In defense of formal modelling in the social sciences

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1st February 2009

Abstract

This essay aims to explain the use of mathematical modelling in the social sciences and diffuse some criticisms that are often leveled against it. Some such criticisms can be countered by stressing the classical 'scientific' benefits of simplicity and clear definitions in producing falsifiable theories. However, many models are not written with such aims in mind. Rather, they aim to be depictions of realities that can be described as charicatures, metaphors or 'alternative worlds'. I discuss some of the problems with using mathematics, which consist mainly in the use of math for math's sake.

1 Introduction

By training I am an economist with interdisciplinary research interests, which lead me to interact frequently with psychologists, sociologists and political scientists. Because of the difference in research methodologies, such interdisciplinary conversations are not always easy. Specifically, my friends from other disciplines sometimes raise eyebrows over the tendency of economists to formulate obvious things in terms of obscure mathematical models.

This essay aims to explain the advantages of mathematical modelling (MM), and to defend it against some of the common criticisms that I have encountered. In a nutshell, the argument here is that capturing the social work in theory necessarily involves abstractions which involves unavoidable trade-offs between what to include and what not to include. Mathematics is a way to make these trade-offs in the clearest possible way, and the clarity if affords makes testing and discussion easier. Such classical or Popperian arguments do not exhaust the use of mathematical models however, and in many cases they do not even touch the aim of MM. Often, models have a more artistic aspiration, of providing a metaphor or caricature of some elements of society in order to understand them better. Finally, like any research methodology in the social sciences, mathematical theorizing does have its limits and associated problems, which I will also briefly discuss.

I concern myself here solely with mathematical theorizing as is used for example in game theory and rational choice models, not with quantitative methods in empirical sciences, i.e. statistics and econometrics. Finally, there is a sizeable literature on this topic with vocal proponents on both sides of

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the debate. Criticism has not only come from outside of economics but also from inside[1]. Papers on this topic are rather frequently published in the Journal of Economic Methodology, so I do not pretend completeness nor any final words. Rather, I hope that this document can serve as a basis for discussion, and comments are more than welcome.

2 Mathematics and social science

In this section I will give some arguments for the use of mathematics that derive from traditional Popperian arguments about the scientific method. I believe these arguments go a long way to address some criticisms of MM in the social sciences that I have encountered myself, and therefore I structure my arguments around these criticisms.

Criticism 1 *Social phenomena are so complex that they cannot be captured in a mathematical model.*

This is really not a criticism of MM, but of all modeling. Any model is by definition a simplification of the real world. I don't think that any (social) scientist can seriously advocate not using models; without simplifying the world, knowledge production is impossible. One simply wouldn't know where to start. Given then that as scientist we need to model, we want to get the degree of complexity right. Models that are too simple miss essential elements of the mechanism that is under observation. On the other hand, it is a basic principle of the philosophy of science that a theory should be as simple as possible to explain the phenomena you want to explain. Theories in which the central point is overgrown by all kinds of side-explanations, special cases, exceptions, and other embellishments are not the stuff of good science.

Math is not neutral in this respect. In mathematical models, including more complexity has a heavy price. There is a limit on the amount of variables that one can incorporate in a model without it 'blowing up', i.e. without making it impossible to derive the implications of all the assumptions that you made. This means that MM drives the researcher towards simplicity. Maths forces researchers to very carefully think of the trade-off between making a model richer and making it more complicated. I call this the *disciplining effect* of MM. This is not to say that a simpler theory is always more appropriate: it is possible to go wrong in this trade-off. Indeed, it is possible that MM leads the theorist to oversimplify. But I think that this is less grave than to err in the other direction. A simple theory is generally easier to refute than a complicated theory, for the simple reason that it is easier to understand and to work with. Theories that are simple and wrong are therefore easier disposed of than theories that are complicated and wrong. Therefore, I consider the disciplining effect of mathematics generally to be one of its virtues.

Criticism 2 *Mathematical models give a false air of preciseness to their results.*

This is in fact a more sophisticated version of criticism 1, and so my answer given above applies here too. However, one aspect of this criticism merits special attention, i.e. the idea that precise, mathematical definitions are not applicable to the social world. One may entertain the idea that it is better to be

[1]Economists who have criticised formalism in economics are Mark Blaug, Tony Lawson, and Robert Heilbroner. Defending formalism are among others Robert Sugden and Partha Dasgupta.

vaguely correct than broadly wrong (Dasgupta, 2001). Vague or broad definitions are also attractive to the theorist, because it allows him or her to twist or stretch the theory to include more or new phenomena.

This methodology is profoundly mistaken, because in the social sciences as in the natural ones, the only way that you can find out whether you are right is to state clearly when you would be wrong. Making theories based on ill-defined concepts makes it much harder to determine if you were right at all. Vague definitions add noise to the dialogue between theorists and empiricists, which makes falsification harder. It also makes communication between theorists more difficult. If essential terms of the theory are ambiguous, it is hard to judge its merits and to compare theories. It is perhaps unnecessary to say that maths helps in defining things clearly, simply because that is what mathematics is all about. This in itself does not solve all problems, because a mathematical model needs to be interpreted, which can be a source of discussion and confusion. The interpretation of certain variables or parameters may be stretched in various ways. But again, the model itself provides a disciplining device, because it alerts attention to a stretched interpretation or an unwarranted inference. In that sense, it is non-mathematical modelling, to the extend that it is vague or ill defined, that can be accused of giving a false sense of understanding. In my view, the fact that mathematics provides a clear and universal set of definitions that facilitates intradisciplinary discussion and empirical testing, is the most important advantage of MM.

Finally, it is a simple fact that policy makers often need models that quantify policy variables. Interest rates need to be set, emission permits need to be issued, tax rates need to be determined. Such policies all involve quantitative measurements, and for better or for worse, mathematical models that are appropriately calibrated least provide policy makers with some idea of the reasonable numbers to use.

Criticism 3 *Mathematical models are tautologies, so they do not tell us anything new.*

This line of criticism says that MM cannot tell us anything, because what comes out depends exclusively on what you put in. This is true in the sense that models 'do' nothing more than drawing out conclusions that are implicit in the assumptions. This need not be trivial however. Indeed, the art of building an interesting model is exactly to get out something that is not an obvious consequence of what you put in. This can happen in several ways. First, maths can sometimes show surprising results of assumptions that would have been very difficult to derive without a formal expression. For example, the famous Keynesian 'multiplier' of government investment would be hard to derive without a formal framework. Similar for Schelling's insight that completely racially segregated neighborhoods can arise from extremely light preferences, for example wanting to live with at least one immediate neighbours from the same race. Second, a mathematical model allows to do what economists call 'comparative statics'. It allows you to play around. Once you have a (Keynesian) model of savings and consumption, you can analyze what happens if the interest goes up or an the government increases spending. In sum, although models may formally be tautologies, in practice they are not (at least the good ones), because they allow you to do things that you could not do without them.

3 Models as artistic expressions.

So far I have used classical Popperian arguments to justify the use of mathematics: clarity of definitions, formulation of precise falsifiable hypotheses, logical correctness, discipline in theorizing. I believe that the classical methodology of hypothesis formulation and (experimental) falsification is more difficult to follow in social sciences than in the physical sciences for a variety of reasons. Nevertheless I think it is the only way to create 'hard' knowledge, and thus should be the aspiration of the social sciences also. I have argued that maths has a natural place in this methodology.

However, this defense of mathematical modeling is somewhat naïve, since I many economic models do not actually do so well in producing testable hypotheses. Some of the most successful models in game theory for example, do not even aim at formulating clear hypotheses. Many games for example exhibit multiple equilibria, which makes predictions ambiguous. Therefore, one should ask if MM serves other purposes. There is no shortage of papers that investigate such different aims. The general gist of these paper is that models reframe mechanisms in the real world in another language, in order to make them more accesible and better understood. Because of its transparent structure, mathematics has proved to be a good language to do so. In this light, modelling is more of an artistic activity than a purely scientific one.

McCloskey (1983) views models as *metaphors* for the real world. The model shares some feature of the world. The test of a good model is the same as for a metaphor: the congruence between the real world and the metaphor has to be illuminating. It has to show reality from a new point of view that was obscured before. A variant of this view is proposed by Gibbard and Varian (1978). They suggest that models are caricatures of the real world. By making extreme assumptions, models overstate certain element of the world. The idea is to distort reality in a way that illuminates certain aspects of that reality (p. 676).

Sugden (2000) analyses two highly successful models in economic theory, Akerlof's lemon's market model and Schelling's model of segregation. Observing that these models do not aim at being realistic or at making specific predictions, Sugden proposes that they are more like *alternative worlds*. They are not so much abstractions from reality as they are an attempt to create a parallel reality. They show what would happen in a different world. For such a strategy to make sense, the alternative world must be credible. Credibility is achieved if models are coherent, and it's elements (markets, people) can be seen as instances of some category, other instances of which are found in the real world. Sugden likens models to literary works of fiction, in which a world is described that is credible to the extent that it *could* be real. Relatedly, in what reads as an indictment of economic theory, game theorist Rubinstein draws an analogy between models and fables (Rubinstein, 2004). Like fables, models often have little claim to testability, sometimes reach absurd comclusions, have little scope, and influence the world mostly trough influencing the people that work with them.

Whether this account of MM should lead the reader to think better or worse about the use of MM I do not know. However, like with works of art, it is sometimes hard not to be struck by the beauty or elegance of a simple mathematical representation of an apparently complex phenomenon.

4 Problems with mathematics.

Having said all this, is there then nothing to the any criticisms of the use of math in economics? There are several signals that something is amiss. First, there is a sizeable community of economists who critize the degree of formality in economics, which has found some degree of organization in the 'Post-Autistic

Economics Network' (www.paecon.net). Their stance towards formalism can perhaps be summarized by the following statement from Mark Blaug (1997, p.3)

> Modern economics is sick. Economics has increasingly become an intellectual game played for its own sake and not its practical consequences for understanding the economic world. Economists have converted the subject into a sort of social mathematics in which analytical rigor is everything and practical relevance is nothing.

The idea that economics is removed from reality is widespread in certain circles, but I think quite effectively countered by Dasgupta (2001). Dasgupta surveys five years of publications (1991-95) in the American Economic Review, one of the major economic journals, and concludes that although some papers are purely theoretical, the overwhelming majority (90%) is either empirical or applied to some factual observation or policy.

However, the idea that maths is used for maths sake is echoed by other, more mainstream sources. In 1988, the American Association ordered a commission to investigate the state of graduate education in economics in the US. The commission expressed a similar fear that 'graduate programs may be turning out a generation with too many idiot savants skilled in technique but innocent of real economic issues' (Krueger et al, 1991, pp. 1044-45). From my own limited experience as a Phd. student in economics, I also sometimes feel that mathematics is more than just a tool that economists use for their research. It has also become a way of judging intelligence. This may not be entirely unreasonable (to the extent that the ability to learn or apply math is correlated with a general ability to do good research), but social science is not mathematics, and clearly other skills and methodologies are required to understand the world.

Another problem in MM is related to a different version of criticism 2, namely the argument that maths grants its models a false sense of *authority*. To the extend that there is a certain awe amongst economists or other social scientists for mathematical formulations and quantitative measurements, this criticism is correct. After all, a mathematical model that explains nothing is just as bad as a verbal model that explains nothing. Both should be treated the same.

Note that in both cases the problem lies not with the use of mathematics per se, but in the communities that deal with it. This suggests that these problems can be overcome by a more realistic assessment of the use and aim of MM. I believe it to be an important tool to understand the social world, but it is certainly not the only one and perhaps not always the appropriate one. This idea is not always appreciated within the economics profession, which impoverishes the profession itself, and in some cases induces a misplaced arrogance. Moreover, misconceptions about the advantages and most of all the *aim* of mathematical modelling has led to a sharp divide between economics and other disciplines, and sometimes within disciplines. In political science for example, there are essentially two competing schools that are divided by their stance towards formal modelling.

5 Concluding remarks

The issue of the relationship of mathematical models and the real world is very subtle. This essay has only given a rudimentary and rather superficial treatment. More subtle criticisms can be given, and more subtle answers to these criticisms are available as well. I have argued that a traditional philosophy-of-science-defense of mathematical modeling helps to counter common criticisms that mathematics is not flexible enough to capture the social world. If it comes to modelling, preciseness of definition and simplicity are virtues. However, the scientific nature of many models is not so clear. In many instances, models are not intended to provide clear-cut hypotheses, but rather as images or methaphors that capture certain aspects of this world. As such they translate the social world and allow a different and more transparent interpretation. In this conception, modelling has more links to art than to science.

I have not meant to suggest that MM should be the only or even the preferred way of theorizing. As far as I am concerned, methodological pluralism is to be valued highly. It remains an open question where mathematics is applicable. I would not be surprised if we will see the fields of (social) psychology and sociology become increasingly mathematical. Although this in itself would not be a bad thing, a clearer picture of the aims of MM could avoid the kind of unproductive methodological civil wars that plague for example political science and has marginalized non-mathematical research methods in economics.

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