Models and the locus of their truth

Uskali Mäki
Academy of Finland

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Abstract
If models can be true, where is their truth located? Giere (e.g. 1988) has suggested an account of theoretical models on which models themselves are not truth-valued. The paper suggests modifying Giere's account without going all the way to purely pragmatic conceptions of truth – while giving pragmatics a prominent role in modeling and truth-acquisition. The strategy of the paper is to ask: if I want to relocate truth inside models, how do I get it, what else do I need to accept and reject? In particular, what ideas about model and truth do I need? The case used as an illustration is the world's first economic model, that of J.H. von Thünen (1826/1842) on agricultural land use in the highly idealized Isolated State.

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1 Introduction

Can scientific models be true? If not, why not, and in such a case does the vocabulary of truth find any use in connection to models? If yes, where exactly is the truth in models located and how is this locus determined? These are questions that can be motivated by their relative neglect in the recent boom in the philosophical inquiry into the nature and functions of models in science. My answers to these questions constitute an attempt to spell out the intuition that, after all, models can be true.

Part of my own motivation has originally derived from a chronic irritation by a feature of economists' disciplinary culture: in response to frequent criticisms of building false theoretical models that employ false assumptions, economists often evasively (and undecidedly) say that it is in the nature of models that they are either necessarily false, or that they are neither true nor false.

Rather than constituting a peculiar special case, typical theoretical models in economics have characteristics that make them particularly suitable representatives for an examination of the issue of truth. Those models and their component parts typically appear false, even utterly so. And they are often heavily criticized, sometimes ridiculed, for their shameless falsity. Yet, economists employing such apparently false models often believe them to provide access to important insights into economic reality. At the same time, those economists are generally unable to articulate this belief in terms of truth. While the primary goal of this paper is to contribute to current philosophical literature on a relatively neglected issue about models, its secondary goal is to show how economists and other practicing scientists could be helped to articulate their metatheoretical beliefs about theoretical models (for earlier attempts, see Mäki 1992, 1994, 2004).

Practicing scientists and philosophers hold two views that I argue should be avoided. Both views hold that a model is "just a model" and not intended as anything as serious as a candidate for truth. But the two views infer to this conclusion differently.

The first idea is that models cannot be true because they contain so much falsehood. Models violate "the whole truth" in that they leave much out and cover so little: *models isolate.* They also violate "nothing but the truth" due to containing assumptions that distort the properties of things in the world: *models idealize*. Both of these ideas are joined in the intuitive thought that the world is much richer and more complex than any such thin streamlined models. Therefore, the intuition (and its philosophical articulations) suggests that getting to truth(s), or closer to them, requires that the models be made thicker and richer by relaxing the idealizing assumptions and thereby adding to their complexity: models must be de-isolated and de-idealized. This is the first popular idea that I want to reject in any general form.

My alternative thought is that there is no necessary conflict between a model being true and that model violating the whole truth and nothing but the truth in the way described above. I accept the weaker idea that a model may be true *despite* false assumptions. I also accept – and argue for in this paper - the stronger idea that a model may help capture truths *thanks to* false assumptions. Thus, many truths are attainable without de-isolation by de-idealization – and indeed are attainable in virtue of isolation by idealization.

Note that the first idea – as well as its rejection – is based on the presumption that a model may be truth-valued. This is denied by the second idea that I argue we should consider avoiding. This second view holds that models cannot be true because they are not the sorts of entity that are truth-valued. An example is Ronald Giere's (1988) view that models are not truth-valued because they are not linguistic entities (but are rather "abstract objects"). On this view, truth at most resides in linguistic statements about models' properties (on Giere's account, such statements are "theoretical hypotheses" about similarity relations, and these are truth-valued).

My alternative to this second idea is to focus on (the nature and locus of) truth bearers *inside* models – as well as the truth makers that make them true. So I am not only interested in truths *about* models, but want to see how models themselves could be true. What will be attempted is a modification and elaboration of Giere's account so as to

relocate truth with respect to models (which gives us a somewhat more radical revision of Giere's account insofar as the issue of truth is concerned). In order to relocate truth *in* models, we mainly need to rethink the bearers and conditions of truth, but we also suggest some rethinking about the concept of model.

Considering the location of the present paper in current philosophy, I take it to address issues that have suffered from a relative neglect. First, the growing body of literature on scientific models and representations has given relatively little systematic attention to issues and concepts of truth. Second, the debates around scientific realism have made strong claims about truth in science, but the specific units of science that might or might not bear those truths have been left obscure. Third, the recent literature on theories of truth has paid relatively little critical and systematic attention to the issues of truth bearers. What follows can be read as an attempt to start putting these issues on the agenda in connection to one another.

So what I want is to give truth a chance, to take a fresh look at the possibility of truth *in* models, or even the truth *of* models (I say more about these two things at the end). The strategic question is: If this is what I want, how do I get it - what else do I need to accept, and what to reject? How do I need to conceive of models and truth to get them into a more intimate connection with one another?

I take models to be isolative representations (see also Mäki 1992, 2001, 2004, 2008). It is by way of examining this notion that I seek to relocate truth in models. Throughout, J.H. von Thünen's famous 1826/1842 model of agricultural land use will be examined as an illustration. The investigation proceeds in three acts. First, *models as isolations*. I discuss the functions of falsehood in von Thünen's model and elaborate on the notions of idealization and isolation. Second, *models as representations*. I outline my account of the very concept of model as pragmatically enabled and constrained representation with representative and resemblance aspects. Third, *models as truth containers*. I ask what moves are required to accommodate the intuition that a highly unrealistic model – such as Thünen's – captures some truths about the world.

2. Models: Isolation by idealization

The simple model of agricultural land use distribution given in Johann Heinrich von Thünen's famous classic *Der isolierte Staat in Beziehung auf Landwirtschaft und Nationalökonomie* (1826/1842) is sometimes called the world's first economic model. Moreover, it has turned out to have a lasting significance. The model remains standard textbook material, and its variations are still widely used in economic geography and geographical economics, in subfields such as location theory, urban economics, and regional science. Given that the model has a geographical dimension, many of its features can be represented visually, which is an advantage for illustrating my argument. Most importantly for our purposes, von Thünen's model employs numerous unrealistic assumptions in envisaging an extremely simple situation that appears to have next to nothing to do with real world situations. It is thus *a most unlikely candidate for truth*, therefore providing a powerful test of my ideas.

The first sentences of von Thünen's book invite the reader to imagine a system that cannot be observed and that does not seem to exist other than in imagination. He does not use the vocabulary of 'model', but given that he is clearly describing a model as we nowadays understand this notion, he is implying that a model is an imagined system. This is how his book begins:

"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)

In this opening passage, von Thünen starts listing some of the assumptions that characterize his model of land use in the isolated state. Later contributors have amended the list. The following list is still incomplete (the dissection is mine), but gives a flavour of the sorts of assumption that are needed.

1. The area is a perfect plain: there are no mountains and valleys.
2. The plain is crossed by no navigable river or canal.

3. The soil in the area is throughout capable of cultivation.
4. The soil in the area is homogenous in fertility.
5. The climate is uniform across the state.
6. All communication between the area and the outside world is cut off by an uncultivated wilderness.
7. At the center of the plain there is a town with no spatial dimensions.
8. There are no other towns in the area.
9. All industrial activity takes place in the town.
10. All markets and hence all interactions between the producers are located in the town.
11. The interaction between producers is restricted to the selling and buying of final products: there are no intermediate products and no non-market relationships between producers.
12. Transportation costs are directly proportional to distance and to the weight and perishability of the good.
13. All prices and transportation costs are fixed.
14. Production costs are constant over space.
15. The agents are rational maximizers of their revenues.
16. The agents possess complete relevant information.

Assumptions 1-16 provide von Thünen's simplest model of land use. The striking observation is that if considered as statements about the world, the assumptions are clearly false, many of them being very far from the truth about typical actual situations. Their falsehood is evident from the start, thus their recognition as false does not emerge as an outcome of some *ex post* empirical testing, for example. Indeed, they are not hypotheses or conjectures that are examined as candidates for truth.[1] Instead, they are purposeful falsehoods that are strategically mobilized and manipulated. They are instances of *idealizing assumptions* employed in modelling, deliberate and strategic falsehood being their characteristic feature. The question to ask then is: what's the point? What function can they possibly serve?

The answer is: the function of such falsehoods is isolation by idealization (Mäki 1992, 1994).[2] Idealizing assumptions 1-16 serve the function of neutralizing a number of causally relevant factors by eliminating them or their efficacy. Assumption 1 eliminates the impact of mountains and valleys on land use. Assumption 2 eliminates the impact of

[1] The English translation of von Thünen's book (1966) may mislead: 'Voraussetzungen' has been translated as 'Hypotheses' which may suggest that their truth-value is an open question. I am calling them 'assumptions' instead.

[2] My terminology deviates somewhat from that used by some others. For example, my use of 'abstraction' and 'concretization' is more restricted than that of Nowak (1980) or Cartwright

rivers and canals on land use. Assumption 4 eliminates the impact of variation in soil fertility while assumption 5 eliminates the impact of variation in climate. Assumption 6 isolates the area from the rest of the world, eliminating the impact of trade (hence "the Isolated State"). Assumption 12 eliminates the impact of roads and railways and any sort of preservation technology (von Thünen envisaged that delivery to the town takes place by oxcart). And so on.

In analogy to the experimental procedure, such idealizing assumptions in many contexts serve the further strategic purpose of *theoretical isolation*. By neutralizing other subsidiary causes and conditions, they help isolate a major cause and its characteristic way of operation. This is also what happens in von Thünen's case. What is isolated by his simple model is *distance (or transportation costs) as a major cause of land use distribution*. This insight will play a core role in my argument.

Note that the term 'isolation' appears also in von Thünen's own exposition: he is analyzing land use in the "Isolated State". The state, or the area, is assumed to be isolated from the rest of the world so as to eliminate any influences on land use from outside the area itself. What I have suggested is the idea that von Thünen's model isolates one causal factor from all others, whether inside or outside of the area. So I am using 'isolation' in a more general sense than did von Thünen himself. It is noteworthy that von Thünen's working title for his book was *Der ideale Staat* (The Ideal State), which is in some ways more informative than *Der isolierte Staat* (The Isolated State). *Der ideale Staat* aptly captures the nature of his model in depicting a very idealized system. It also highlights the fact that the system is "ideal" in the sense of being imagined by our ideational powers.

Indeed, we were invited by von Thünen to imagine a highly idealized system characterized by a set of idealizing assumptions. Right after having outlined a few of those assumptions, he asks what happens in the imagined situation, that is, in the model. What sort of land use pattern will emerge?

(1989). I explain and defend my use of '(de-)isolation', '(de-)idealization', 'abstraction', and 'concretization' in Mäki (1992, 1994).

"What pattern of cultivation will take shape in these conditions?; and how will the farming system of different districts be affected by their distance from the Town?" (1966, 8)

He then immediately answers the question, that is, he describes the outcome that emerges within the model. It is the land use pattern under the peculiar circumstances characterized by the idealizations of the model.

‘‘... near the town will be grown those products which are heavy or bulky in relation to their value and hence so expensive to transport that the remoter districts are unable to supply them. Here too we shall find the highly perishable products, which must be used very quickly. With increasing distance from the Town, the land will progressively be given up to products cheap to transport in relation to their value. For this reason alone, fairly sharply differentiated concentric rings or belts will form around the Town, each with its own particular staple product.’’ (1966, 8)

So what emerges is a pattern of concentric rings around the point-like town where the market lies. On the inner rings, we find dairying and intensive farming of vegetables and fruit because products such as milk and tomatoes must be transported to the market quickly; and the production of timber and firewood because they are heavy and bulky, hence expensive to transport in relation to their value. On the outermost ring, we find stock farming or ranching because animals are self-transporting, they can walk to the town to be sold or butchered. In between, there are rings for extensive farming of crops such as grains that are more durable than fruit and less heavy than wood. The upper half of the following image, drawn from von Thünen’s exposition, describes the pattern of the famous *Thünen rings*:

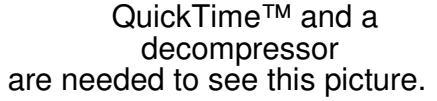

Figure 1
Thünen rings: land use in the model world
Source: von Thünen 1966, p. 216

In the lower half of the image, von Thünen envisages a situation that emerges in a model that has two characteristics that are missing in the simplest version: a river flowing through the central city and a smaller subsidiary town. Assumptions 2 and 8 that describe the simplest model are here relaxed.

It is important to see that von Thünen's exposition suggests that the model is distinct from its descriptions. The model here is the imagined world, possessing the characteristics provided by the set of idealizing assumptions and missing many characteristics of real world situations. The model is being described by those assumptions and by the figure of concentric rings. It can also be described in terms of various mathematical instruments. So we can have various verbal, geometric, and algebraic descriptions of features of the model.

The first implication of the separation between model and its descriptions highlights the *locus of inference in modelling*. The properties and behaviour of the model are examined by inferring from some of its features to some others – such as from those given by assumptions 1-16 to those that can be visualized in terms of zones that have the form of concentric rings. Here the role of model descriptions becomes essential. The properties

of the model are examined by performing inferences among model descriptions. Land-use patterns are derived through land values, or rent gradients (as they became to be called in the later Thünenian tradition). This derivation is shown in Figure 2.[3] The facts that correspond to this inference in the model itself are that land rents are higher closer to the city and transportation costs are higher further away from the city; and that land users compete in the land market maximizing their net revenues, and are pulled by the two cost factors, finally settling on a location that balances them so as to give rise to the pattern of concentric rings. I will call this set of facts *the Thünen mechanism*.

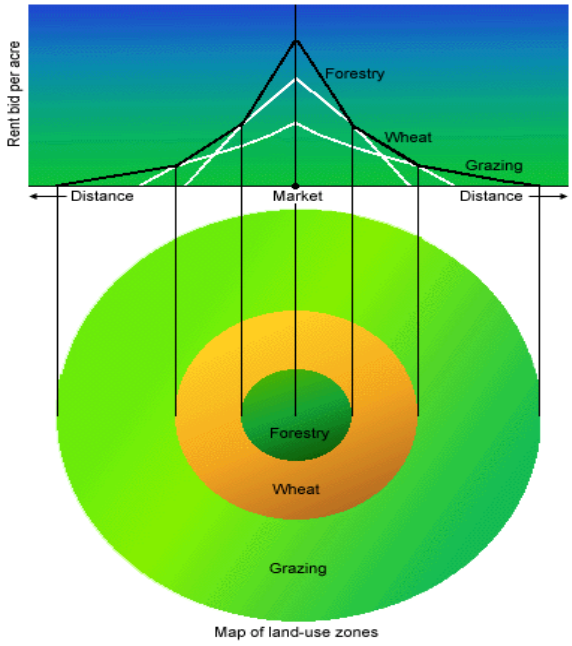

Figure 2
Inferring land use zones from rent gradients
Source: Hoover and Giarratani 1999

Now thinking of von Thünen's assumptions and the Thünen's rings from the point of view of truth, the striking observation is that there seems to be nothing close to the truth in the offing. Falsehood rules. What we see is a set of utterly false assumptions and an utterly false prediction. The assumptions appear to get the facts wrong about the world,

[3] This perspective connects with accounts of models that focus on their inferential functions (e.g. Suarez 2004). In my account, the representational and inferential perspectives complement one another.

and there are no concentric rings to be observed in real-world land use. The model seems just false. As we will see in a later section, von Thünen himself is fully aware of this.

The standard response is to say that what von Thünen has provided is just the simple "first approximation" or some such, and it is only by way of making the model more complex and comprehensive that truth about land use can be approached. We must relax the model's idealizing assumptions one by one, thereby letting previously excluded causal factors work out their impact on the outcome, to get closer to the true representation. This is to say we must continue the process started in the lower half of Figure 1. So de-isolation through de-idealization offers the only route to truth, or so the popular doctrine mentioned in the introduction goes (see, e.g., Nowak 1981). Figure 3 illustrates this.

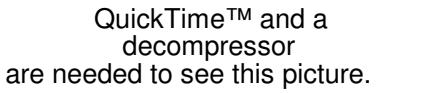

Figure 3
De-isolation through de-idealization
Source: Peet 1969, p. 287.

Here one begins with the simple case of concentric rings (Section I), governed merely by the Thünen mechanism. One then adds some variation in fertility (Section II) and another town (Section III), then relaxes the perfect rationality assumption (Section IV). By proceeding like this, and finally combining many such relevant "complexities", one hopes to create an image of land use that is close to the true representation (Section V).

It is undeniable that such a procedure of de-isolation is needed for acquiring some interesting truths about the world. But I dispute the popular doctrine that de-isolation through de-idealization provides the only route to all possible truths. I will argue instead that von Thünen's simplest model is in principle capable of conveying importantly true information about the world without de-isolation (Mäki 1992, 1994, 2004).

But first I point out a troubling feature of the above reasoning. This is the second implication of the separation between models and their descriptions, dealing with the representational - rather than inferential - functions of models. Model descriptions are what their name suggests: they describe models rather than the real world. If one takes the separation between models and their descriptions strictly, it becomes problematic to say that the idealizing assumptions 1-16 are false of the real world. The same applies to the image of concentric rings. They are true about the model, and they are neither true nor false about the target of the model. To deal with this issue, we first need to understand what it is for a model to represent. So I next outline an account of models as representations.

3. Models as representations

Like most contemporary philosophers, I treat models as representations. But my account has some special features that need to be spelled out for the purposes of the rest of the argument. I take models as representations to have two aspects: the representative aspect and the resemblance aspect. Models are *representatives* of some target systems: they are surrogate systems that stand for their targets and are examined in place of their targets.

Resemblance is a further relationship between the surrogate system and the target system dealing with how adequately the model functions as a representative.

The representative aspect highlights the intentionality and voluntary character of models, the fact that model properties are up to us, that models are made by us to serve our interests (captured by the phrase, "anything can serve as model"). The model users' goals and contexts provide the *pragmatic constraints* that shape models, thus there is a strong pragmatic flavour in this account. On the other hand, the resemblance aspect stresses the involuntariness of representation, the fact that models are, or should be, constrained by the characteristics of their targets. This provides an *ontological constraint* on modelling, thus there is also an underlying realist spirit in this conception. My account of models as representations can be nutshelled like this:

> Agent *A* uses object *M* (the model) as a representative of target system *R* for purpose *P*, addressing audience *E*, prompting genuine issues of resemblance between *M* and *R* to arise; and applies commentary *C* to identify the above elements and to coordinate their relationships.

This account has some distinct features. It incorporates the idea of *audience* as part of the pragmatics of representation. I find this an uncontroversial amendment to previous accounts of models given the collective nature of scientific work. Models are not built and examined for one's own private pleasures, but largely to meet and shape audience expectations. Models enable communication, models help convey information, models enhance agreement, and models are used to persuade others to revise their belief intensities. Audience-dependence may be explicitly public, and it may be a matter of anticipated audience responses shaping private modelling activities. The role of the audience is also obvious in shaping model descriptions: the media that are employed for describing a model partly depend on the audience that is addressed. Bringing in the audience should be perfectly in the spirit of Giere's account. Together with other purposes *P*, audiences constitute the pragmatic context that shapes the "perspectives" that Giere (2006) talks about.

The second novelty is that the account requires *prompting genuine issues of resemblance to arise* – rather than successful resemblance or no reference to resemblance at all. By 'genuine issue' I mean to express two ideas. First, representation presupposes that *M* has the capacity to resemble *R*. Successful resemblance should not come out as utopian, as an unattainable goal regarding which no sensible issue can or should arise as to whether it has or has not been attained. For a genuine issue of resemblance to arise, successful resemblance should lie within our reach, within the horizon of our cognitive possibilities. Second, genuine issues of resemblance do not deal with just any of the numerous arbitrary ways in which *M* and *R* do (not) and might (not) resemble one another. At issue are specific respects and degrees of resemblance that meet the pragmatic constraints at desired levels of abstraction.

Mere resemblance is not sufficient for representation. Think of the pattern of concentric rings in the model world of the Isolated State. This pattern may resemble very closely the real-world pattern I create by dropping a pebble in a still water. Yet, the Thünen pattern is not a representation of this or any other real pattern on the surface of water – simply because it is not properly related to the model that von Thünen intended to construct as a representative of agricultural land use dynamics. For the issue of resemblance to arise, the respective representative must be about the intended or otherwise relevant domain. The relevant domain can be partly identified by the pragmatic constraints, and partly by the kinds of causal mechanism presumably in operation. The causal mechanisms responsible for the patterns of land use in the Isolated State and of the patterns on the surface of water are too different for the resemblance of these patterns to be at all illuminating. This is a remarkable point given that the pattern of concentric rings may have a far greater resemblance with a pattern on the surface of water than with any real-world land use patterns.

This last observation may seem like saying that resemblance is not necessary for representation either. But on the other hand I have claimed that representation does require the resemblance aspect, so the representative aspect alone is not sufficient for

representation. The tension resolves in two steps. First, representation does not require achieved resemblance but just the issue of resemblance to arise. Second, representation does not require that the issue of resemblance would legitimately arise in regard to all parts of the target in all possible respects. I will next explain how my account helps take the second step; I will then point out an implication and an alternative phrasing of the first.

Representation does not require that all parts of the model resemble the target in all or just any arbitrary respects, or that the issue of resemblance legitimately arises in regard to all parts. The relevant model parts and the relevant respects and degrees of resemblance must be delimited. The important observation is that the model itself is unable to discriminate between its various parts (m_1, m_2, m_3, …) as serving different functions. This is where the pragmatic components take on active roles. The pragmatic constraints determine the required respects and degrees of resemblance - instead of complete and precise resemblance - between model *M* and target *R*. In accomplishing this, the recognition of the relevant purposes *P* and audiences *E* helps assign different functions to different model parts. So we may say that 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, ...

But this function lacks the capacity to identify itself, so it cannot speak on its own behalf. The challenge is to identify and coordinate the various components so as to align them with one another in such a way that both the ontological and pragmatic constraints will be met. This is where Commentary *C* enters the picture. It supplies connecting links between the components such that it becomes clear what aspects and degrees of resemblance are to be sought, and how various model parts play their roles in pursuing the goals. The role of Commentary will be illustrated in the next section.

The first step mentioned above has implications for the issue of 'misrepresentation' occasionally addressed in recent discussion on models. Part of this discussion seems confused due to a failure to keep the representative and resemblance aspects of representation sufficiently separate. The immediate implication of my account is that 'representation' is not a success term with any high degree of ambition in terms of

resemblance. Using a representative of some target for some purpose while facing the issue of resemblance is to represent. Now failure to represent in this sense is not what 'misrepresentation' is usually taken to denote. I think it is rather supposed to be used when talking about failure to resemble. But this tends to be obscured because the representative and resemblance aspects are not clearly distinguished.

Naturally, an account of scientific representation must accommodate failures. The notion of 'prompting issues of resemblance to arise' starts taking care of this. Failing to prompt those issues is a major failure in representation (and it is here that 'misrepresentation' may be appropriately applied), while failing to resemble is a lesser failure. Respectively, prompting issues of resemblance gives us weak success, while succeeding to resemble is a matter of stronger success.

Another way of characterizing successful representation by a model is to say that in virtue of pursuing and possibly achieving the right kind of resemblance between the model and the target, the direct examination of the model's properties may indirectly provide information about the properties of the target. One learns about the target by studying the model. This is what justifies calling the model a *surrogate system* that potentially provides epistemic access beyond itself, to the target system. By contrast, if the study of a model at most yields information about the model's properties, perhaps because there is no interest in anything beyond the model, or because the model lacks the capacity to resemble the target, the model only functions as a *substitute system*. While a surrogate system functions as a bridge to the target, a substitute system is a disconnected island with no links to the real world. (Mäki 2009a, 2009b)

Of course, we may want to be more relaxed about successful representation by bracketing target *R* and focusing just on *M-P-E* relations. For example, we may be able to say that an *M* serves a useful purpose in educating the audience of students of urban economics to operate with rent gradients. No doubt von Thünen's model provides a simple set-up that facilitates learning a craft – this is one reason why the model is included in standard contemporary textbooks. But such functions of a model do not rule out its capacity to

serve other functions, such as highlighting truths about the world, or inspiring the construction of further models that have this capacity.

4. Models and truth

Putting now our challenge explicitly in terms of truth, we ask: What would it be for a model to be true or to contain truths? What is the locus of truth in relation to models? Where should we look to find it? The account of models that I have suggested offers a few possible lines along which to think of how to ascribe truth to models. I think I have already revealed my preferences that direct the attention towards the notion of resemblance, but this is not the only possibility. There are other options that isolate and exploit the *pragmatic* components in the notion of model as representation: purpose and audience.

Indeed, we can *get truth into models* by adopting a suitable pragmatic concept of truth and then ascribing the respective pragmatic property to models. The account of models in the previous section makes two such pragmatic properties available: usefulness in regard to a purpose, and persuasiveness in regard to an audience. Respectively, concepts of truth can be put in these terms: *truth as usefulness* in serving a purpose, and *truth as persuasiveness* in shaping or conforming to the beliefs of an audience. A given model may thus be said to be true if it successfully serves a purpose such as helping attain a policy goal; or if it is found persuasive by an audience, enticing the audience to accept the model.[4] Note that both of these options – the usefulness notion of truth and the rhetorical notion of truth – are inclined towards treating models in an indiscriminate manner. Truth is ascribed to models as wholes, not to some limited parts of them.

This is not my strategy of getting truth into models, but I will not discuss these conceptions here (but see, for example, Mäki 2004b) other than pointing out a couple of intuitions that I am not prepared to sacrifice. An agent *A* can successfully use a false

[4] Philosophers are familiar with the tradition of usefulness accounts of truth, but perhaps less knowledgeable about persuasiveness accounts of truth, popular in the recent rhetoric of inquiry movement (see, e.g. McCloskey 1985; Gross 1990; for criticisms, see Mäki 1995).

model *M* to impress an audience *E*. And *A* can successfully use a false model *M* to serve some other purpose *P*. These intuitions suggest that truth is independent of usefulness and persuasiveness.

So when attempting to locate truth in relation to models, one should not have one's primary focus on the *M-P* and *M-E* relations. One should instead start first with isolating the *M-R* relation from the pragmatic components in representation. Once this focus is chosen, an account is needed that is able to pay respect for another intuition, namely that *A* can successfully use a model *M* that involves a lot of apparent falsehood to capture truths about target *R*. A key principle that guides my thinking is that *a model is a structure with component parts that may have different and varying functional roles, including the role of primary truth bearer*. These roles are partly determined by pragmatic components *P* and *E* (and identified by Commentary *C*). So at this second stage *P* and *E* are brought back to the stage: they make indispensable contributions to truth acquisition. But *P* and *E* do not constitute truth. They rather help isolate relevant truth bearers within models. Truth acquisition is a joint product of a pursuit that meets the pragmatic and ontological constraints of modelling simultaneously.

Let us see how we can spell out this rough idea in somewhat more detail. As I see it, there are two interrelated issues that we must resolve. One is the locus issue: where in models might the appropriate truth bearers be located? The other is the stuff issue: what is the appropriate ontology of truth bearers?

It is useful to start with Giere's account since the account I am pursuing can be viewed as a (more or less radical) modification of his. On Giere's account, models are non-linguistic "abstract objects" that are linguistically described or defined by assumptions. Since models are not linguistic, they are devoid of truth-value. Since model descriptions are linguistic, they are truth-valued, and because they "define" what they are about, they are trivially true. Models are connected to their targets, not by truth but by similarity. Model systems may be similar to their target systems in varying respects and degrees. Further statements are needed about these relationships. These are the theoretical hypotheses that

are truth-valued (linguistic) claims about (respects and degrees of) similarity between the model and the real system. (Giere 1988, 1999, 2006)

So on this account, models themselves are not true or false, nor do they contain truths, but true claims can be made *about* models. So much for the locus issue. The requirement that truth bearers be linguistic suggests a stance on the stuff issue. I will challenge the truth-scepticism in Giere's account by dealing with these two issues and showing how we might get truth inside models. I will remobilize von Thünen as my spokesman for the idea of truth-in-models (while I admit that some interpretation is needed since he does not explicitly invoke the vocabulary of truth).

So what are the relevant truth bearers and real-world truth makers in regard to von Thünen's model? One option would be to say that the assumptions of the model are its truth bearers. These are linguistic, so would satisfy Giere's requirement. But there is nothing in the real world that would make them true. As von Thünen agrees, the idealizing assumptions are false, and they are false in the sense that they do not correspond to real-world conditions. But they are indispensable strategic falsehoods:

"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)

Another option is to view the pattern of concentric rings as the truth bearer of the model. These are geometric images, thus not quite in Giere's approved category. And actual land-use patterns would seem to do a poor job as truth makers anyway. However, there is often an abstract resemblance in place: land-use is frequently patterned in some rough zone-like manner. But even this can be defeated if other causal factors are strong enough. In any case, in regard to further details on top of zone-likeness, the degree of resemblance varies from case to case, from fairly close to hardly recognizable.

In response to both of these candidates for truth bearer status – the assumptions and the geometric pattern - the obvious objection is that they do not constitute the model, they rather describe it. We would not get truth inside the model. And even if they were accepted as truth bearers, their truth maker would be the model itself, not anything in the real world. However, I see no reason not to be more flexible about this. We can as well consider the assumptions and the pattern also as possible truth bearers that are false (rather than truth-valueless) about that target. This manner of speaking does not rule out the primary role of the assumptions and the pattern to truly describe the model (and the primary truth bearers within the model regarding the target to lie elsewhere).

A third option finally gets the relevant truth bearer inside the model. I first focus on the locus issue and will take up the stuff issue in a moment. Now think of what sorts of thing inhabit von Thünen's model, the Isolated State. This imagined world is one with perfectly informed maximizing farmers competing for parcels of land and ending up with cultivating a flat and evenly fertile soil with no rivers or roads or external trade. If there is a natural truth bearer here, it is neither this model as a whole nor just any arbitrary parts of it. It is rather a special component of the model, namely the causal power or mechanism that drives this simple model world: the Thünen mechanism. This truth bearer has a fair chance of being made true by its truth maker, the respective prominent causal "force" or mechanism in the real system. It is the mechanism that contributes to the transformation of distance into land use patterns through transportation costs and land values. At any rate this appears to be von Thünen's own view:

"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)

As I read this comment, Thünen here combines two ideas. The model isolates the major cause of land use, the functioning of the *wirkende Kraft* of distance, from all its other

causes. And what the model isolates theoretically is also present in the real system even though here it is not isolated from other influences. In short, the *wirkende Kraft* in the imagined model world is the truth bearer and the respective *wirkende Kraft* in the real world is its truth maker. Whatever else the model contains, and whatever else modifies the manifestation of the *Kraft* in the real world do not participate in the truth making of the model. This is von Thünen's solution to the locus issue.

In dealing with the locus issue, the model Commentary plays a crucial role. The other components of the representation are unable to identify the relevant truth bearers, and in general to assign suitable functions to various model parts. A Commentary is needed to perform a higher-order isolation of the truth bearers amongst the ingredients of a model. Another way of putting this is to say that the Commentary helps determine the respects in which resemblance between the model and the target is to be sought. Illustrations have been provided already: the passages I have quoted from von Thünen, especially the last two, are important parts of his Commentary of his model.

As I said earlier, the task of the Commentary is to identify and coordinate the various components in a representation. The isolation of truth bearers in the model is dependent on specific cognitive goals (to establish the operation of the *Kraft* in contributing to land use patterns) and audience expectations (note that Thünen explicitly addresses his comments to the "reader"), and it is the task of the Commentary to help manage these dependencies in varying contexts.

The Commentary also helps turn mere resemblance (or similarity) into truth. This is needed because resemblance is symmetric, while truth is asymmetric. In order to say that the model is true or contains truth about the target, we must establish that there is resemblance between the relevant truth bearer in the model and its truth maker in the target, and that indeed truth-making runs in this direction.

Now suppose we have settled the locus issue. The next step is to ask whether we can envisage tolerable solutions to the stuff issue such that we can stick to the above solution of the locus issue. Is there suitable stuff available in that location?

In attempting to get truth in models, one line to be pursued would be a radical pluralism about the ontology of truth bearers: any kind of stuff goes, from sentence tokens to visual images, from propositions to utterances, from beliefs to physical objects, and so on.[5] This would allow things such as a concrete image of concentric rings or an abstract object of the Isolated State to serve as truth bearers. Whatever the ontology of models, truth-values can be ascribed.

Another line would be to take the more restrained view that – at least some, or ultimately all – truth bearers are thoughts. Recall that von Thünen's first passage begins with "Imagine …" suggesting that the Isolated State is an imagined system. Supposing that to imagine is to think, this is still ambiguous as to whether thoughts are the stuff of which the Isolated State is made, or whether the model is separable from the respective thoughts.

One possibility is to view thoughts as mental objects (such as *the thought of the Isolated State*). This could be taken to involve a language of thought with a mental logic, which would nowadays be viewed as an unattractive option. Alternatively, it could be taken to involve "cognitive equivalents of scale models" (Waskan 2006), which might be a more attractive idea. Closer to Giere's view of the stuff of models, we may take a model and the respective thought separable. Instead of thought as a mental object, we could focus on *what is thought* as an abstract object. Such an abstract object could have a thing-like structure (such as *the Isolated State containing the Kraft*), or it could have a fact-like structure (such as *that the Kraft – distance through the land-value plus transportation-cost mechanism – strongly contributes to land use distributions*). Such abstract objects could function as truth bearers, in contrast to Giere's view. A possible further line to take would be to offer a compromise to Giere by expressing the propositional contents of the last mentioned fact-like structure in sentential terms ('the *Kraft* strongly contributes to land use distributions') and taking this as a linguistic truth bearer whose truth makers lie

[5] Such as teddy bears! In Kirkham's catchy phrase, "truth is not too big a burden for a bare bear to bear" (Kirkham 1995, 61).

in the real world target. Its propositional contents would be equivalent with the respective abstract object in the model. We do not need to choose between these different options in order to suggest that the stuff issue might be resolvable in such a way that we can have truth bearers inside models.

Insofar as von Thünen's model contains a truth about the *Kraft*, we may be tempted to call it a partial truth. This would seem right for two reasons. First, the *Kraft* is only one among many causal factors actually shaping land use. A truth about the *Kraft* is a partial truth of the whole causal structure. Second, only one part of the model - and not other parts – is identified by the Commentary as the relevant truth bearer that reflects the relevant respects in which the model is supposed to be connected to its target. But on the other hand, once the part has been isolated, what we have may be the whole truth about that part – such as the *Kraft* - at a certain level of abstraction. This weakens the second reason.

In any event, whether partial or whole, it is not as such approximate truth. If we take partial truth to reflect the respects of resemblance or similarity between the model and its target, approximate truth can be viewed as reflecting degrees of resemblance, once the relevant respects have been fixed. In other words, Giere's distinction between respects and degrees can be utilized to enrich our talk about truth in relation to models: models have the capacity of containing partial truths and approximate truths. But these are truths in models, not truths about models – and they are species of truth, not just of similarity.

The final issue remains whether we might now be entitled to talk about truth *of* models or more modestly just about truth *in* models. The latter is clearly less problematic. We have located a component in the Isolated State, the Thünen mechanism, and it is right here that we may have a truth *in* Thünen's model. Now there is a way of seeing things that would permit us to infer that we may also have truth *of* Thünen's model. Having the above truth *in* Thünen's model means having the truth *of* its component. If component m_n - the Thünen mechanism - has been isolated (under the guidance of the pragmatics of this representation) as *the only* relevant truth bearer in model *M*, then this means that the truth

of m_n is both truth *in M* and truth *of M*. So we may say *M* is true simply because none of its other parts are supposed to be relevant candidates for truth. These other parts are not idle parts: in many cases they (if interpreted as truth valued) must be false in order to serve the higher goal of getting the privileged component true. Given the pragmatic constraints, there are no other veristic aspirations but to ensure the truth of that privileged component part. So saying that m_n is true and saying that *M* is true amount to the same thing. I am not claiming that one is compelled to talk in this way about truth in models and truth of models, just that one might not be compelled not to.

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