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For Heather and for Neeta

PREFACE

This book project began with a question raised by an undergraduate student: Why test deductive models? The question seemed simple, even obvious, but after thinking it through, we decided that it was not so simple. A few years earlier, the Empirical Implications of Theoretical Models (EITM) project had gotten under way, and finding new ways to test theoretical models was all the rage. We felt that a paper exploring the logic of testing theoretical models was in order. After writing that paper, we felt that we had more to say, not only about theoretical models but also about empirical models and the conditions under which the two should be combined. This book is the result.

Many people helped us revise, refine, and improve our argument from its initial incarnation. Sometimes we disagreed with the advice that we received, and sometimes the advice givers disagreed among themselves. Thus, all errors are ours, and ours alone.

Among our colleagues at the University of Rochester, we are particularly indebted to Jim Johnson, who supported this work from the beginning, patiently engaged in seemingly endless conversations about models in political science, and who was gracious enough to read a number of drafts. John Duggan, Mark Fey, Hein Goemans, Gretchen Helmke, Bethany Lacina, Michael Peress, Larry Rothenberg, Curt Signorino, and Randy Stone also provided helpful comments and advice. Our arguments have been sharpened by exchanging views with Rochester graduate students both in seminars and in hallways. Outside the department, we benefited from interactions with Chris Achen, Jim

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Earlier versions of the manuscript were presented to the Political Science Department at Washington University in St. Louis (March 2009), the Directions in Political Methodology Conference at Emory University (November 2010), and a symposium at the University of Illinois (January 2011). Too many individuals to name offered helpful comments and criticisms on these occasions; we thank all of them.

The initial version of the book's argument appeared as "Modernizing Political Science: A Model-Based Approach" in *Perspectives on Politics*. Earlier versions of this article were presented at the 2004 Annual Meeting of the American Political Science Association and at the 2005 Annual Meetings of the Midwest Political Science Association and the Canadian Political Science Association. We thank participants at these conferences for their feedback.

We also acknowledge the support and encouragement of our editor at Oxford University Press, David McBride, as well as Caelyn Cobb and the staff at Oxford University Press for their help in putting the manuscript together.

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A Model Discipline

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> Practical economists, who believe themselves to be quite exempt from any methodological influences, are usually slaves of some defunct methodology.
>
> —Economist Kevin Hoover

1.1 THE MODEL IN POLITICAL SCIENCE

This book is about how to think about models and the roles they play in our discipline. Models have come to be the dominant feature of modern political science and can be found in every corner of the field.[1] Pick up any recent issue of the top social science journals, and you will find models. Some are mathematical or formal models, and some are computational or algorithmic models. An even greater number are empirical or statistical models, and some are verbal or nonmathematical models. Despite this ubiquity, most political scientists know very little about models, their properties, or how to think about models in a rigorous fashion, even though political scientists are highly skilled at model construction.

Our goal in this book is to provide political scientists with a coherent way of thinking about the models that pervade our discipline. The approach we take is known as the model-based or model-theoretic view, which holds that models, not theories, are the primary units of scientific interest. Models are seen as objects, thus neither true nor false, and are judged by their usefulness for a particular purpose. The standard analogy is to maps, which share many of the characteristic traits of models. We develop the implications of this understanding and establish why existing practice is based on outdated and faulty ideas. Most political scientists, we suspect, will raise few objections to thinking about models in the way we suggest. That being said, we also suspect that resistance will begin when the consequences of this approach dictate jettisoning cherished pieces of our research tradition. These include the notions that theoretical models must be tested to be of value and that the ultimate goal of empirical analysis is theory testing.

Consider Baron and Ferejohn's (1989) legislative bargaining model, in which a dollar is distributed among legislators interested in maximizing their share. The game begins when a randomly chosen legislator makes a proposal to divide a fixed amount of public expenditures. In the simplest form of the game, if an offer is rejected, a new proposer is chosen, and the process continues until an agreement is reached. The Baron and Ferejohn legislature comprises *n* members, a recognition rule (random — every member has the same chance of being recognized to make a proposal), an amendment rule (open or closed), and a voting rule (majority). The legislature depicted in the model shares little isomorphism, structural or otherwise, with any existing legislature. There are no parties, no leadership, no disputes over social policy or even debates about the size of overall spending. The benefits are distributed only once. Despite these departures from reality, we clearly recognize the model as being that of a legislature.

Baron and Ferejohn's model cannot be considered either true or false. The model represents some features of actual legislatures and omits others. Moreover, the omissions are purposeful. In constructing the model, the authors sought in part to highlight the roles that proposal power, endogenous agenda formation, and the sequential nature of the legislative process play in the distribution of resources. To that end, the model focuses on proposal rights and amendment rules at the expense of other real-world features of legislatures. The way to think about this modeling effort is to say that Baron and Ferejohn use their model to represent actual legislatures for the purpose of understanding bargaining in the legislative process.[2]

Reasonable people can disagree about whether the representation is useful—the model may be unilluminating, for example—but truth and falsity, and therefore testing, are beside the point. That being said, it is difficult for anyone to argue that the model has not been useful; it spawned a large body of literature and, according to the Social Sciences Citation Index at the time of writing, has been cited over 300 times.

Even if one accepts the misguided notion that theoretical models can be true or false, we demonstrate that the method we use to test theoretical models—derive a comparative static from a model and see if it holds in a regression-like statistical model—does not actually work. There are two reasons. First, the logic of the test prevents us from drawing interesting conclusions about the theoretical model. Second, we never test theoretical models with data; we test theoretical models with models of data. As data models share all the same characteristics of theoretical models and are often exceedingly fragile, assigning the data model to be the final arbiter of the theoretical model is untenable.

Theoretical model testing, in our view, is illogical; moveover, it is often unnecessary. Models can be useful in different ways without being tested. There are foundational models upon which others build, organizational models that collect empirical generalizations under a single framework, exploratory models that investigate putative causal mechanisms, and models that predict. With the exception of predictive models, none of the other uses require testing. Similarly, empirical models can be useful in the absence of theoretical models for measurement, characterizing a data set, and prediction. Two threads, therefore, comprise the argument: model testing is illogical, and model testing is often superfluous.

Our collective ignorance of the nature of models no doubt strikes many political scientists as unproblematic; after all, the ability of social scientists to construct models of precision and elegance is paramount. Increasingly, however, models are being used in ways that are antithetical to their nature. Ask a political scientist if her model is true or false, and she will most likely reply that her model is false. Conventional wisdom holds that all models are false. Ask the same political scientist why she is testing her model, and a reply is likely to be much slower in coming. The initial response is often to make a claim such as "we are not testing the model, but what comes out of it," or "the model is technically false, but it is a good enough approximation," or "well, we are not really *testing* per se." These half-formed arguments just generate additional questions and confusions. Why would we be interested in the implications of a false model? Are the implications of all models approximations? What does that mean for data analysis? If we are not testing the model, why is the deductive connection between the theoretical model and the empirical model necessary?

The true importance of these topics becomes readily apparent when we consider graduate teaching. Broadly speaking, methodology is the study of the ways in which political scientists justify their conclusions about the world (Blaug 1992). We are teaching a generation of top graduate students that there is a preferred way of making substantive claims. The method we teach, however, cannot be justified. It is based on outdated ideas and fails the test of logic; there is no evidence that its use has moved the field forward. Our goal is to help political scientists reach better justified conclusions by highlighting the use of models and by thinking carefully about what models can and cannot do for us.

1.2 METAPHORS AND ANALOGIES, FABLES AND FICTIONS

Before going any further, it will prove useful to put our conception of models into context by reviewing some of the different ways modern scholars have thought about scientific models. Central to any discussion of models is the idea of representation, and central to the idea of representation is use. The act of representing lies not in any necessary physical resemblance between a model and what it purports to represent, but in the way the model is used. Van Fraassen (2008, 23) writes, "There is no representation except in the sense that some things are used, made, or taken, to represent some things as thus or so." Even a novel about animals can represent a political system. George Orwell's *Animal Farm* can be read either as a fantastical story of animals taking over a farm or as an allegory for the events leading to Stalinism (Godfrey-Smith 2009). Whether the novel represents Russia in the early twentieth century depends on the interaction between intention and use.

Modern treatments of scientific models go back to Black's (1962) seminal discussion of models as metaphors. Black begins with *scale* models, by which he means three-dimensional versions of objects that have been scaled either down (as in a model ship) or up (as in a model of an atom). The objects being modeled may be real (such as the Space Shuttle Endeavour) or imagined (such as models of spaceships from movies or television shows). These kinds of models are designed to serve specific purposes that range from the pedagogical to entertainment, and depending on the use, some features of the original are important to the representation whereas others are irrelevant. A child would find a model airplane that could not fly quite dull, whereas an adult collector would not care less, provided the model sported authentic detail. Either way, the change of scale must introduce distortion, and it follows that "perfectly faithful" models do not exist. A model can represent "only by being unfaithful in *some* respect" (Black 1962, 220).[3]

Black moves toward the types of models used in political science when he writes of *analogue* models in which an object is represented in some new medium. Whereas a scale model shares features with its original, an analogue model shares only a structure or pattern of relationships. A subset of analogue models are mathematical models through which structures are represented in the new medium of mathematics. Black (1962, 223–24) writes of the use of mathematical models in the social sciences in a way familiar to any political scientist (at least until the last sentence):

> The original field is thought of as "projected" upon the abstract domain of sets, functions, and the like that is the subject matter of the correlated mathematical theory; thus social forces are said to be "modeled" by relations between mathematical entities. The "model" is conceived to be *simpler* and *more abstract* than

> the original. Often there is a suggestion of the model's being a kind of ethereal analogue model, as if the mathematical equations referred to an invisible mechanism whose operation illustrates or even partially explains the operation of the original social system under investigation. This last suggestion must be rejected as an illusion.

Theoretical models, according to Black (1962, 230), stand in relation to their originals in the same way that analogue models and their originals do. That is, the theoretical model represents the structure of the original. Black describes such models as metaphors with the power to bring "two separate domains into cognitive and emotional relation" by using the language of one as "a lens for seeing the other" (236–37). Like models, metaphors may fit well or not, and the outcome of metaphorical thinking is unpredictable; the metaphor may help the scientist see new connections.

An idea closely related to the view of models as metaphors is that of models as analogies, which are often important in understanding metaphors (Bailer-Jones 2009). Hesse (1966), drawing on the work of Campbell (1920), makes the models are analogies argument and illustrates her approach with an example from the dynamical theory of gases: gas molecules are analogous to billiard balls. The analogy has three components. The positive analogy contains the properties of billiard balls that are shared with gas molecules. The negative analogy contains the properties of billiard balls that are not shared by gas molecules. The neutral analogy contain those properties of billiard balls that are unknown or cannot be classified as positive or negative. A model can be either physical, such as the billiard balls, or mathematical. Hesse argues that models are essential for building theories and suggesting hypotheses:

> If gases are really like collections of billiard balls, except in regard to the known negative analogy, then from our knowledge of the mechanics of billiard balls we may be able to make new predictions about the expected behavior of gases. Of course the

> predictions may be wrong, but then we shall be led to conclude that we have the wrong model.
>
> (Hesse 1966, 9)

It is not a great leap from metaphors and analogies to fictions and fables. Much of the work in this area is due to Nancy Cartwright. In her classic book, *How the Laws of Physics Lie,* Cartwright introduces her simulacrum account of explanation and makes the claim that "a model is a work of fiction. Some properties ascribed to objects in the model will be genuine properties of the objects modeled, but others will be merely properties of convenience" (Cartwright 1983, 153). The properties of convenience make mathematical theory applicable to the objects being modeled (Bailer-Jones 2009). In addition, Cartwright argues, in a view similar to ours, that models serve a variety of purposes, and any particular model should be judged according to how well it serves the purpose at hand.[4]

A more recent example comes from Godfrey-Smith (2006, 735), who notes that "modelers often *take* themselves to be describing imaginary biological populations, imaginary neural networks, or imaginary economies." He defines an imaginary population as one that, if it were real, would be a "flesh-and-blood" population. He suggests that these imagined populations should be treated as the imagined objects of literary fiction, such as Conan Doyle's London and Tolkien's Middle Earth. Again, in a view similar to ours, Godfrey-Smith claims that models are partial and provides an amusing example noting that when most people read *Lord of the Rings,* few imagine how many toes an orc has (2006, 735). In addition, he claims that we could describe these fictional worlds in mathematical terms, just like an economy, and we can easily compare them just as fiction fans might discuss the similarities between two fictional worlds (Middle Earth and Narnia) or the similarities between a fictional world and a real one (Middle Earth and medieval Europe) (737).

In later work, Cartwright (1991) defends a claim that the relationship of moral to fable is like the relationship of scientific law to model. The argument is that fables transform the abstract into the concrete by providing "graspable, intuitive content for abstract, symbolic judgments" (58). The moral is a symbolic claim, and the fable provides specific content. Models work in the same way, giving specific content to scientific laws, which are symbolic. Laws are true in models just as morals are true in fables. Thus, a model "fits out" a scientific law by providing a concrete example where the law holds.

Noted economist Ariel Rubinstein also sees models as fables or fairy tales (2006, 881). The difference in the accounts is that Cartwright is concerned with the abstract versus the concrete, whereas Rubinstein claims that both models and fables parallel situations in the world and both impart a lesson. For Rubinstein, a fable, like a model, abstracts from irrelevant detail and may seem unrealistic or simplistic. This lack of detail may allow us to see connections that might otherwise remain hidden. Although fables exist in a netherworld between fantasy and reality, they teach us something—a moral or a lesson—about the world, and those lessons can have significant consequences. Models, therefore, are neither of the real world nor completely divorced from it. Rubinstein's (2006, 882) conclusion is that it makes no more sense to test a model than it does to test a fable.

In a final account, Morrison and Morgan (1999b) see models as mediating instruments. That is, models stand, or mediate, between theories and the world and are partially independent of both. This partial independence arises from the ways scientists construct models. Built from bits of theory, bits of data, and a structure that may be mathematical, models comprise a "mixture of elements," including some from outside the field of inquiry (Morrison and Morgan 1999b, 14). Although models are only partially independent, they can function autonomously as instruments to aid scientists in the exploration of both theories and the world. This learning occurs not only through the construction of models (learning occurs when modeling choices are made) but also through the manipulation or use of models. The authors point to the urn model in statistics as an example of a model (in this case a thought experiment) that has taught generations of students the behavior of certain probability laws.