragmatic components in representation. It is the resemblance aspect of representation that is akin to truth in some intuitively obvious manner. Nevertheless, the pragmatic components of a representation do play an important role in truth ascription as we will see. Second, because it is in the nature of models that they in no way resemble their targets accurately and in their entirety, resemblance has a chance only if models themselves are functionally decomposed. Indeed, the key principle that informs this approach is that *a model is a structure with component parts that have different and varying functional roles, among them the role of the primary truth bearer*. Models are not candidates for truth as wholes, rather their privileged parts can be considered for truth. Other model parts may be idle or they may actively facilitate the pursuit of truth without themselves claiming any such status. To enable truth ascription, the modeller must be able to identify the relevant model parts and the relevant respects and degrees of resemblance - instead of complete and precise resemblance.

The model itself is unable to discriminate between its various parts (m_1, m_2, m_3, …) as playing different functional roles. It is here that the pragmatic components become active. The pragmatic constraints shape the limited respects and degrees of resemblance between model *M* and target *R*. The recognition of the relevant purposes *P* and audiences *E* informs the assignment of different functions to different model parts in a particular context. The required respects and degrees of resemblance are a function of $<M, R, P, E>$ where M consists of m_1, m_2, m_3, ... They are not constant across contexts. In different pragmatic situations, different bits of truthful information are being sought.

I said above that *M-P* and *M-E* relations do not constitute truth. But as soon as we settle on *M-R* relations as key to truth, we must bring *P* and *E* back to the stage because they make indispensable contributions to truth acquisition. They help isolate relevant truth bearers within models. They determine the respects and degrees of resemblance that matter. Of all possible bits and pieces of truthful information that a model can capture – and that are true or false in virtue of the properties of the target system *R* – the pragmatic components of representation select the ones that are pursued in any given context. In this way, truth acquisition is a joint product of a pursuit that meets the pragmatic and ontological constraints of modelling simultaneously.

These various components are not self-identified, nor is their coordination automatic and transparent. It is necessary to identify the components, to assign them with functional roles, and to align them with one another in such a way that the ontological and pragmatic constraints have a chance of being met in a given context. This is where model commentary *C* becomes indispensable. It provides connections between the components and makes clear what aspects and degrees of resemblance are being sought, and how various model parts play their roles in the endeavour. Only a model commentary can answer questions such as: what in *M* is supposed to resemble what in *R*?

4. Idealization, isolation, and truth

Consider the structure and composition of models from the point of view of the use of idealizing assumptions in describing models. It is generally recognized that such idealizing assumptions are put in terms of extreme or limit values (zero, infinity, one), and as such they may often appear to be brutally false about any real world situation. If one were to have an idea of models on which such idealizing assumptions are among a model's elements, an unavoidable conclusion would be to admit that there is a lot of falsehood in models, or even that models are inescapably false. So there would be no chance for a model to be true.

But let us look at such idealizations from the functional decomposition point of view. If we consider models to be imagined objects or systems that are to be distinguished from their descriptions, we can think of idealizing assumptions as belonging to model descriptions *D*. Their function is to describe the imagined system by telling what is not in it and what is included in it. Other assumptions identify items – for example, important causal factors – to be included more directly. Models are often imagined systems in which a simple streamlined mechanism is in operation isolated from any other complexities and interferences. Those potential interferences are neutralized by means of idealizing assumptions. Such assumptions are among the vehicles that have the function of isolating mechanisms from disturbances. Making and manipulating idealizations is analogous to experimental controls in material laboratory experimentation – it is the experimental moment in theoretical modelling. In both cases, one controls for other things in order to isolate one thing so as to let it act on its own. In material experiments, the controls are based on causal manipulation, while in theoretical models they are implemented by making idealizing assumptions. (Mäki 1992, 1994, 2005, 2009a, 2009b)

Now thinking of idealizing assumptions as truth bearers with truth-values, the crucial first decision to make is about what their appropriate truth makers might be. If they are interpreted as claims about actual real world systems, they typically emerge as false claims. But if they are interpreted as claims about models viewed as imagined systems, they are straightforwardly true for the simple reason that as part of model descriptions idealizing assumptions not only are about models, but also determine what those models are. They not only describe a pre-existing imagined system, but also articulate the details of the product of the imagining. Or, as it has also been put (Giere 1988 etc), they define the model, and what defines a model is trivially true about it. So conceived, the falsehood of idealizations with respect to real world systems may seem apparent or irrelevant. Again, the story is more nuanced, but cannot be told here (see Musgrave 1981, Mäki 2000, Hindriks 2006).

5. The locus and stuff of truth

There are two interrelated issues about truth in regard to models. The locus issue is about where in, or around, models is truth possibly located. The stuff issue is about the ontology of truth-bearers, about the stuff they are made of. A stance on one constrains the range of possible stances on the other.

On Giere's account, truth-bearers must be linguistic. This stance on the stuff issue has implications for the locus issue. For Giere models are non-linguistic "abstract objects" that are linguistically described or defined by assumptions that are trivially true of the models they describe. Since models are not linguistic, they are devoid of truth-value. This does not mean that models are unconnected to their targets – they are, but not by truth. The connection is that of similarity. Model systems may be similar to their target systems in varying respects and degrees. Statements about these relationships are "theoretical hypotheses" that are truth-valued claims about (respects and degrees of) similarity between the model and the real system. (Giere 1988, 2006) So two kinds of true claims can be made *about* models. Models themselves cannot be true or false.

Since I am looking for ways of avoiding this last conclusion, I begin with questioning Giere's view of the stuff issue. I don't require truth bearers to be linguistic. A simple step to take is to permit thoughts among possible truth bearers. Thoughts can be expressed linguistically, diagrammatically, and otherwise. If thoughts can be true, such expressions can also be – perhaps derivatively – true. A thought that things are thus and so is true if things are thus and so.

Models viewed as imagined systems might be made of the kind of stuff that is fit for this line (but the details depend on whether models are viewed as *thoughts* or as *what is thought*; see Mäki 2009c). A modeller thinks of a simple system governed by a streamlined mechanism undisturbed by any interferences. The system is described in terms of assumptions many of which are idealizations that appear false if taken as claims about real world systems. By exercising inferences and manipulations among model descriptions, the modeller refines her thought about the structure and functioning of the modelled mechanism. Model commentary may point to this thought as the primary truth bearer within the model. This thought is true of those real world systems in which the mechanism is in operation (or is possibly in operation if this is the thought). -

The above presupposes that the model is being used for representing a target, with the components identified by [A] in place. A model as an imagined system may serve as a representative of a target and may resemble the target in certain selected respects. Many characteristics of such a model system fail to resemble features in real systems, but this does not have to be taken to imply that the model is false since those characteristics have not been included among the relevant truth bearers. The model and its target relevantly resemble one another in case the mechanism in the model and a mechanism in a target resemble one another. In such a case, one may choose to go as far as saying that the model is true. A more moderate line would be to say that a part of the model is true. (For qualifications, see Mäki 2009c.)

6. A brief illustration

The ideas outlined in the foregoing are well illustrated by the simple model of agricultural land use distribution provided in Johann Heinrich von Thünen's famous book on the Isolated State (1826/1842). Here land use allocation takes place in a highly idealized simple model world. The book begins with the following passage:

> "Imagine a very large town, at the centre of a fertile plain which is crossed by no navigable river or canal. Throughout the plain the soil is capable of cultivation and of the same fertility. Far from the town, the plain turns into an uncultivated wilderness which cuts off all communication between this State and the outside world. There are no other towns on the plain." (1966, 7)

This is part of von Thünen's model description. Here he lists some of the idealizations that characterize the Isolated State, his simple model world. Later literature has amended the list with many other idealizing assumptions (such as the town being a point and agents being perfectly informed). If taken as truth-valued claims about real-world land use, they are false, many of them utterly so. It is notable that von Thünen implies that the Isolated State is an imagined system. Note also that the book is directed to an audience from the start: it invites the reader to join the author in "imagining" a model system.

The author's model commentary is informative. Much of it is directed to the audience of readers. Here is von Thünen on the function of idealizing assumptions:

> "I hope the reader who is willing to spend some time and attention on my work will not take exception to the ***imaginary assumptions*** I make at the beginning because they ***do not correspond to conditions in reality***, and that he will not reject these assumptions as arbitrary or pointless. They ***are a necessary part of my argument,***

allowing me to establish the operation of a certain factor, a factor whose operation we see but dimly in reality, where it is in incessant conflict with others of its kind." (1966, 3-4; italics added)

Indeed, idealizing assumptions are vehicles employed in the method of isolation that captures the operation of a causal mechanism undisturbed by others such as those that transmit the influence of rivers, roads, mountains, uneven fertility, foreign trade etc. – ones that actually contribute to the shaping of land use in real world systems. But in the imagined world of the Isolated State, land use allocation is governed by a simple mechanism of transportation costs and land rents that depend on distance. Land rents are higher closer to the city and transportation costs are higher further away from the city. Land users compete in the land market trying to maximize their net revenues, and are pulled by the two cost factors, finally settling on a location that balances them. The equilibrium outcome is a neat pattern of concentric rings around the town, each zone accommodating just one kind of specific activity. The geometric image of concentric rings is another description of an aspect of von Thünen's model.

Considered as representations about real world systems, the assumptions and the outcome of the model do not get the real world facts right. But they are true about the model. Could the model in turn be true of real systems? Yes it can – at least this is von Thünen's view as his model commentary suggests:

"The principle that gave the isolated state its shape ***is also present in reality***, but the phenomena which here bring it out manifest themselves in changed forms, since they are also influenced at the same time by several other relations and conditions. ... we may divest an acting force [eine wirkende Kraft] of all incidental conditions and everything accidental, and ***only in this way can we recognize [erkennen] its role in producing the phenomena before us***." (1910, 274; my translation, italics added)

I read this passage to suggest that the principle or mechanism isolated in the imagined model world – the thought of the mechanism - is the relevant truth bearer, and the respective mechanism in real systems is the respective truth maker. Whatever else the model contains, and whatever else modifies the manifestation of the mechanism in real systems do not directly participate in the truth making of the model. The model and the real world may resemble one another in limited but important respects, thus the model may be a true representation. (For a more extended discussion, see Mäki 2009c.)

7. Conclusion

I have outlined what I've called a functional decomposition approach to the issue of whether models might be true. The approach insists on decomposing both the activity of representing and the model that is being used for representing a target. Allowing models and truth bearers to be made of the same stuff – thoughts or what is thought - truth can be located inside models.

While one should agree with Wimsatt that models can serve as means for other true (and in many cases, truer) models, the account submitted here suggests that the initial models may be true as well. The key to seeing this is to ask: what in a model might be true about what in a target? There are many different truths to be pursued about a target, not just different models in pursuit of one truth. The Perfect Model Model is indeed false.

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