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GENERAL INTRODUCTION

1. THE ENDS AND THE MEANS

For more than half a century there has been a deep malaise in the social sciences. The gap between empirical and theoretical research is accompanied by a divorce between the researchers: those undertaking empirical studies and those who seek theoretical syntheses scarcely communicate at all, and sometimes appear to inhabit very remote planets. On the empirical side, techniques of investigation have become ever more refined and sophisticated, and the results generated, from qualitative as well as quantitative methods, pile up year on year. But even more pressing becomes the question as to how these results contribute to a better understanding of social life. Do they provide us with better criteria of decision and action? Do they improve our explanations of social reality, and our grasp of the forces regulating social change? It is widely agreed that the empirical work would be better aimed were it based on firmer theoretical underpinnings. For example, before gathering data, several choices are necessary: the field of observations must be specified, as must the relevant objects within this field (agents, attitudes, values, organisations, social classes, institutions, and so on); those facts considered pertinent must be identified; variables and indicators must be chosen. Most often these choices are guided by common sense and received wisdom. It would be preferable were we able to give them a theoretical foundation. But how can this be achieved? How can theory be given its rightful place at the heart of empirical research?

The use of models is widespread nowadays throughout the different disciplines of social science. How should we go about modelling in such a way that empirical research profits most from theory? The collaboration of thirteen researchers from different fields allowed the examination of the following modelling practices: statistical models and mathematical models, conceptual models, diagrams and maps, machines, artificial neural networks and computer modelling. These practices have been approached through different disciplines: archaeology, demography, economy, engineering, geography, comparative politics, experimental psychology, sociology and philosophy of science. The authors of this book met for four days, to explore the questions on which they differed, and matters on which their analyses had concurred. The editor worked their conclusions into a larger framework, which is that of the book as a whole. There are four Parts, each including several chapters. The concluding sections of each Part put forward solutions to general problems which are analyzed in the chapters. The book progressively works out a method of constructing models which can bridge the gap between empirical and theoretical research and improve the explanatory power of models. This method has been reviewed by the book's contributors, but remains the editor's responsibility. It is summarized in the general conclusion.

R. Franck (ed.), The Explanatory Power of Models, 1–8.

2. SYNOPSES OF THIS BOOK

PART I

Can theory improve statistical models? And, conversely, can statistical analysis provide any help in the construction of a good explanatory theory? Part I tries to answer to these questions. In order to explain statistical correlations, one can propose some hypothetical social mechanism which could generate them (chapter 1). When such a mechanism is advanced in general terms, we often say that we are dealing with a theory. Theory so understood can then inspire the design of statistical modelling processes. Still a theory of this kind can be interpreted in different ways, or encounter competing theories. Thus it does not enable us to create a consensus among researchers concerning the design which should be adopted. In consequence, it is not easy to build up cumulative knowledge. How could theory induce researchers to work with the same variables, and to model the variables in the same way?

The social mechanism retained by hypothesis may itself be expressed statistically, by means of causal modelling, in order to test its validity. Explanatory theory (i.e., a social mechanism) and statistical modelling are thus closely associated (chapters 3 and 4).

Still, even after the explanatory theory has been tested, difficulties remain. The choice of conceptual variables which belong to the theory, and their indicators, might have been different, and the nature of the relations between variables chosen remains obscure. Is there a solution to these difficulties?

Here is the solution put forward in the concluding section of Part I. A mechanism covers a number of functions. In order to represent a social mechanism, constructing a causal model of this mechanism is not enough; we must also model the combination of functions of the mechanism. The combination of functions within a social mechanism may be represented by a diagram; and simulation models are used just as often today (though more rarely in social science) for modelling functions. The functional architecture of a social mechanism, once modelled, may guide the design of the causal model of this mechanism. It confidently guides the choice of variables and indicators, and teaches us regarding the nature of the relations between these variables. It improves the explanatory power of causal modelling.

That which is theoretical in a social mechanism is its functional architecture, not its causal architecture. When attributing theoretical value to the combination of causes and effects which is operative in a given social mechanism, one encounters an insoluble difficulty: one would like to be able to attribute to a particular combination of causes and effects the general (if not universal) applicability which we expect from a theory. But everyone realizes this is impossible. A combination of functions, on the other hand, can be generalized. The possible contribution of theory to statistical modelling appears to lie in the modelling of the functions of a social mechanism.

PART II

Questions about how to construct a functional model are taken up in Part II of this book. The discussion of the role of statistical analysis in psychology (chapter 2), draws attention to the fruitful distinction between the properties of a psychological or social system and the mechanism which generates those properties. Through the study of the properties of a system we can, in fact, discover the functions of that property-generating mechanism. In cognitive psychology it is thought normal to identify by induction, and starting from observed behaviors (i.e. the properties of the system), the architecture of cognitive functions. Such a procedure in social science is relatively rare. It is rare to see someone model the functional architecture of a social system, starting from a close analysis of its properties. That possibility is explored in Part II.

We look closely at the method of *reverse engineering*. This method employed by engineers consists in reproducing the functional structure of a machine, starting from the study of its properties. The same procedure inspires simulation models, and it is the source of their usefulness. Potential uses of computer simulations based on the reverse engineering method are examined in macro-economics (chapter 5). Next, we concentrate on the explanatory power of artificial neural networks (chapter 6). These networks do not represent the material architecture of a mechanism, but they are still explanatory, because they can represent its functional architecture.

Functional models are transferable to various material systems. This offers new theoretical perspectives with regard to the possibility of generalizing research findings in social science (concluding section). In practical terms, reproducing by other means and in other contexts the success of a road safety campaign, or efficiency in the medical service, for example, is no longer a matter of luck when those in charge design their programs according to a functional model which will generate the desired results.

PART III

Part III widens our focus. The fecundity of a large number of different models for the description and explanation of social phenomena is the subject of an extended discussion in economic geography (chapter 7), demography of migratory phenomena (chapter 8), comparative politics (chapter 9), and the sociology of sports and games (chapter 10).

This discussion allows us to penetrate more deeply into the nature of social theories, and to differentiate theoretical models from empirical models (concluding section). In contrast with empirical models which represent the network of relations—quantitative or qualitative—which exists between observable variables, theoretical models represent a structure which is formal, necessary, generalizable, and which has the status of a principle. The explanations to which theoretical models give rise are also different from the causal explanations provided by empirical models. We will ask ourselves whether the combination of these two kinds of explanation can help to bridge the gap between empirical and theoretical research.

PART IV

The last Part of the book focuses our attention on the need to leave behind certain elements of current epistemological thinking. The covering law approach hinders social research and leads to a pessimistic view of the explanatory capacities of the social sciences. To hold law-like generalizations necessary for true scientific explanation is to sacrifice any possibility of the social sciences deserving such scientific status. To hold instead that in social sciences just as in natural sciences, facts can be explained in two complementary ways, with reference to the mechanism which generates them, and with reference to the formal system which commands the mechanism, opens new avenues of research, as much empirical as theoretical. For example, this point of view offers the possibility of validating the models obtained with computer simulations and of assessing their explanatory power (chapter 11). The semantic approach in philosophy of science goes some way towards offering a satisfactory epistemological basis for differentiating theoretical (formal) explanatory models from empirical (causal) explanatory models.

The deductive concept of explanation is another important idea in the covering law approach. Is this less onerous for the social sciences than the demand to produce law-like generalizations? The deductive concept of explanation was rejected by the pioneers of modern science (Bacon, Galileo, Descartes, Newton, etc.) in favor of an inductive concept of explanation (concluding section). These authors had a different idea of induction than the one which is familiar to us (generalization from particular facts). Induction consisted in discovering a system's principles from a study of its properties, by way of experiment and observation. This procedure—the procedure of classical induction—is given in Parts I and III the task of constructing theoretical models, including functional models. This is also the procedure illustrated in Part II by the reverse engineering method. The deductive concept of explanation has replaced classical induction in philosophy of science, and this deprives the social sciences from the advantages which the natural sciences enjoy, since they never stopped using the method of classical induction. We might add that the empiricism and realism which accompany the concept of classical induction are quite different from the empiricism and pseudo-realism (phenomenalism) of the covering law approach.

The programme of "practical epistemology" (chapter 12), which is proposed for the analysis of the content of an argument in archaeology and also more generally in social science, demonstrates that in addition to deductive implications, there are inductive implications. These consist in the discovery of that which is implied by certain facts or things. It is that which is implied by facts or things that explains those same facts or things. This explanatory procedure is common in the sciences, and we can liken it to the procedure of classical induction when it rises to the level of generality of principles.

3. SOME CHARACTERISTICS OF SCIENTIFIC MODELS

Before we begin to read the chapters of this book, let us draw attention to some general characteristics of scientific models, in an attempt to leave behind the confusion that often accompanies the term "model".

Scholars have turned to models since the birth of modern science. It seems that modelling is indispensable for science. Nature is highly complex and changeable, as is the social world, and neither the natural nor the social world can be conceived except via simplifying schemas. *Models provide a simplified representation of the phenomenon* (1). This is the first characteristic of scientific models of which we take notice.

It would be impossible to test a representation seeking to copy all aspects of a phenomenon. Only a simplifying schema is susceptible to testing in experiments. *Scientific models are testable* (2).

Here is a third characteristic. *It is the model itself that, in the scientific approach, becomes the object of study* (3), rather than the real phenomenon (which is too complex). This characteristic of scientific models has been a theme of the semantic approach to philosophy of science (see F. Suppe 1989).

We generally think of a scientific model as a representation. But a model is more than a representation. According to one of the ordinary uses of the word, a model is that to which something should conform: for example, it can be a figure seated before an artist or a prototype. The notion of representation is absent from this current use of the word "model". The model is that which inspires the artist, it is not his painting; the model is the prototype, and not the product that conforms to it. In short, the model is that to which the representation must be faithful, and not the representation itself. By extension, when we describe a scientific representation as a model, we may suggest that such a representation, rather than copying the object represented, represents some object's essential characteristics. A formal structure, for example, may be termed a model in this sense. Hold this thought: *scientific models may represent that which is essential to the object.* (4). This is a fourth characteristic of scientific models. But what is essential? That we will discover shortly.

Let us illustrate these first four characteristics via the familiar example of Galileo's (1968) work on acceleration.

> "If I notice that a stone, which is initially at rest but then falls from a height, accelerates as it falls, why should I not believe that this acceleration occurs in the way which is simplest to understand? And there is no multiplication, no increase, simpler to understand than one that occurs at a constant rate. (...) So, if we take any number of equal periods of time following the instant when the body began its fall from the position of rest, the speed attained during the first and second periods taken together will be double that attained during the first period. The speed attained in three time periods will be triple, and in four periods the quadruple of that which the body had attained by the end of the first time period. (...) It therefore seems that we can suppose speed to be a function of time, without contradicting the truth."

As this extract shows, Galileo presents *a simplified representation* (1) of the acceleration of a falling body: "why should I not believe that this acceleration occurs

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