

Beware the lure of models



By Mark Buchanan

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Scientists cannot help but use models – to help clarify the consequences of theoretical assumptions, or to draw out complex lines of cause and effect. They need models to estimate boundaries of safety or to tease out which observations might be most informative about some phenomenon. Without simplified conceptual models, scientific communication itself would be largely impossible.

Of course, mathematical models also underlie some of the sciences' most impressive achievements, ranging from the accurate predictions of Einstein's general relativity to today's numerical weather predictions. Our world has been transformed by myriad electronic devices all based on an effective understanding, through models, of the quantum physics of solid states of matter. Without models, we would have no insight into ways to engineer exotic electronic states in materials such as graphene.

Even so, models should come with safety warnings. Most people realize that model predictions can be wrong, and often are wrong. Yet misplaced confidence can draw individuals, groups or entire governments into making painfully poor decisions. Worse, as Erica Thompson of the London School of Economics examines in her incisive new book *Escape from Model Land*, models have an almost magical capacity to lure their users into mistaking the sharp, tidy and analytically accessible world of a model with actual reality, with unfortunate consequences.

As Thompson notes, this theme took on dramatic importance during the first wave of the COVID-19 pandemic, as governments turned to epidemiologists and their models to get some idea of what might happen and what they could do about it. The prevailing lack of information about the virus provided an unsettled foundation for making momentous decisions. Should societies be shut down to avoid hospitals being overrun, or was that an overreaction? How would people respond? Would wearing masks have any significant effect?

The COVID-19 episode was a real-time experiment illustrating an array of deep conceptual difficulties inherent to modelling

as an activity. These are often overlooked, especially by the public. Thompson's expertise and experience is in climate modelling and weather prediction, and her book offers a delightfully informal yet penetrating survey of modelling issues by someone who has been thinking deeply about them from well before the COVID-19 era. Her message is that we should all learn to use models more safely – and also learn when not to use them. Models are hugely valuable, but we need a healthy respect for the risks of confusing Model Land for the real world.

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Thompson highlights several modelling issues that arise repeatedly, especially in this era of big data. As the world is increasingly “awash in data” coming from satellites, sensors, mobile phones and computing devices, scientists might think they can just “stick to the data”, and so avoid modelling, but this is clearly impossible. Data, without an interpreting framework, is “a meaningless stream of numbers”. You can choose which kind of model to use, complex or simple, but you will still be using a model – even if merely analysing your data on the back of an envelope.

A second and perhaps more troubling confusion, Thompson argues, is thinking that models can somehow be developed in a way that is free from values, ethics or politics. Scientists seeking intellectual cleanliness may hope to avoid such influences, but it's not possible. Whether in models developed for climate, epidemiology or traffic management, modellers make decisions of what to include and what to exclude, and these decisions ultimately rest on goals reflecting extra-scientific values. Once in use, models become more than tools for scientific analysis – they are also tools of social persuasion and objects of political contestation, often used in ways

the scientists developing them could never have imagined.

But perhaps the greatest problem with models is something no modeller is likely to see as a problem – using them is good fun! “Model Land is a wonderful place,” says Thompson, because in Model Land “all of our assumptions are true, we can really make progress on understanding the model and how it works. We can make predictions. We can investigate many different configurations of the model, and run it with different inputs to see what would happen in different circumstances.”

A researcher can build a comfortable and rewarding career in Model Land. Many scientists do, and such work is valuable. But if models are to be useful for decisions in the real world, scientists also need to understand the pathways by which they can escape Model Land, and see the risks blind trust in their models brings. Models aren't good or bad in any absolute sense, just useful or not for different purposes. Scientists who become trapped in Model Land forget this at their peril.

Models also need to be adapted to the task at hand. For example, early on in the COVID-19 epidemic in the UK, some large-scale academic models made alarmingly large projections for the likely number of deaths in the absence of public health measures. They were immediately subject to vicious criticism on various technical points in the software of the models. Yet there was no need then for a complex epidemiological model to make a crude projection of the likely number of deaths, which could be done in a few lines of algebra on the back of an envelope. The criticisms totally missed the point. The question, in part, determines what's needed in the model.

In all, *Escape from Model Land* is a refreshing and fearless examination of the strengths and weaknesses of scientific modelling, and its interaction with the habits of the human mind. In an era of increasing public distrust of science, it might be tempting to defend modelling as something always done in a legitimate scientific spirit. But the truth is messier – modelling is hugely valuable, and also the source of much confusion.

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