
A Model Discipline: Political Science and the Logic of Representations
Kevin A. Clarke and David M. Primo

Print publication date: 2012
Print ISBN-13: 9780195382198
Published to Oxford Scholarship Online: May 2012
DOI: 10.1093/acprof:oso/9780195382198.001.0001

# What Is a Model?

Kevin A. Clarke
David M. Primo

DOI:10.1093/acprof:oso/9780195382198.003.0003

## Abstract and Keywords

Most political scientists would be hard-pressed to provide a definition of the term model that encompasses the many uses to which models can be put. Discussions of models in political science primarily focus on the construction and composition of models, as opposed to what models do or what models are. We are told that models “abstract from reality” and “simplify reality” and that models should “generate interesting hypotheses.” We are told that models contain assumptions and predictions. Without an understanding of what a model is, however, we cannot understand why or how models perform these functions, or why models are constructed in a particular way. In this chapter, we answer the question, “what is a model?” Our answer is that models should be viewed as tools or instruments, in particular, like maps. Both models and maps display limited accuracy, partially represent reality, and most importantly, reflect the interest of the user. That is, models and maps are “purpose relative.”

*Keywords:* maps, models, semantic view, model-based view, theories

“What do you consider the *largest* map that would be really useful?”

“About six inches to the mile.”

“Only *six inches!*” exclaimed Mein Herr. “We very soon got to six *yards* to the mile. Then we tried a *hundred* yards to the mile. And then came the grandest idea of all! We actually made a map of the country, on the scale of *a mile to the mile!*”

"Have you used it much?" I enquired.

"It has never been spread out, yet," said Mein Herr: "the farmers objected: they said it would cover the whole country, and shut out the sunlight! So we now use the country itself, as its own map, and I assure you it does nearly as well."

—Author LEWIS CARROLL

## 3.1 INTRODUCTION

Our claim in this book is that models are—and should be—the central feature of scientific reasoning in political science. Despite the ubiquity of models in political science, we understand little about their nature or how they operate. What a political scientist means when she uses the word *model* is rarely clear. She might, for example, be referring to the game that informs the theoretical side of her work. Or she might be referring to the regression equation in the empirical portion of her work. She might even be referring to the computational simulation she ran to investigate the assumptions she made in her game. She need **(p.53)** not even be a quantitative researcher. After all, there exist constructivist models of international relations (Wendt 1992) and qualitative models of judicial decision making (Pogrebin 2003).

Despite all these uses of the term, most political scientists would be hard-pressed to provide a definition of model that encompasses these myriad uses. Discussions of models in political science primarily focus on their construction and composition, as opposed to what models are. We are told, in works too numerous to list, that models "abstract from reality," "simplify reality," and should "generate interesting hypotheses." We are told that models contain assumptions and predictions. Without an understanding of what a model is, however, we cannot understand why or how models perform these functions, or why they are constructed in a particular way.

In this chapter, we answer the question, "what is a model?" Our answer is that models should be viewed as tools or instruments, in particular, like maps.[1] Both models and maps display limited accuracy, partially represent reality, and most importantly, reflect the interest of the user. That is, models and maps are "purpose relative" (Morton 1993).

This analogy between models and maps should be familiar to social scientists. The authors of one well-known economics textbook explicitly use maps in a discussion of abstraction (Baumol and Blinder 2009). Even more to the point, the authors of a recent book on computational modeling write, "One of the best models that we encounter in our daily experience is the road map" (Miller and Page 2007, 36). Our approach should be considered an offshoot of the Semantic Conception of models, which was briefly introduced to the field by Henry Brady (2004b) in an introduction to a symposium on the science of politics. We begin with an extended discussion of maps, which draws on the work of Ronald Giere (1990, 1999).

## 3.2 MODELS AS MAPS

Consider the map of the Boston subway system in figure 3.1. If a tourist were to ask, “Is this map true?” a Bostonian might reasonably **(p.54)** respond, “True in what sense?” The tourist might then ask, “Well, is it accurate?” Again, the Bostonian might reasonably respond, “Accurate in what sense?” The exasperated tourist might finally ask “Is the map spatially correct?” and the answer to this question is “no.” Any map that precisely reflected the facts on the ground would be as large as the area of interest and therefore useless. Any smaller map translates a three-dimensional object into a two-dimensional object. All maps are, therefore, inaccurate to some degree. Most people who inquire into the accuracy of a map, however, are not asking whether the map is spatially correct. Rather, what they really want to know is whether the map is **(p.55)** similar enough to the facts on the ground to be used for the purpose of navigation. We still cannot answer this question in a general way, though. Whether the subway map is useful for navigation depends on the mode of transportation. The subway map is similar enough to the world to be used for the purpose of navigating the subway, but it is not similar enough to be used for other purposes, such as driving. As we will argue, the subway map is not rendered useless just because someone using it might make inaccurate predictions regarding the spatial layout of the Boston area.

As anyone who knows the Boston area will tell you, the subway map accurately reflects neither the spatial layout of the greater Boston area nor the spatial layout of the Boston subway system. Consider, for instance, the eastern side of the Red Line, which runs from South Station near the heart of the city to Braintree and Mattapan in the southeast. Looking at the map, you might assume that Mattapan is south of Braintree. In fact, Braintree is considerably farther south than Mattapan. By the same token, the eastern side of the Blue Line, which runs from Aquarium to Wonderland, is not actually straight but curves north at Suffolk Downs. Thus, the subway map does not accurately reflect

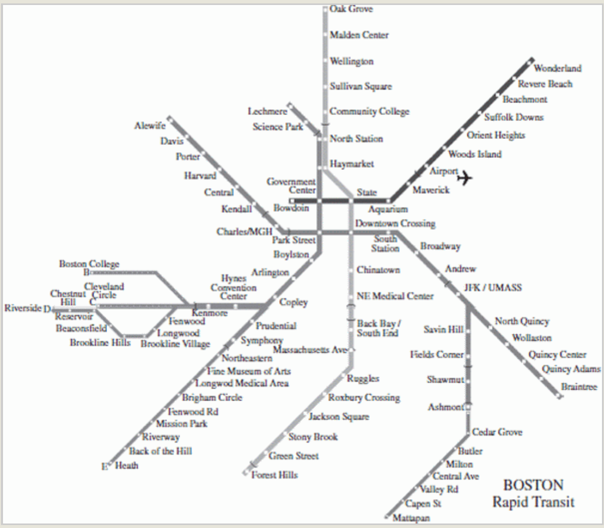


*Figure 3.1* Boston Subway Map, Prior to the Addition of the Silver Line. *The map is schematically similar to the Boston subway system. Subway riders find it useful, while pedestrians and drivers find it of little use. Map © 2005 Robert*

either Boston or the subway system in any spatially accurate sense; some predictions based on it will be wrong.

*Schwandl (urbanrail.net) and reproduced with permission.*

The point here is not that visitors to Boston find themselves saddled with an inaccurate map of the area. The possibility of incorrect predictions does not make the map useless. Quite to the contrary, both commuters and tourists find the subway map uncommonly helpful. The problem lies not with the map but with the question. Asking whether the map is accurate (or true) is the wrong question. Instead, we should be asking whether the map is *useful*. Although not spatially accurate, the Boston subway map is very useful for navigating Boston's century-old subway system.

We do not argue, of course, that a map—or a model—can be completely divorced from reality and still be judged useful. The question then arises how similar does the map—or model—have to be to the real world to be useful. The answer is that it has to be similar enough to be useful for a particular purpose. The subway map has to **(p.56)** be similar enough to the real-world subway system to make it useful for commuters and tourists. At this point, the reader may object to the similarity criterion. Two objects, after all, can be similar to one another in any number of ways. Doughnuts and coffee mugs are similar in the sense that they both have one hole. The similarity claim, however, need not be vague if the respects in which the two objects are similar and the degree to which they are similar are specified (Giere 1999, 4).

In what sense, then, is the Boston subway map similar to the Boston subway system? It is schematically similar. We can see the arrangement of stations on the Blue Line (Bowdoin to Wonderland), and we can see where the Blue Line intersects with the Orange Line (State) and the Green Line (Government Center). This kind of similarity makes the Boston subway map, despite its inaccuracies, useful for tourists who wish to navigate the city by subway. That is its purpose.

For other purposes, the Boston subway map is not similar enough to a particular real-world system to be useful. For instance, although a number of the stations are named for towns or cities, the spatial relationships between these stations and the towns or cities they represent are quite dissimilar. If one were interested in driving from town to town, for example, the subway map would prove completely useless. The spatial relationships between the towns on the map are not similar enough to the real world to be used for driving.

The road map in figure 3.2, however, is similar enough to the metro Boston road system to be used for driving. If you wanted to drive from the north shore of Boston, say, Revere, to the south shore, say, Quincy, this is the map you would want. Again, this map is inaccurate in an almost infinite number of ways, as a comparison between this map and a U.S. Geological Survey topographical map of the region would reveal. Many of the predictions based on this map would be wrong. The map is nonetheless useful for driving between towns. (It might be even more useful if it included exit markers.) On the other hand, the map is almost completely useless for navigating around Boston itself.

The most detailed map of Boston included here is the walking map in figure 3.3. Although this map is also inaccurate in its way (hundreds of small streets are missing, for example), it is useful if one intends **(p.57)** **(p.58)** **(p.59)** to walk the Freedom Trail (the numbered path in bold) from Boston Common to the Bunker Hill Monument. The map is of little use for driving around Boston, as many of the streets depicted in it are oneway. It is also of little use in navigating the subway system (none of the subway stops are marked). The usefulness of the map derives from its similarity to the street system of downtown Boston and the purpose for which it is designed: walking.

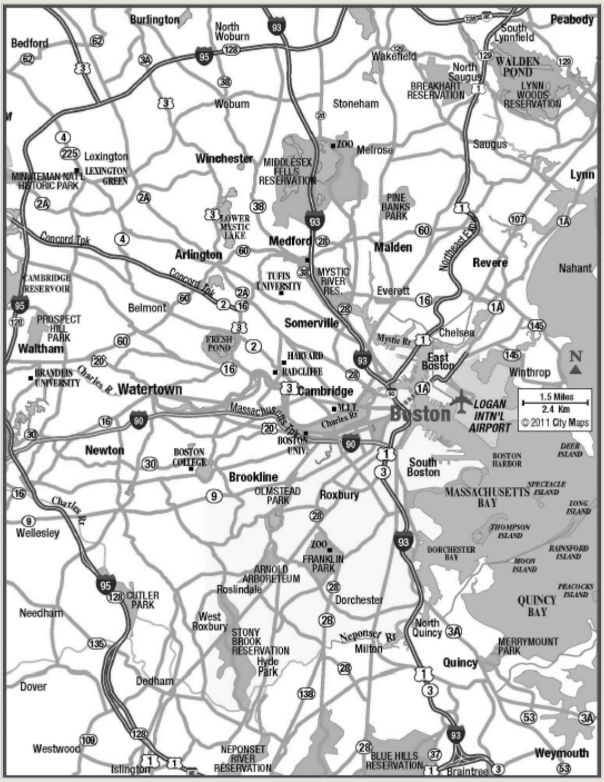


*Figure 3.2* Boston Highway Map. *This map is useful for driving from town to town outside of Boston, but is of little use for driving in Boston or walking in Boston. Map © 2011 City Maps Inc. and reproduced with permission.*

All three of these maps—the subway map, the driving map, and the walking map—have at least one area in common (downtown Boston). Each has a particular purpose, and each is useful for that purpose and pretty much that purpose alone. The subway map would quickly get you lost if you were driving and vice versa. The design element that makes these maps useful for a particular purpose is their partial nature. The maps contain little extraneous material that would add to the clutter but not to the usefulness. The walking map does not include subway stops, and the driving map does not include the sites of historical interest in downtown Boston. Although we could imagine (and have probably seen) dual-use maps, it is not necessarily true that such maps are more useful. A map that serves two purposes while maintaining a high degree of simplicity would be welcome, but generally there exists a trade-off between the number of purposes to which a map can be put and its simplicity. Usefulness is often a function of simplicity.

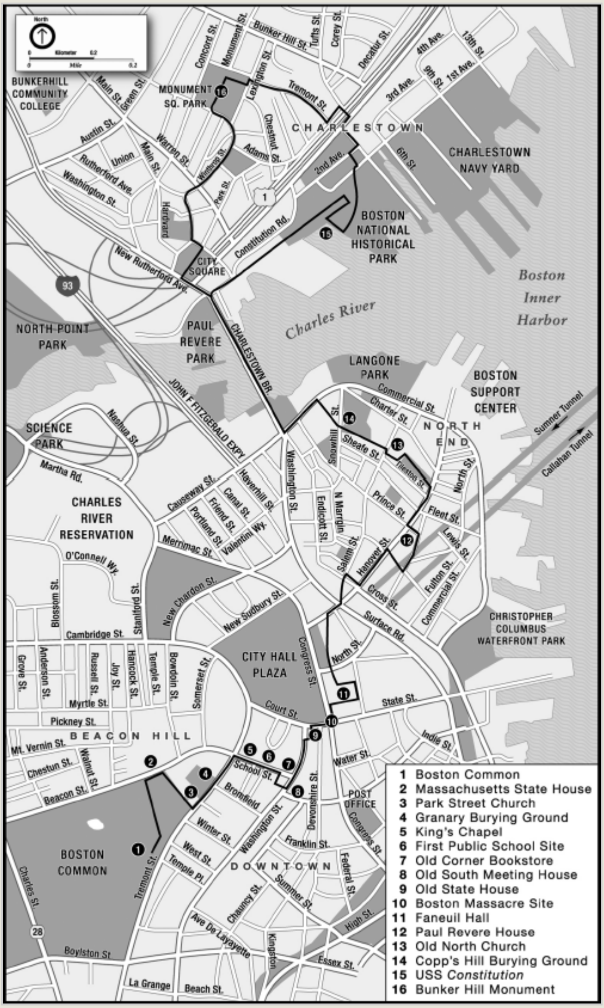


*Figure 3.3* Boston Walking Map. *This map is useful for walking around downtown Boston, but is less useful for driving around downtown as none of Boston's many one-way streets are labeled. Map by Chris Erichsen.*

Our discussion of maps has raised a number of points that we should keep in mind when we talk about models.

- *Maps are objects and thus neither true nor false*. A map is an object. More specifically, it is an object that represents another object, a system in the real world. Like other kinds of objects (airplanes, coffee mugs, gas grills), maps are neither true nor false. They exist, and the question to ask of them, which is the same question we might ask of a coffee mug, is whether they are useful. Certain maps are useful in certain contexts and not in others.
- *Maps have limited accuracy*. As noted, each of our three maps has a large number of inaccuracies. In fact, when compared **(p.60)** to the real

world, each map sports an infinite number of inaccuracies. The spatial relationships between features on the maps, for example, do not accurately reflect the spatial relationships that exist on the ground regardless of the purpose of the maps. In no case, however, do the inaccuracies impact the usefulness of the maps for the purpose for which they were designed. Accuracy and usefulness are simply two different concepts.

• *Maps are partial*. Maps represent some features of the world and not others. Which features are represented depends on the use to which the map is to be put. Walking maps do not include highway on-ramps and off-ramps, and highway maps do not include side streets. As previously argued, usefulness is a function of simplicity. When simplifying, however, attention must be paid to the purpose of the map. Some features are crucial. Eliminating side streets from a highway map makes understanding the map easier without damaging its usefulness. Leaving exit markers off of the map does not have the same result. Less simple or not, a highway map with exit markers is more useful than one without exit markers.

The major point made by our three examples is that

• *Maps are purpose-relative.* A map is designed to be similar enough to a system in the real world to be used for a specific purpose. That is, a map reflects the interests of those who designed it and those who use it. Whether a map is useful is a meaningless question unless one understands the purpose for which the map is to be used.

## 3.3 A FEW EXAMPLES FROM POLITICAL SCIENCE

The argument we are making is that we should view models in the same way that we view maps. That is, models should be viewed as objects and thus as neither true nor false. Models have limited accuracy and represent only certain features of a real-world system. **(p.61)** Most importantly, we argue that models are purpose-relative and that model assessment cannot take place without understanding the purpose for which the model was designed and used. The fact that a model makes incorrect predictions does not mean that it is useless. Asking whether a model is true or false is the wrong question; we need to ask whether a model is useful for the purpose for which it was intended.

To help fix these ideas, let’s consider three important models of legislative policymaking: Keith Krehbiel’s (1998) pivotal politics model, David Baron and John Ferejohn’s (1989) divide-the-dollar model, and James Snyder and Tim Groseclose’s (1996) vote-buying model. Like the three Boston maps, each of these models covers essentially the same territory: legislative policymaking. Also in keeping with the Boston maps, we argue that asking whether these models are true or false is the wrong question. We need to ask whether these models are useful for their particular purpose. Like the maps, these models have limited accuracy; none is a faithful representation of the legislative policymaking process, and yet these inaccuracies do not render the models less useful. These models are also partial as they exclude (or trivially include) key features of the legislative process, such as committees, bicameralism, and political parties. Nevertheless, these models are seen as important contributions to the legislative politics literature.

In Krehbiel's (1998) pivotal politics model, bargaining takes place over a proposal made by the median voter of the Senate. The proposal concerns a single policy (bargaining is therefore one-dimensional) and can be blocked by a filibuster, presidential veto, or both. Krehbiel (1998, 19) argues that his model fills a "basic need" by offering more reasonable results about the conditions under which policy gridlock is observed than the extant literature, which predicts either all gridlock or no gridlock. The model, however, is of very little use in understanding questions of distributive politics (the allocation of benefits to specific groups) or the role of interest groups in influencing policy outcomes.

Baron and Ferejohn's (1989) divide-the-dollar model features bargaining in which a proposer, chosen randomly from among all **(p.62)** legislators, makes a proposal to divide a fixed amount of public expenditures. In its simplest form, if the offer is rejected, a new proposer is chosen, and this process continues until an agreement is reached. The model offers insights into the role of the agenda setter and amendment rules. Just as the Krehbiel model is of little help in understanding distributive politics, the Baron and Ferejohn model focuses on a very specific type of policy battle and has little to say about gridlock.

Groseclose and Snyder's (1996) vote-buying model is one where a "vote buyer" (e.g., a party leader, interest group, the president) uses resources to target members of a legislature. The vote buyer's goal is to build a winning coalition in support of a piece of legislation. Once this vote buyer has made offers to legislators, a second buyer, who is on the opposite side of the issue, can make counteroffers. The model demonstrates that coalitions larger than the minimum needed to pass the bill are the norm in this setting. Unlike Baron and Ferejohn, Groseclose and Snyder take the proposal as given and therefore do not address the role of the agenda setter. Unlike Krehbiel, Groseclose and Snyder do not address the role of the filibuster and the presidential veto.

The analogy we draw between maps and models is quite sound. Like maps, models are neither true nor false, they have limited accuracy, they are partial, and most importantly, they are purpose-relative. A researcher interested in understanding the role played by the filibuster in policy debates will find both the Baron and Ferejohn and Groseclose and Snyder models to be of little use. Those interested in understanding distributive politics, on the other hand, will have little use for either Krehbiel's model or Groseclose and Snyder's vote-buying model. The important question to ask of a model is whether it is useful for a particular purpose.

## 3.4 THE RECEIVED VIEW OF SCIENTIFIC THEORIES

What we are arguing may seem uncontroversial; after all, most any scholar will tell you that his or her model is false in some respect. In our view, however, stating that a model is false is a mischaracterization akin **(p.63)** to stating that a model is true. A model is an object, nothing more and nothing less. Philosophers of science have developed an approach to thinking about models that makes this point. The approach is known as the predicate or semantic conception of theories, and it is most closely associated with the work of Patrick Suppes (1967), Frederick Suppe (1977; 1989), Bas van Fraassen (1980), and Ronald Giere (1990).[2]

The important advance made by the semantic philosophers was to see models as objects and not as linguistic entities. To understand what a radical departure this was, we need some understanding of how an earlier, very influential group of philosophers of science viewed the role of theories in scientific reasoning. Briefly introduced in the previous chapter, these philosophers, known as logical positivists, saw theories as the central feature of scientific reasoning.[3] Theories, in their view, comprise a logical calculus and a set of "correspondence rules." Suppes (1967, 56) provides a succinct sketch of the account:

A scientific theory consists of two parts. One part is an abstract logical calculus. In addition to the vocabulary of logic, this calculus includes the primitive symbols of the theory, and the logical structure of the theory is fixed by stating the axioms or postulates of the theory in terms of its primitive symbols. For many theories the primitive symbols will be thought of as theoretical terms like "electron" or "particle" that are not possible to relate in any simple way to observable phenomena.

The second part of the theory is a set of rules that assign an empirical content to the logical calculus by providing what are usually called "co-ordinating definitions" or "empirical interpretations" for at least some of the primitive and defined symbols of the calculus.

Put another way, a scientific theory is "a set of uninterpreted sentences fabricated out of 'meaningless' symbols" (Schaffner 1969, 280). The correspondence rules provide an interpretation for the "meaningless" symbols. That is, they connect the nonlogical terms of the theory with empirical entities (Sloep and van der Steen 1987).[4]

**(p.64)** More formally, the Received View holds that scientific theories comprise the following elements (Suppe 1989, 39–40). The main components are a first-order language $L$ and a calculus $K$. The nonlogical constants of $L$ are $V_0$, which contains the observation terms, and $V_T$, which contains the theoretical terms. $L$

and $K$ are divided into two subgroups corresponding to the observation language ($L_0$, which contains only $V_0$, and $K_0$) and the theoretical language ($L_T$, which contains only $V_T$, and $K_T$). A partial interpretation of the theoretical terms and of the sentences of $L$ containing them is given by the theoretical postulates $T$, the axioms of the theory, and the correspondence rules $C$. The latter must be logically compatible with $T$ and contain no extralogical terms not in $V_0$ or $V_T$. A scientific theory is denoted by $TC$, where $T$ is the conjunction of the theoretical postulates, and $C$ is the conjunction of the correspondence rules.[5]

Scientific theories, then, according to the logical positivists, are "partially interpreted axiomatic systems $TC$ where the axioms $T$ were the theoretical laws expressed in a theoretical vocabulary $V_T$; $C$ were correspondence rules that connected $T$ with testable consequences formulated using a separate observational vocabulary $V_0$" (Suppe 2000, S103). Under this view, a model is an interpretation of the theory such that the axioms of the theory are satisfied.

To make these ideas more concrete, consider Riker and Ordeshook's (1968) seminal paper "A Theory of the Calculus of Voting." Riker and Ordeshook are quite explicit about the deductive nature of their theory, as shown by the title of their article. Let $R$ be the reward that an individual voter receives from her act of voting; $B$ be the differential benefit that an individual voter receives from the success of her more preferred candidate over her less preferred one; $C$ be the cost to the individual of the act of voting; $P$ be the probability that the citizen will, by voting, bring about the benefit, $B$; and $D$ be the satisfaction an individual feels when she has voted. Riker and Ordeshook state that these variables are related in the following lawlike fashion:

**(p.65)** If $R\rangle0$, then it is rational to vote, and if $R\leq0$, then it is not rational to vote. From this "law," the authors conclude that for those who do not vote, it must be that the cost of voting is greater than the instrumental value of voting, $PB$, plus the expressive value of voting $D$:

They also conclude that it always must be true that for those who vote, the instrumental value of voting must be greater than the difference between the cost of voting and the expressive value of voting:

These mathematical expressions are part of the calculus of which logical positivists talk. The symbols $R$, $B$, $C$, $P$, and $D$ are part of the nonlogical vocabulary. These terms must be interpreted for the calculus to have empirical content. When interpreted, these symbols stand for the various benefits and costs of voting.

These mathematical expressions are part of the calculus of which logical positivists talk. The symbols $R$, $B$, $C$, $P$, and $D$ are part of the nonlogical vocabulary. These terms must be interpreted for the calculus to have empirical

content. When interpreted, these symbols stand for the various benefits and costs of voting.

Correspondence rules assign empirical content to the calculus by connecting it with the world of observation. Riker and Ordeshook (1968) operationalize $P$, the probability that the citizen will, in essence, affect the election outcome, with pre-election interview responses about how close the respondent believes the outcome of the presidential election would be.[6] $B$, the differential benefit from the success of the more preferred candidate, is measured by the pre-election responses as to how much the respondent "cares" about the outcome of the election. $D$, the satisfaction a voter feels from voting, is constructed out of four pre-election interview questions regarding the duty to vote. The cost of voting, $C$, is constructed out of $D$.[7]

The approach to thinking about theories just outlined is known as the Received View of scientific theories, and it is no surprise that the early formal modelers in political science found it attractive. The Received View, with its origins in classical mechanics, seemed a natural fit for scholars looking to put their young discipline on an equal footing with the "hard" sciences. When describing "formal, positive, political **(p.66)** theory" in an application to the Center for Advanced Study in the Behavioral Sciences, Riker wrote, "By Formal, I mean the expression of the theory in algebraic rather than verbal symbols" (Bueno de Mesquita and Shepsle 2001, 8).

Soon after the publication of Riker and Ordeshook (1968), philosophers abandoned the Received View as a description of scientific theories.[8] The Received View was attacked on a host of grounds, two of which we mention here.[9] First, it was argued that not all theories can be meaningfully, or usefully, axiomatized. Suppe (1977, 64), for example, persuasively argues that "fruitful axiomatization of a theory is possible only if the theory to be axiomatized embodies a well-developed body of knowledge for which the systematic interconnections of its concepts are understood to a high degree." Many of the theories in the social sciences are just one set of examples given by Suppe where the state of theory development does not admit axiomatization. The precision involved in axiomatizing an informal theory would constitute an entirely new theory. Second, the idea of correspondence rules proved difficult (Sloep and van der Steen 1987, 3). Correspondence rules were thought to (a) define theoretical terms and (b) specify experimental procedures for applying theories to phenomena. In some cases, however, correspondence rules cannot capture the full meanings of theoretical terms, and more than one procedure for attributing meaning to theoretical terms could be found (Morrison and Morgan 1999a, 2). Additional problems included the reliance of correspondence rules on auxiliary theories (see our discussion of the Quine-Duhem problem in the previous chapter), and the implication that a change in the correspondence rules of a theory constitutes a new theory.

The Received View was also known as the Syntactic Conception because *syntax* refers to the relationship **(p.67)** among symbols, and when the symbols are words, syntax refers to grammar. Thus, the Received View with its emphasis on the deductive structure of theories (the grammar, if you will) was, in essence, syntactic. The account that has developed in response to the Syntactic Conception is known as the Semantic Conception. Whereas *syntax* refers to the relationship among symbols, *semantics* refers to the relationship between symbols and the things for which the symbols stand (Salmon et al. 1992). The Semantic Conception, therefore, is concerned with the relationship between models and the actual world the models represent. The most important feature of the semantic account is that models, not theories, are central to the scientific enterprise.

## 3.5 THE SEMANTIC CONCEPTION OF SCIENTIFIC THEORIES

Although the Semantic Conception exists in a number of different versions, all agree on two points: one, models are neither true nor false; and two, models play the central role in science. Support for the Semantic Conception among philosophers of science is strong. Suppe (2000, S105) notes that "the Semantic Conception has been very successful. It is widely accepted with remarkably little published criticism of it—none fundamental or fatal." So widespread has been the support for the Semantic Conception that many consider it to be a "new received view" (Contessa 2011, 3).

The starting point of the Semantic Conception is Tarski's (1953, 11) definition of a model: "A possible realization in which all valid sentences of a theory *T* are satisfied is called a model of *T*." Thus, if a theory *T* contains axioms *A*.1–*A*.3, any structure in which those axioms are true is a model of *T*. Note that many different models can be consistent with *T*.[10] So a model under the semantic view could be a set-theoretical entity or a state space. This definition is a logician's sense of a model and comes from mathematical model theory, but Suppes (1961) argues that the concept of a model is the same in mathematics and the empirical sciences. His examples from the social sciences include quotes from Kenneth Arrow and Herbert Simon.

The semantic view comes basically in two flavors: one associated with Suppes (1961), and one associated with van Fraassen (1980). For Suppes, a model is a "set-theoretical entity which is a certain kind of ordered tuple consisting of a set of objects and relations and operations on these objects" (6). As an example, he presents a model of classical **(p.68)** particle mechanics as an ordered tuple, $P = \langle P, T, s, m, f \rangle$, where *P* is a set of particles, *T* is an interval of real numbers corresponding to elapsed times, *s* is a position function defined on the Cartesian product of the set of particles in the time interval, *m* is a mass function, and *f* is a force function defined on the Cartesian product of the set of particles, the time interval, and the set of positive integers. The connection between this very abstract notion of a model and the phenomena being modeled is one of isomorphism. That is, the mathematical structure is isomorphic to a particular empirical system.

Van Fraassen (1980, 64) version of the semantic view also argues that to "present a theory is to specify a family of structures, its *models*; and secondly, to specify certain parts of those models (the *empirical substructures*) as candidates for the direct representation of observable phenomena." A model, according to van Fraassen, comprises three related elements: the possible states of the system using mathematical entities to represent these states in a state space, a set of elementary sentences that identify measurable physical magnitudes describing the physical system, and a satisfaction function that connects the state space with the elementary sentences (Minogue 1984, 115–16). Thus, "If *X* is a system of the kind defined by the theory, and there is a function '*loc*' that assigns a location in the state space *T* to *X*, then a model for the theory is the couple *⟨loc, X⟩*; that is, a model for the theory involves the assignment of the location in the state space of the theory to a system of the kind defined by the theory" (Thompson 1989, 80).[11] As in Suppes's version, the relation between the model and the physical system is one of isomorphism.

The previous two paragraphs are arguably the most confusing and technical in this book, and both accounts seem to have little to do with how scientists actually use models. As a corrective, we turn to what we call the model-based view, which, although based on the semantic view, is far less abstract and is similar to the ways some prominent economists view models (see Hausman 1992 and Mäki 2009). We focus on work by Ronald Giere, who presents an admirably clear version of the model-based view. Giere, like Suppes and van Fraassen, insists that models are neither true nor false and contends **(p.69)** that theories are collections of models. He differs from Suppes and van Fraassen in replacing isomorphism with similarity relations and rejecting an axiomatic approach to theory (Morrison and Morgan 1999a).

## 3.6 THE MODEL-BASED VIEW OF SCIENTIFIC THEORIES

A *model*, according to Giere (1990), is a system characterized by a definition, and by a definition, he means a stipulation. That is, a model stipulates how certain terms are to be used. Just as a definition is constructed—Nelson Goodman constructed the definition of his term *grue* (see Chapter 2)—a stipulation is an agreement on the meaning of important terms. A model, therefore, is constructed or defined by a researcher. When a model includes equations, one might be tempted to ask if the model is true, but that question is not the right one to ask. The model is defined as a system that exactly satisfies the equations (Giere 1990, 78–79). Giere's example is the simple harmonic oscillator, which is a system that satisfies the law

The law states that a restoring force, $F$, is proportional ($k$ is a positive constant) to the displacement, $x$.

The simple harmonic oscillator is neither true nor false; it is a system that satisfies the equation. For a more complex example, consider the following model: "A Newtonian Particle System is a system that satisfies the three laws of motion and the law of universal gravitation" (Giere 1984, 81). That is, the model *asserts* that a system is a Newtonian Particle System if the system satisfies the three laws of motion and the law of universal gravitation. The stipulation can be more complicated and more specific:

We can define a Newtonian theoretical model that may be used to represent the Earth/Moon system. This model would consist of two masses, one having about 1/80 the mass of the other **(p.70)** and located approximately 240 thousand miles away. Depending on the exact masses, distances, and velocities that we specify, the laws defining the Newtonian Particle System would tell us the exact behavior of such a system. There is no need to cite evidence to justify claims about the behavior of the model and its component particles.

(Giere 1984, 81)

For an example oriented toward political science, we consider a model of distributive politics, a phrase that refers to the allocation of government projects or programs that benefit specific groups or legislative districts. Scholars doing research in distributive politics generally concern themselves with explaining either the outcomes of bargaining or the roles various institutions play in producing the outcomes of the bargaining process. Those in the first group ask which groups or legislative districts receive projects and why, ask whether the projects are efficient, and inquire into the level of total spending, given a minimal legislative structure. Those in the second group ask what is the role of bicameralism, what is the role of an executive with veto power, and what is the role of political parties. The Baron and Ferejohn (1989) paper discussed earlier is a classic of the distributive politics literature. Here, though, we discuss the work of Ansolabehere, Snyder, and Ting (2003), who build on the Baron and Ferejohn model by including a bicameral legislature. At the same time, these authors circumscribe the previous model by assuming that no amendments to a proposal are allowed (that is, a closed rule) and that legislators are perfectly patient (that is, no discounting occurs).

The model takes the form of a definition or stipulation. There is a lower chamber (a House) where members represent districts with equal population within a state. There is an upper chamber (a Senate) where members represent entire states. Each district has one representative, and each state has one senator.

Public expenditures can be divided down to the district level, legislators are responsive to their median voters, and both chambers vote by majority rule. The actual bargaining takes the following form: a member of the House is **(p.71)** selected at random to propose a division of the public expenditures. If a majority of each chamber votes in favor of the proposal, it passes, and the game ends. If the proposal fails, a new proposer is chosen at random to make a proposal. The game continues until a proposal is successful.

Note that this model is based on a stipulation, and there is no way to falsify it—it is a definition.[12] As in Giere's example, there is no need for evidence to justify the claims of the model. The outcome is determined by the original definition and whatever values we specify for the unknown parameters. The question we should ask of this model is not whether it is "true," but rather, is it similar in certain respects, and for certain uses, to a system in the real world.

The relationship between a model and a real-world system is asserted by the *theoretical hypothesis*. Where a model defines a certain class of systems, a theoretical hypothesis asserts that certain (sorts of) real systems are among members of that class (van Fraassen 1989). Such a hypothesis takes the following form: "A model *M* is similar to system *S* in certain respects and degrees" (Morrison and Morgan 1999a, 4). In other words, a theoretical hypothesis asserts that an object, a system known as a model, is similar, in some respect and for some purpose, to another object, a real-world system. Objections are often raised because similarity is a notoriously tricky concept. As noted earlier in the chapter, any object is similar to any other object in some respects and to some degree, and as previously argued, a similarity claim is not vacuous provided the respects and degree to which two objects are similar is specified explicitly. Giere (1990, 81) provides the following example: "The positions and velocities of the earth and moon in the earth-moon system are very close to those of a two-particle Newtonian model with an inverse square central force."

As Giere points out, "position" and "velocity" are the respects in which the Newtonian model and the earth-moon system are similar. The degree to which these two systems, one abstract and one real, are similar is "very close." Although the theoretical hypothesis is a linguistic entity, and thus true or false, its testability is not particularly important. The hypothesis claims only that "an indicated type and degree of similarity exists between a model and a real system. We can **(p.72)** therefore forget about truth and focus on the details of the similarity" (Giere 1990, 81).

To return to the Ansolabehere, Snyder, and Ting example, a theoretical hypothesis asserts some degree of similarity between the model and the distribution of public expenditures by the U.S. Congress. The authors are quite explicit about the respects in which and the degree to which their model is similar to bargaining in Congress. Bicameralism is clearly an important point of similarity. The authors argue that the application of previous research featuring a single chamber is significantly limited. “Strictly speaking, none of these models apply, for example, to the U.S. Congress or to 49 of the American states” (Ansolabehere, Snyder, and Ting 2003, 472). They also point out that just as in the U.S. Congress, geographic areas of representation are nested in their model (473). In addition, they note that simple majority rule in their model “approximates the behavior of legislators in practice” (473).

At the same time, the authors are quite explicit about the ways their model is not similar to bargaining in the U.S. Congress. They point out that the closed rule is a special case, and they argue that they can safely ignore modeling the resolution of differences between the chambers because it “adds a layer of complication that is not needed to gain important insights” (473). They choose to model the upper chamber as having only one member from each state. Moreover, by considering only bills that are entirely distributive in nature, they capture only a small part of actual legislation. The point of the theoretical hypothesis is not to claim that models that fail to include bicameralism are “false,” or that modeling open amendment rules is unimportant. Rather, the theoretical hypothesis states the extent to which the model is similar to a particular real-world system and for what purpose. Ansolabehere, Snyder, and Ting are interested in the effects of bicameralism on bargaining, and for that purpose, bicameralism is of course important, and open amendment rules are not. The theoretical hypothesis is neither vague nor vacuous.

The results they obtain by making these choices provide significant insight into the distribution of public expenditures under **(p.73)** bicameralism. Conventional wisdom holds that small states are advantaged in distributive bargaining because they have equal representation in the Senate—a senator from Rhode Island has the same voting power as a senator from California—and therefore can obtain greater resources for their state than their size would suggest. Contrary to this wisdom, the authors show that in their primary model, small states have no advantage in bargaining, despite their disproportionate influence in the upper chamber.[13] In building the cheapest coalition possible in the House, the proposer simultaneously constructs a winning coalition in the Senate (because the benefits going to districts benefit the states in which those districts are located). So, no projects need to be awarded with the single goal of attracting the support of a senator.

## 3.7 MODELS AND THEORIES

Our discussion of the model-based view defined what a model is (a definition) and how models are connected to reality (theoretical hypotheses). Although we have noted that under this account theories are collections of models, we feel the need to expound upon this point given the ubiquity with which the term theory is used in political science. We do so with the understanding that more than one leading proponent of the semantic view has argued that the issue is unimportant (Suppes 1967, 63). We begin with another discussion of the harmonic oscillator model.

At its most abstract the linear oscillator is a system with a linear restoring force, plus any number of other, secondary forces. The simple harmonic oscillator is a linear oscillator with a linear restoring force and no others. The damped oscillator has a linear restoring force plus a damping force. And so on. Similarly, the mass-spring oscillator identifies the restoring force with the stiffness of an idealized spring. In the pendulum oscillator, the restoring force is a function of gravity and the length of the string. And so on. …

**(p.74)** "The linear oscillator," then, may best be thought of not as a single model with different specific versions, but as a *cluster* of models of varying degrees of specificity. Or, to invoke a more biological metaphor, the linear oscillator may be viewed as a family of models, or still better, a family of families of models.

(Giere 1990, 79–80)

That is, a *theory*, according to the semantic view, is a collection of models or "a set of models" (Salmon 1988, 6). More specifically, Giere (1990, 85) defines a theory as "comprising two elements: (1) a population of models, and (2) various hypotheses linking those models with systems in the real world." A theory, then, is not a well-defined entity, and there are no rules regarding which models are included in a particular theory. This use of the term *theory* seems very much in line with casual usage by political scientists. A recent review of democratic peace theory, for example, lists six different "logics" nested within the theory (Rosato 2003). These include one normative logic (norm externalization leads to mutual trust and respect) and five institutional logics (public constraint, group constraint, slow mobilization, surprise attack, and information, all of which work through an accountability process). Similarly, a recent view of realism attempts to come to terms with the myriad positions encompassed by the term (Bell 2008).

The relationship between a theory and the models that comprise the theory is depicted in figure 3.4. A real-world system, $S$, is characterized by $m$ features, $f_j$, $j = 1, \ldots, m$. In terms of the Ansolabehere, Snyder, and Ting example, the system is the legislative bargaining process in Congress. The features of the system include bicameralism, nested representation, particular amendment rules, and many others. The theory, $T$, is characterized by $n$ models, $M_i$, $i = 1, \ldots, n$, and $k$ theoretical hypotheses, $TH_l$. Each theoretical hypothesis states the respects in which and the degree to which its respective model is similar to the system, $S$. The arrows indicate which features of the system are included in the different models (and we have to imagine that the arrows can tell us the degree of similarity). If $M_1$ were the Ansolabehere, Snyder, and Ting model, the arrows would be pointing **(p.75)** at bicameralism and nested representation. To be clear, the arrows themselves are not the theoretical hypotheses, but we can think of the collection of arrows emanating from a single model as its theoretical hypothesis. Note that the theory, *T*, encompasses the models and the theoretical hypotheses, but not the real-world system.

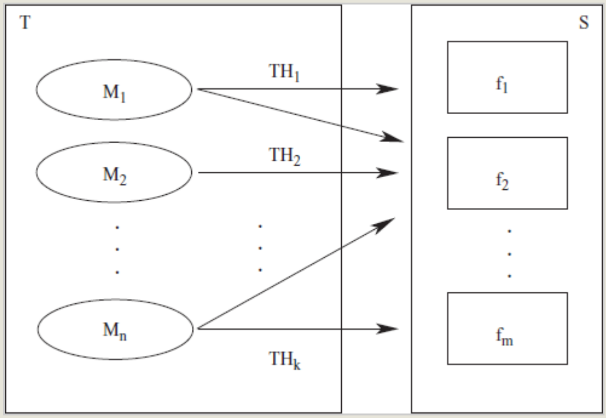


*Figure 3.4* The Relationship between a Theory, Its Models, and a Real-World System. *A theory, T, comprises n models, $M_i$, and k theoretical hypotheses, $TH_l$. A real-world system, S, comprises m features, $f_j$, which can be modeled.*

To return to our example, the "theory of distributive politics" is really a family of models concerned with the distribution of public expenditures among competing actors. Like harmonic oscillator "theory," distributive politics "theory" includes both basic and very abstract models as well as more sophisticated models. The earliest models include Riker (1962) and Buchanan and Tullock's (1962) seminal work on coalition building. The models provide the basic logic for understanding why minimum-winning coalitions (the smallest group large enough to impose its will) form when dividing a fixed amount of public expenditures. Weingast (1979) explains why **(p. 76)** legislatures develop norms whereby individual legislators can pick projects for their districts with little interference from the rest of the legislature. The reasons include uncertainty regarding the composition of the minimum-winning coalition, and the fact that the amount of public expenditures to be divided is not fixed (leading to non–zero-sum bargaining).

Later models focused more on institutions. Baron and Ferejohn (1989) created a framework for focusing on the role of amendment rules on spending in a noncooperative bargaining environment. Numerous other models both expand and circumscribe that model. Diermeier and Feddersen (1998), for instance, look at the vote of confidence procedures in parliamentary systems, and McCarty (2000) looks at an executive with veto power. Chari, Jones, and Marimon (1997) include voters in an effort to study split-ticket voting. Battaglini and Coate (2007) address distortionary taxation and public goods spending, whereas Snyder, Ting, and Ansolabehere (2005) incorporate weighted voting.

Note the relationship between the collection of models just described and the three maps discussed earlier in the chapter. Like the three maps, the distributive politics models cover essentially the same ground but from different perspectives. That multiple models describe the same object is quite natural; there is no such thing as the one, true model. George Stibitz (1966, 41), one of the fathers of modern digital computing, writes, The fact I want to bring out is that, for the same physical object or phenomenon, there are many conceivable models. These models may range through many orders of complexity and through many degrees of completeness or of precision. There is no unique correspondence between a thing and its model. Just as a circular cylinder may serve as a model for a glass tube, for a copper tube or for a hole in a block of steel, so a model for the glass tubing may be a simple cylinder, an irregular geometric form or even a statistical distribution of mathematical points.

**(p.77)** Thus, these models of distributive politics have limited accuracy and are purposefully partial; they are not sequential in the sense that later models do not always incorporate all the features present in earlier models. They are purpose-relative; the authors choose the level of abstraction and list of features to be modeled with a particular purpose in mind. Taken together, they comprise the theory of distributive politics.

What are the precise boundaries of distributive politics theory? Which models should be included in the theory, and which should be excluded? These are the wrong questions to ask. There are no definitive answers to these questions, and it is precisely in this sense that we are arguing that models should occupy pride of place in scientific reasoning. Precisely delineating the boundaries of distributive politics theory is unnecessary. What matters is evaluating the extent to which these models fulfill the purposes for which they were intended.

## 3.8 CONCLUSION

Dissenters may claim that our argument here amounts to nothing more than a change in language. What we used to call theories we should now call models. Even if that were the case, it would be a contribution. After all, “model” and “theory” are the terms we use to communicate with one another. However, our argument has important implications beyond the semantic ones. The most sweeping of these implications relates to the evaluation of models, and to determine whether a model fulfills the purpose for which it was intended, we need to understand the various roles models can play. To that end, we discuss theoretical models and statistical models separately, for although they are all models, they often serve quite different purposes. We detail those purposes in the next two chapters.

Notes:

(1.) To be specific, maps are tools that work in a particular way: by representing. In this way, models are more akin to maps than to other sorts of tools, such as hammers.

(2.) Although the semantic and predicate views are theoretically distinct, the two terms are often used interchangeably in practice with little harm. In both approaches, models are nonlinguistic entities. We use the term “semantic.”

(3.) We are eliding, as in the previous chapter, the difference between the logical positivists and the logical empiricists.

(4.) A set of sentences is fully interpreted if all the sentences have meanings that make them either true or false.

(5.) The Received View changed in both subtle and not-so-subtle ways over the years. This characterization is close to the final version.

(6.) The authors rely on survey data from the 1952, 1956, and 1960 presidential elections.

(7.) The authors assume that $C$ is weakly negatively correlated with $D$ and is constant within categories of $D$.

(8.) Most scholars date the death of the Received View to the opening night of the Illinois Symposium on the Structure of Scientific Theories, March 26, 1969 (Suppe 2000, S102).

(9.) See Suppe (1977) for a complete account of the rise and fall of the Received View.

(10.) Van Fraassen (1980, 41–43) uses the Seven Point Geometry as an example. If theory $T$ includes the axioms: $A0$: There is at least one line; $A1$: For any two lines, there is at most one point that lies on both; $A2$: For any two points, there is exactly one line that lies on both; $A3$: On every line there lie at least two points; $A4$: There are only finitely many points; then, the Seven Point Geometry is a model of $T$ because all five axioms are true in the structure.

(11.) Van Fraassen (1972, 312) provides an example. “Let the states of a classical particle moving along a straight line be represented by triples of real numbers, such that the particle is in state $\langle m,x,v\rangle$ at time $t$ exactly if it has mass $m$, position $x$, and velocity $v$ at that time. Then if $U$ is the statement that the kinetic energy equals $e$, we have $h(U)=\{\langle m,x,v\rangle: \frac{1}{2}\,mv^{2}=e\}$. This defines the set of states that satisfy $U$; $U$ is true when related to a given system exactly if that system is in a state belonging to $h(U)$.”

(12.) There is always the possibility of “internal falsification” stemming from errors in reasoning or mathematics. Such a statement is very different from the claim that a model is false.

(13.) The authors also consider extensions that demonstrate conditions under which inequities among states can arise.