Why model?

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Abstract

The domain of application of formal models is unlimited. It therefore includes all aspects of anthropology, including kinship, ritual, choice, behaviour, etc.? Formal models enable the researcher to economically describe a wide range of *relationships* with *a degree of precision* usually not attained by the only other tools we have to describe them: natural languages. The possibility of falsifying a concept by implementing it as a model and testing it against observed data is one of the major gains of a modelling approach.

It seems to me that the questions posed by the organisers of this session boil down to: "If and when you are able to observe human behaviour all around you, why would you want to model such behaviour? And if you do, what can you hope to achieve?" I will try to answer them, and some others, from the narrow perspective of one of anthropology's sub-disciplines: environmental archaeology.

Four particularities about that sub-discipline are important in this context. Firstly, we deal with a distant past about which we often know as little as about the future. Archaeologists have been called "prophet[s] turned backwards". They cannot assume that their sense of the relationships between cause and effect, or between people and their artefacts, is the same as that of the people they study. It has been argued that "the past is a foreign country" – we can therefore not be sure in how far to use 'common sense' in our interpretations, or even the observed behaviour of other human beings.

Secondly, in the absence of writing, our data are non-relational. They reflect the *results* of relationships between people and materials, landscapes, monuments, etc., but they do not reflect these relationships themselves. They therefore do not point to specific relationships between cause and effect as observed by the people who left the remains behind.

Thirdly, archaeology bases its interpretations on few and meager clues about the past. In contrast to most other disciplines, it does not aim to reduce a wealth of data to a few essentials, but to do the reverse: To put flesh and clothing on 'bare bones'.

Finally our discipline is fundamentally 'interdisciplinary' in, the traditional sense. We use information that is derived from widely different kinds of data, interpretations that attempt to combine the natural and life sciences and the social sciences and humanities etc.

Why, then, model? Formal models are extremely valuable tools in the arsenal of the researcher, which enable him or her to economically describe a wide range of *relationships* with *a degree of precision* usually not attained by the only other tools we have to describe them: natural languages. Moreover, certain kinds of formal models are able to describe the *changes* occurring in complex sets of relationships with such precision and economy of space. Due to these properties, modelling is very *suitable to formalise dynamical theories* about certain phenomena, which can then be compared with our observations.

In a social science context, another important aspect of formal models is that they are not formulated in the same language as describes the phenomena to be modelled. That has several advantages, of which the most important is possibly that it allows us to abstract, to highlight features that are in our opinion relevant. It is a common assumption, for example, that one may not compare apples and oranges. Yet if one wishes to *explain* why oranges are better at rolling in a straight line than apples, one invokes an abstract dimension (roundness) and compares both kinds of fruits in terms of that dimension. The applicability of any particular model to a set of phenomena does not follow 'naturally' from the nature of the phenomena, but is defined by the person who applies the model. Models can therefore, at least in theory, be useful in solving problems in which it is important to infer relationships between the observed behaviour of certain phenomena, and characteristics of these phenomena which have as yet not been identified.

The domain of application of formal models is unlimited. It therefore includes all aspects of anthropology, including kinship, ritual, choice, behaviour, etc. But while that may be a necessary reason to use formal models, it is not a sufficient one. I find formal models particularly useful in an interdisciplinary context, as they are sufficiently abstract not to be confounded with reality, and sufficiently detailed, rigorous and (in the case of some computer models) 'realistic' to force

people with different backgrounds to focus on the same relational and behavioural issues.

What can one hope to achieve by using formal models? Maybe the best way to answer that is by referring to some of the models we have designed and used in the context of our study of the causes and consequences of desertification, land degradation and land abandonment. A first series of models, of the Palaeolithic dynamics of herbivore and carnivore fauna, attempted to get a sense of the natural dynamics in the mediterranean environment before the impact of human beings transformed that environment. Studying a model based on extant predator-prey equations, we came to the conclusion that the predicted dynamics did not come anywhere near the real ones. We then built a multi-agent model of the same situation, and in running it discovered that the 'overkill' hypothesis on which these equations are based does not explain much unless the behaviour of the individual animals is spatialised. Coupling a GIS-based map of the main landscape units to the simulation allowed us to predict with reasonable accuracy the dynamics that could be inferred from the data.

Another series of models dealt with rural-urban dynamics. These dynamics concern many different spatio-temporal scales. We combined a multi-agent model of the last 2000 years of settlement dynamics for a part of Southern France, based mainly on historical and archaeological evidence, with a similar model of the dynamics of individual migration in the area in recent times. The former model concerned the interaction of whole settlements (from small villages to towns). After many runs, we had to conclude that the parameters included in it would not explain the present-day spatial configuration of urban centres in the area. These parameters were based on a conceptual model of rural-urban interaction which is valid for the roman and medieval periods. By adding a set of self-triggered parameters based on a conceptual model of industrial towns, however, we achieved a model that did replicate the whole of the settlement system reasonably well. These parameters began to kick in after about 1500 (yearly) cycles of the model. Interpreted in historical terms, this exercise pointed out that the dynamics occurring from about 1500 AD on, are indeed qualitatively different from those driving earlier developments of the system.

On a different, decadal time-scale, the urban system of southern France is heavily dependent on migration, and the above model cannot take that into account. We therefore built another multi-agent model of the population dynamics in Southern France as a function of individuals' life-time decisions, from conception and birth, through education, partner choice, career development etc., to death. This model allowed us to gain additional insights in the operation of the settlement system dynamics, which were not to be gleaned from the first (settlement-level) model.

In a third case-study, of the agricultural dynamics of a region in southern Greece, we built a whole series of models, ranging from relatively abstract, master-equation-based and only roughly spatialised models to detailed, multi-agent models of decision-making which took local decision-making procedures and –criteria into account. Experimenting with each model in turn taught us the need to view environmental problems as the result of a co-evolution, and allowed us to assess the adequacy of our ideas by successively adding more and more parameters to an initially relatively simple model. In conclusion, in our work the possibility to falsify a conceptual model by implementing it and testing it against observed data turned out to be one of the two major gains of a modelling approach.

But the second major gain was at least as important. We heavily exploited the possibility offered by dynamic modelling, to focus the minds of many people from different disciplines and cultural backgrounds on the same set of phenomena. The multi-agent models used rapidly became the focus of true interdisciplinary collaboration in the project. This seems due to two facts. Firstly that they act as a kind of mirror that reflects the implications of different conceptual models in a neutral way, and secondly that multi-agent models are based on a bottom-up principle which facilitates implementing combinations of conceptual models about individual behaviour. It thus reduces the numbers of degrees of freedom to be input, without jeopardising the degrees of freedom inherent in the interaction between people.