Video: The real risks of a pandemic

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The COVID-19 pandemic is a reflection on our society and shows us just how vulnerable we are, despite all the advanced mathematical models that are supposed to make policy- and decision-makers aware of the potential risks associated with a pandemic.

"Yet," write scientists Pasquale Cirillo (TU Delft) and Nassim Nicholas Taleb (New York University) in their recently published paper in *Nature Physics*, 'most of these models do not look at the tail risk of infectious diseases, and there is very little questioning of the reliability of the various parameters." According to the scientists, extreme value theory (EVT) offers a solution for modeling the actual risks of a pandemic.

Extreme values

But what is extreme value theory? It is useful to know that this theory is primarily used to model the risks in an out-of-the-ordinary situation. And in particular a situation in which something breaks down or threatens to break down, not through a gradual deterioration but a sudden overload. Examples of this include a freak heatwave, a meltdown or high water along the coast after a period of heavy rainfall. It is a theory that both scientists actually use with great regularity. "Personally, I have used extreme value theory from time to time for modeling market, credit and operational risks, as well as for analyzing the number of victims in armed conflicts or in times of terror," explains Pasquale Cirillo.

Smallpox plague in Montreal

Extreme value theory enables you to model extreme deviations from the median. The theory focuses mainly on tails, that is the part of a probability distribution relative to very large or very small values. The frequency of occurrence of extremes depends on the thickness of these tails. In their paper Tail risk of contagious diseases, Cirillo and Taleb explored several major pandemics in the history of humankind. Epidemic jaundice, a smallpox plague in Montreal, an outbreak of measles on the island of Fiji: countless datasets were turned inside out. "We studied the distribution of the fatal victims of major pandemics throughout history (over a period of around 2500 years) in order to build

a statistical picture of their tail characteristics. We can use extreme value theory to show that the distribution of victims of infectious diseases is extremely fat-tailed."

Correction mechanism

Besides looking at extremes, Cirillo and Taleb also applied their own dual distribution method. Cirillo explains: "If we examine the data, the variability is so great that you might be led to think that the risk of a pandemic is potentially infinite and that a single pandemic could destroy the entire human population of the planet. Although there are many risks associated with infectious diseases and they should certainly not be underestimated as some politicians tend to do, we show that the risks are not infinite. The dual distribution method acts as a correction mechanism; it makes sure we are not tricked by the data."

Risk theory

In the past months, the whole world has been in the grip of the coronavirus outbreak, as has Cirillo. Yet estimating disease risks is not the natural domain of this TU Delft researcher. "Although epidemiology—preventing the occurrence and spread of diseases within and between populations—is not my field of research, I have been working together with doctors and medical specialists for years as a statistical advisor and I find the data they gather very interesting. Moreover, risk theory—which is my field—can be applied to countless things, including pandemics. If you are interested in policy decisions, then you cannot ignore risks and you have to be able to rely on models. If there is one thing that COVID-19 has taught us, it is that mankind is not all-powerful."

More information: Pasquale Cirillo et al. Tail risk of contagious

diseases, *Nature Physics* (2020). DOI: 10.1038/s41567-020-0921-x

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