A Primer on Decision Making with Uncertainty

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The current coronavirus epidemic has broad to very public attention the frequent need for policy decisions, most dramatically the announcement of the UK government's lockdown restrictions on 23 March 2020, to be made quickly, and on the basis of incomplete information.

The government and the general public receive scientific advice related to the coronavirus from a range of sources. One of these is the Royal Society's DELVE initiative, whose particular focus on data-driven methods (as opposed to modelling, which provides another very important perspective). An immediate difficulty with providing such advice is that there is a great deal that we do not know about the virus and how it is transmitted, and the kind of information we would like takes a long time to obtain, especially if one wishes to apply the usual standards of scientific rigour. But the virus will not wait for us, so governments are forced to make decisions despite many important facts being unknown. This situation is known as 'finite horizon' -- there is a fixed time after which if you have not acted, then the decision is effectively made for you.

What constitutes good scientific advice when there is a finite horizon? With complete information, one can offer a cost-benefit analysis of the various options between which the government must choose. But when the information is only partial, probability comes into the picture, and this becomes a *risk*-benefit analysis.

This can be illustrated with a simple example. Suppose you are on holiday and you visit an island. At the end of the day you need to catch a ferry back to your hotel, which leaves at around 11pm, but you are not quite sure of the precise time. You are running a bit late, and as you arrive at the terminal, you see that a ferry is just about to leave. You do not speak the language and do not have time to check whether it is the right ferry.

One part of deciding what to do will be to weigh up the costs and benefits of the possible outcomes. If you do not get on the ferry, you will probably spend the night on the island, so you will consider what that would be like: whether it would be safe, whether there is anywhere to stay, etc. If you do get on the ferry, then you may end up back at your hotel, which is the ideal outcome, but you may perhaps be taken somewhere else, where you will arrive, late at night, not speaking the language.

Another part of the decision is assessing probabilities. For instance, if there are very few ferries, then you may judge that it is likely that the departing ferry is the right one, but if there are many, then you will be less sure. This assessment will have an important effect on your decision: the more likely the ferry is to be the right one, the lower the risk of ending up in the wrong place, and therefore the more sensible it is to jump on.

DELVE comprises a highly diverse group of experts from public health, epidemiology, economics, immunology, mathematics, statistics, machine learning and psychology. The group aims to offer the best policy advice it can, on the time frames where that advice is

useful. Its reports assimilate evidence from these different fields and advise on the implications of this evidence for policy-making'. Where scientific consensus is available it can give this advice on the basis of that consensus. But where there is no consensus, it can still offer advice based on our best understanding of the outcomes of any interventions that might be made. Often those outcomes will be uncertain: in such situations we try to assess the risks of the interventions and the likelihood of potential benefits, in order to offer the best possible advice given the evidence we have.

For example, DELVE recently reported on the use of face masks, concluding that more widespread face mask use can help reduce the risk of onward transmission from asymptomatic individuals and could play an important role in situations where physical distancing is not practical. The scientific evidence that this would make a significant difference to transmission rates is by no means conclusive, but neither is the scientific evidence that it would not make a significant difference. DELVE judged that there was a reasonable probability that masks would make a difference. For example, if they reduce the transmission rate, then they could potentially reduce the length of the lockdown, and each day of the lockdown is estimated to cost £2.4bn. On that basis, despite the uncertainties, we felt confident in our advice.

A few general points are worth bearing in mind.

1. It may be that as decisions-makers accumulate more evidence, they will come to realize that another decision is better: given how rapidly the evidence is changing, it is important to be flexible and ready to change our minds.
2. In some situations maintaining the status quo until more evidence accumulates is a good default decision. But in an emergency such as the current pandemic, inaction can have serious adverse consequences, so its risks and potential benefits should be assessed along with those of possible interventions.
3. While science has a very important part to play in decision-making, important aspects of decision-making are not scientific. For instance, science may be able to tell us that there is approximately a 1% chance of a certain catastrophe occurring, but science alone cannot determine how much money it would be worth spending on interventions to reduce that chance to 0.5%.

In summary, because there are many uncertainties associated with the situation in which we find ourselves, we will often have to make decisions in the absence of a scientific consensus. That need not prevent us from making good decisions. We should look at the evidence in order to assess the probabilities of the possible outcomes of any intervention and the likely costs and benefits of those outcomes. This will not always make the decisions easy, but it will give them a much better foundation.

Note. The authors are members of the DELVE Working Group, but are writing in their personal capacity. A good starting point for further reading is a blog-post by LSE Economists Matteo Galizzi, Benno Guenther, Maddie Quinlan and Jet Sanders:

https://coronavirusandtheeconomy.com/question/risk-time-covid-19-what-do-we-know-and-not-know