Uncertainty and the future

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One of the most interesting things to emerge recently (by which I mean over the past 5 years) relates to the treatment of uncertainty. The extent of shared statistical underpinnings across ostensibly very different subject areas often comes as a surprise to outsiders.

For all their individual idiosyncrasies, much econometrics would be instantly recognisable to an engineer. Indeed, the concept of signal extraction from noisy data has been directly lifted from engineering. Likewise, the similarities between the kinds of time-series analysis widely used in finance and economics and much spatial modelling in geography are undeniable. Epidemiological modelling, incidentally, operates within the same paradigm.

Yet perhaps this isn't as surprising as it should seem. The probabilistic underpinnings do not vary, being governed by laws that follow inexorably from the axioms of probability. Much of this is common sense (on a fair die you have the same chance of rolling a six as rolling a one), but a great deal is not.

An (in)famous example, is the case of Sally Clark, in which the so-called "prosecutor's fallacy" led to the wrongful conviction of an innocent woman in the late 1990s. In this case, an expert witness and numerous legal professionals – all highly intelligent people – failed to properly apply Bayes' rule and a miscarriage of justice was the result.

Two other (linked) mistakes that occur frequently are to assign excessive weight to point estimates (e.g. "Brexit will cause a 3.4% decline in GDP by 2030") and to assume that because estimates disagree dramatically they are worthless. The former is often done by the media (who will tend to take a number that agrees with their preconceptions or those of their audience). Yet go to the original research and the results are usually heavily caveated and contain a confidence interval (e.g. "between 2.2% and 4.6% of GDP).

Even this understates the level of uncertainty inherent in such analyses and academics are complicit here. After all, we love to believe that we are “correct”, that our model of the world captures the “truth”. In reality, the level of uncertainty is much greater than that suggested by our results because of model uncertainty – what if our underlying assumptions are wrong?

There are ways of dealing with this uncertainty – Bayesian model averaging being a key method – although this tends to sit uneasily with many who are wedded to Popper’s “hypothetical-deductive” approach and grounded in frequentist statistics. We typically compound our errors by failing to appreciate that in the real world, probability distributions are sometimes skewed in one direction and typically are surprisingly “fat-tailed” (outcomes far from the average are much more likely than we assume) – *leptokurtic* for those who like complicated words!

So what does this mean for how we treat uncertainty back in the real world? We can’t rule out extreme outcomes and we need to be better prepared for “extreme” eventualities. Take pandemics, for example.

In all probability, this will not be the last pandemic during my lifetime, although I sincerely hope that it is. Why do I make such a statement? After all, history would suggest these are once-in-a-century events: the last deadly pandemic was the (misnamed!) Spanish flu.

Unfortunately, much in the same way that severe flooding appears to be increasing frequency, we cannot be sanguine that historical norms will continue to apply. We’ve had a worrying number of near-misses in recent years and they appear to be getting more common. Even I (not an expert in the field) can name several in recent years – SARS, MERS and “swine flu” – not to mention the emergence of several other deadly diseases which spread less easily (HIV and Ebola being obvious examples). How do we change our behaviour if we treat the emergence of a virulent pathogen as a one-in-twenty event rather than a one-in-one-hundred one?

Of course, while they’re at the forefront of everybody’s minds right now, pandemics are hardly the only challenge we face over the coming decades. Two that are readily identifiable (and hence can be mitigated) are antibiotic resistance and climate change. In both cases, the mitigation strategies are obvious in theory but challenging to pursue in practice.

Both represent problems of coordination relating to what the economics profession terms “externalities”. When I drive a car, much of the “cost” is borne by other people. If the greenhouse gases emitted by my exhaust change the climate such that drought is more likely to afflict Sudan or flooding is more likely in Bangladesh, the cost is borne by the people living there, not me.

Similarly, if the fumes from my exhaust cause lung damage to people living in central Birmingham as I drive past, they bear most of the cost of that (through ill-health and shorter lifespans), not me. Of course, I bear (some of) the cost of other peoples’ exhaust fumes. Theoretically we could all come to an agreement to drive less and everyone would be better off (I’d be inconvenienced by not driving but that would be more than compensated for by better health due to fewer exhaust fumes).

Sadly, the costs of bargaining (and enforcement!) preclude coming to an efficient outcome, an insight attributable to the renowned economist Ronald Coase[1]. Much the same is true of antibiotic resistance: the cost of abuse (taking antibiotics unnecessarily) to me is close-to-zero but the cost to the world is high.

In all cases, the outcomes are highly uncertain. We don’t know their precise impact. However, since extreme outcomes are so devastating and we cannot rule them out, the lesson is that we need to take quite strong actions to minimise their probability of occurrence.

In an ideal world, that involves close co-operation across the whole species. Unfortunately, that’s unlikely. We can, however, act unilaterally. That means appropriately taxing carbon domestically and on imports in terms of climate change. It also means rapid investment in renewables, potentially including elsewhere in the world as an act of altruism.

We can dramatically increase research funding into new antibiotics and eliminate their unnecessary use domestically. We can keep residual manufacturing and engineering capacity even when it is “uneconomic” to do so in order to render a large scale-up feasible if needed (and a pandemic is just one example of this). Over-provisioning is a waste of resources in normal times, but can be worthwhile as an insurance policy in case of catastrophic outcomes.

The lesson of recent years is this: expect disruption and change. They are the new normal.

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1. Coase, R.H., The Problem of Social Cost. The Journal of Law and Economics, 1960. ***3****: p. 1-44.*