A Conversation With Prof. Paul Embrechts on the upcoming book: "Risk Revealed: Cautionary Tales, Understanding and Communication"

Author: Prof. Paul Embrechts

Interview By Isabel Britez

Abstract

I interviewed Professor Paul Embrecht, emeritus Professor of mathematics at ETH Zurichs' and the Risk Center Ambassador at the same institution. The theme of our conversation was his next book, "Risk Revealed: Cautionary Tales, Understanding and Communication" to be published by the Cambridge University press, and co-authored with Valérie Chavez-Demoulin (Lausanne) and Marius Hofert (Waterloo). The authors explore, through examples of risk-based decision-making, how statistical tools from the realm of Extreme Value Theory can be widely used. They also highlight the struggle of communicating extreme events, and how episodes such as the pandemics amplify these difficulties.

Keywords: Extreme Value Theory, extreme events, risk modeling, quantitative risk management, risk mathematics

Una conversación con el profesor Paul Embrechts sobre el próximo libro: " Riesgo revelado: cuentos de advertencia, comprensión y comunicación"

Resumen

La entrevista se refiere a un próximo libro, que será publicado por Cambridge University Press, en coautoría del Prof. Paul Embrechts (ETH Zürich) con Valérie Chavez-Demoulin (Lausanne) y Marius Hofert (Waterloo). Presentaré algunos ejemplos de toma de decisiones basada en el riesgo y mostraré cómo las herramientas estadísticas del ámbito de la teoría del valor extremo pueden usarse como parte de la solución. La pandemia actual ha demostrado claramente que la comunicación de evidencia científica tiene una posición difícil en el entorno omnipresente de las redes sociales. Destacaré esta lucha.

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Palabras clave: teoría del valor extremo, eventos extremos, modelización del riesgo, gestión cuantitativa del riesgo, matemática del riesgo

与Paul Embrechts教授就即将出版的新书进行对话：《揭示风险：警示故事、理解与传播》

摘要

本文进行了一项访谈，访谈主题为剑桥大学出版社即将出版的一部新书，后者由Paul Embrechts教授（苏黎世联邦理工学院）、Valérie Chavez-Demoulin（洛桑大学）和Marius Hofert（滑铁卢大学）合著。我将展示一些基于风险的决策示例，并表明极值理论领域的统计工具如何能用作解决方案的一部分。当前的大流行清晰表明，科学证据的传播在无处不在的社交媒体环境下遭遇困境。我将强调该困境。

关键词：极值理论，极端事件，风险建模，量化风险管理，风险数学

Introduction

The book is to come out sometime this year (2023) with Cambridge university press. And you will see the title though the title changed a bit, but we want to review various aspects of risk. The important subtitles are 'precautionary tales, understanding and communications', so the book's whole idea is a transition from the more technical books I wrote in the past about extremes and quantitative risk management. The first was more on the mathematical side of extremes, and the second was more about finance and insurance. Now we wanted to reach a general audience. Although they still need to know a little bit of the basics of mathematics, we introduced what is needed.

First chapters and examples

What is very important in the book is that in the six or seven first chapters, we introduce various very concrete examples of risk disasters. No technicalities. Floods, earthquakes, tsunamis, Fukushima, the financial crisis, and the coronavirus. Moreover, we discuss them from a general risk perspective and explain to the audience, the readers of the book, what kind of questions are asked.

Just one example, that is the first example in the book: in 1953 when a serious flood happened in the Netherlands, should the government start building dikes and strengthening the existing ones for a one in ten thousand years event? This is already a very difficult topic you want to convey to the general public and politicians. What does that mean? How do you estimate that? How do you map this timescale of ten thousand years to today?

I think this is one of the key aspects of the book, that it keeps on going back in all the examples: how do you estimate it from data? For important areas in different ways, but how do you communicate that and convince politicians about actions needed to be taken?

The core

From that, we go into a central part of the book, which is basically, as you saw, different ways of communicating that and how you can convince politicians about actions needed to be taken. From there we part to a central part of the book, which is basically a hike in this field.

When the stories are finished, we get to basic mathematics, in such a way that is only aimed to discuss the examples from the beginning in a bit more detail. For instance, how do you estimate a one in ten thousand years event? How do you estimate the maximum sea high? How do you estimate or communicate certain aspects of the coronavirus? Exponential growth, etc. So what technology do you need at minimum to understand and convey the message to the audience?

Data

I could add that for all the examples we included, and there are about four or five main examples, we really explain to the reader very much in detail where we get the data from. Because you cannot just open a drawer somewhere and look for data. A lot of work goes into pre-processing and understanding.

Climate anomalies

For instance, we look at anomaly data for temperature, that is a very long data set for England, even going back to the seventeenth century. In what form can you prevent, analyze and apply the learnings? This is also relative to Brazil, because there is a specific time of yield in agriculture, and climate plays an important role.

Of course, we have a discussion about climate change through various examples. It is not a book on climate change by any means, but we discuss it.

The final part

Moreover, under the final straw, we give some examples we hope you will find interesting. Then we sort of roll out and talk a bit about networks, we talk a bit about the famous case in actuarial science of, well the black tulips. I don't know whether you know the story, but the tulip mania in Holland was one of Stockholm's first bubble experiences. Was it a bubble or not, and how do you communicate it? I mean, communication is very important. So that is an overall aspect of the book.

Cartoons and figures

It has a lot of figures in there which are produced mainly by us. Moreover, it has twenty-two cartoons, because the husband of my co-author Valérie Chavez-Demoulin is a professional statistician and an outstanding cartoonist.

So, here are aspects of the book; when you open it has an appealing visible appearance. It is not just dense mathematics, not at all. Not just dense text. It is a vast combination, but people will have to work.

Who should read this book?

That is an interesting question I've been discussing with my wife for the last two years. It is something that came out, ah, I started discussing when I wrote. She would immediately ask, but who is the person you are writing to? It is a very difficult question to answer. First, it's a book, let's say, ideal for people interested in risk, interested in learning about risk, and interested in investing a bit of time in going through some of the more statistical details.

Surely all students from universities, from specialized schools with a bit of background in mathematics should be able to read the book. It would be difficult for those who are too afraid of formulas, but there's still enough material there. I mean, I tell you the story in the book about how Galileo defended heliocentrism in the seventeenth century concerning the inquisition; it is a wonderful story. How he defended that through a three-day text called Dialogo, the dialogue in which different philosophers and people discussed for four days the pros and contras of this heliocentrism, that any person should be able to read. So there are various longer pockets in the book that everybody can read.

Everybody should be able to read the first six or seven chapters. The last three also. For the more strenuous middle part, which is long, you can definitely take it out. Let's say I have a little interest in this simulation, or I'm a bit interested in how you estimate an extreme event. Or how do you describe a record? How do you communicate record rainfall or flash rains? Let's say, as we saw after Aida in New York. How do you communicate what happened around the mudslides in Brazil? How do you look at that before an event? What were the discussions before the event, and where did people react poorly

Communication

The L'Aquila earthquake happened in northern Italy on April 6th, 2009. The way the earthquake goes: it was a 6.3 earthquake, a moderate earthquake, nothing like to the 1960 Chilean earthquake or the 2011 Fukushima earthquake. But as a consequence of the pre-discussions, the warnings, and political discussions, Initially, six scientists were convicted. That's a major thing. Yet, in the end there was a very, very in-depth hard discussion about how science communicated, and a major issue you will always find through the book is evidence-based communication. In the case of the 2015 Brazilian mudslide, you can tell there is an emotional side and one environmental side, but if you look at the scientific background, the scientific information, and the scientific evidence, how do you communicate that?

Communication - social media vs. science

And there is always the tension between us scientists to communicate based on scientific evidence, and we just go slower—peer reviewing, testing and all that. Whereas, on social media, it is instant. We always doubt ourselves. A mathematical proof is checked, is correct, and there is no doubt of evidence. But scientific communications enter this road of risk. We are always questioning our hypotheses, we test them, and keep asking questions. That's how evidence-based communication goes. If you go to social media, they are instantly sold as a hundred percent truth. That's a huge difference.

The if to the 'what if'

Secondly, in French, you say *fil rouge*, the guiding thread throughout the book. It is all about the difference between *if* and *what if*. A *'if'* risk is a frequency; this event may happen once in ten thousand years, and people can say well, one in two thousand years is so rare I don't care about it. No, no, that's not what I mean. You should go from *if* to *what if*. You should ask the question, but if it happens. If, even if very rare, what are the consequences? If the consequences are enormous, then you better take action.

Precautionary Principle

A crucial aspect that we also mention in the book, especially in the corona case, is the precautionary principle, which comes from the medicine Semmelweis hospital in Vienna - that's a story in the book. *'If'* there's something new, like climate change. We know climate change has many consequences, and proving casualties is not easy. People might say well, this is so rare that this or that happens, that's true, but given if the temperature increase is two degrees, what are the consequences?

What if

People may discuss well; it may not be two, perhaps it is one point two. Whatever. But 'if it were two degrees what are the consequences? And in these climate consequences are now so enormous that we better start doing something. And the same is true for the coronavirus. We didn't know in the beginning ah, and I wrote part of the book sitting in lockdown in Switzerland; we didn't know the exact consequences, but we knew that if certain rare events would happen, like the spread of the disease, or a super spreading of the disease, that we had a high threshold of serious illnesses. And if preceded, we would have many problems in the hospitals. So this 'if' warning is always important, financially also.

Fukushima

The Sendai earthquake was an enormous earthquake, depending on how you measure it. Let's say a nine-point zero or nine-point one on the moment magnitude scale, an enormous earthquake a couple of hundred kilometers from the coast. There were two main nuclear power stations. The first one everybody knows, and you know it too, I'm sure: Sendai, well, Sendai nuclear power plant where you had Fukushima - Daiichi one and two. Everybody knows these names: Fukushima, meltdown. The world is reacting now because of energy, turning away from nuclear energy. And there's a huge discussion now because of Fukushima. Of course, we had Three Mill island before and Chernobyl before. Still, Fukushima woke up many people and politicians around the world.

What only a few people know is that a couple of hundred kilometers north of Fukushima, there is a town called Onagawa. Onagawa was even closer to the epicenter of the quake. They also had nuclear power plants, but they could stop the plant and restart it without significant problems. Both sides, Fukushima and Onagawa, had fourteen, up to fourteen meters of tsunami waves. Fukushima had only about six meters of sea walls. Onagawa had a 14 meters seawall. Why? Because the engineer who started the Onagawa project was extremely stubborn. He was so stubborn he said: of course, I know that the probability of a 9.0 earthquake is very, very, very remote. But given that it happens, that we have such a high wave, the consequences are catastrophic. We've seen that.

So these are examples we discussed. This *if* to *what if*. Don't put it aside from a very rare event and say it's rare. It's not on your radar screen. Keep it on your radar screen, do the mental exercise, and do the discussions of 'if it happens, what are the consequences?'. Making a seawall with six to fourteen meters is relatively little money compared to the enormity of losses that Japan and the whole world experienced. And then, of course, the discussions of how the politicians get involved comes. You really have to go to the local discussion of the very specifics and look at government reports and look at lines of communication—those things we also discuss in examples.

And when you say that communication is really relevant. Could you see patterns of communication that happened and prevented extreme risk events and patterns that could've avoided it? Or is every extreme event special and unique on its own?

That's a good question. Presumably, because of the geographical situation, every major unique event is a catastrophic event. Well, as a rare event, which is a statistical statement, but it is a catastrophic event when people are involved and people die. I mean, that's a little of the language chosen.

So from that point of view, the underlying theory is just a theory that is useful.

Katrina flooding

Knowing it and getting the 'what if' thinking more into the ears of the politicians is important. For example, there is New Orleans. You know of the Katrina flooding in New Orleans, which was a disaster. After that flooding, the US corps of army engineers called me, and they asked me (because they knew I lived close to the Netherlands) 'can we use extreme value theory?', so we discussed a bit, and I got in contact with experts in the US.

As a small consequence, New Orleans started to rebuild its defenses. They do not call it dikes in America; they call levees there - from the French word 'levée.' And they built their dikes, pumping stations, canals, etc., warning systems for people that prevented hurricane's Ida major flooding last year. That 'if' clause improved internal communication, which went well there. Unfortunately, in too many examples I know, the communication typically starts after the event. That is human nature, and we can only begin to venture by pressing people to the scenario thinking, the *what-if* thinking. It is clear that we have to build a higher dike, or in the Brazil case, we have to do different handling of the deposits of the companies there. That's clear. But you see that when these disasters crack, it is much, much worse.

And I'm thinking about Brazil, but about all of the examples. In the city next to Fukushima, you told me people had prepared before and were prepared for an extreme event. You also told me the technician was very stubborn. Besides stubbornness, what do you believe leads people to think in a 'what if' mode? And what could increase this?

I always have to go by examples, I think. So referring to the main example throughout the book, which is the dutch dike disaster. Why the Dutch dikes? I was born two days after the barriers broke in Holland on the 3rd of February of 1953; the dikes broke on the 1st of February. So I have always been very close to where that happened. So that always followed me, my life as an example. A lot of Extreme Value Theory was developed out of that.

Now, in the book, we discuss the whole political discussion. What politicians were able to accept and how the politicians, in the beginning, did not want to talk about uncertainty. They were happy that they'd got a number of five meters but didn't inform the public about uncertainty. The world is different now. First of all, the world has to accept uncertainty. Full stop. The second thing is the risk measurement you choose. You cannot build a dike with any guarantees. To match the risk measure you'll use, in that case, near the coast of Holland, it was a one in ten thousand years event.

Now how do you communicate that? How do you convince the government of even a one in one hundred much lower year events? Then, the whole problem is that the communication of one in so many years is not a very good one - it should be done daily. You should ask yourself, ok, so one in ten thousand year event. This interpretation is the following: we want to construct a dike with such a height that at the beginning of the year, the maximum water level will not go over the dike with a high probability, or will go over the dike with a chance of one in ten thousand.

And that is repeated every year. It's like you stand on the top of your dike at the beginning of the year, take five dice, throw them, and they are all six. That probability is about one in ten thousand. Ok? You go there every year, and if there are no five sixes, you will not have a dike overseas.

So you can already communicate those rare events in the experiments that people know. Or you can go to the Casino, and you get 19 times richer in the Casino; that's about one in ten thousand. So it happens in some cases. You first of all want to inform people about this event and then start discussing the mechanical situation. You talk about the mechanical life cycle of, in this case, a dike. A dike has existed for about one hundred to two hundred years.

I can make the same story by the way about nuclear power plants. But let's focus on the dikes. Let's say the lifecycle of a dam is two hundred years. So after two hundred years, it goes through significant changes. Then, the real question you should ask is, what is the probability of a catastrophic overtopping of the dike during its 200 years lifecycle. So now you are staying on the top of the dike, and you're throwing your dice and you calculate the probability that at least in one of those two hundred years an overtopping of the dike happens. And if you calculate, that's about 10 percent. See?

So bring it back from this far distance; ten thousand years surely will not be here. I am curious if the world will be here, but bringing it back to today and thinking about communicating makes all the difference. So that's an aspect we discuss in many examples.

In one of your talks, you mentioned the economic Nobel prize of 2018 that proposed a solution to carbon emissions. So if you think about climate problems now, what would you suggest for you to say—well, for us to protect our city from the rise of the oceans? People still think this is far even though this is happening in thirty/forty years maximum. How can we use the same logic for diminishing a time series so that these problems seem closer to the population and politicians, which can have a tangible impact on what's been made?

I would say educate the politicians and the country. Again, if you look at the dutch case, I use this example because I've studied it in very much detail. If you look at the Dutch case now, the dutch are already thinking of going from one in ten thousand to one in a hundred thousand because of climate change and the IPCC reports. The latest update is from 2019, and they started looking at climate stress scenarios and seeing what that means for their countries.

You must realize that, in Holland, more than *fifty percent of people lie below sea level.* At or below sea level, there is an existential danger for that country, but every country has its own existential threats, especially in the current geopolitical difficulties.

We have to look at the relevant, possibly rare events we should take care of and seek what we can do in the near future. That's called more environmental work by not only reducing too much plastic and things like that - these are environmental concerns that we could do, we should do that instantly. Separating your garbage and all that can be done. But some extreme climate risks are thirty, forty years from now. There is, again, the precautionary principle. I'm not an expert, but I don't have causality proof of the rising temperatures in so many years.

Evidence-based decision-making

At least, I can look at the various scenarios, and if they go from the rise of a certain temperature to a much higher, and if you say, well, that in the lower temperature, we can just keep on polluting, and that doesn't matter. But if the higher temperature in my uncertainty interval tells me that we are in big trouble, then we better start acting to prevent it from becoming sufficiently high. We must be able to make evidence-based decision-making and communication in a world governed by uncertainty, and there is no trick to that.

I've been giving every example. Again I come back to the Dutch case because it is all there. The Dutch primary dikes are at particular spots at sea. And I can replace the word dike with everything. If it goes above a certain level, in this case, three meters at a certain point, major dams close. But we don't close the dikes like in the old days, with a man or a woman standing there with a wheel closing the barriers. No, these are driven by enormous computer programs. Now, computer programs can be hacked. You embed in your system protection in cyber risk, and many people forget that.

There are many increasing precautions we need to take in society. This also happens with dike constructions. We say, 'if the water is high enough, we push a button, and the dikes close.' But someone can push another button and say, 'well, you pay me ransomware, or you cannot have your computer back.'

These are things that we should discuss more. Throughout the book and also throughout my work, the main work is really interdisciplinary work. Meaning for example, engineers, statisticians, economists, sociologists, psychologists, and medical people are back in the pandemic. We have to sit together and decide if we'll lock down. Perhaps just too late, we discussed the psychological consequences for children, for real people. We have talked about long-term COVID on the medical side, but what is long-term covid on the psychological side? It's serious; I'm sure it's serious. You see that we should really think about major risks. We should really think about how to bring from early on different experts together and listen to them.

Moshe Szyf's work regarding transgenerational epigenetic transmission talks about that. Specially the "long-term effects of early-life stress on depression vulnerability'[1]

1 https://www.futuremedicine.com/doi/epub/10.2217/epi-2021-0483

I didn't know this example, but this is exactly the kind of example I was alluding to, what I called long term covid psychological and medical problems. There are many aspects, and if we bring them in our discussions early on, then at least you are warned. The best guard against risk is to really inform yourself about the various aspects, because it's such a multifaceted theme of serious risks that it's never only *this little thing*. And I think our society, and also our academic society, still work a lot in compartments. For proper risk management you really have to go out there, and it makes it exciting to work. It is not easy, but it is exciting.

We are talking about uncertainty, and about events that once happen have extreme consequences. How do politicians prioritize which uncertainty they should work with?

That's where the difficult transition from scientists to politicians takes place. First of all, scientists have put all the best scientific evidence facts on the table; that's our job. Politicians, in any democratic country, are chosen by the people to make decisions. Scientists should not make decisions; they should be listened to. And there are alternative views. There are alternative views on prioritizing risks. Of course, this is much more difficult in countries that are not as developed as other countries, where basic nutrition and medical provision are perhaps much more important than some very specific issues, such as cyber risks.

I don't know, this is a very difficult thing, and in certain countries, like the Netherlands, it's clear that they have to prioritize their coastal defenses because the country is so vulnerable in that aspect. However, you asked how we rank vulnerabilities to society, but then you are not far away from how you rank loss of human life to loss of infrastructure. Of course, in every problem both enter, because if a dike breaches, people die, and economic losses occur.

Ethics

And nobody will make an equation out of that, but this is discussed. I can tell you about many of these problems. People take these components very seriously, but then, of course, we weigh them with our own social values, and again, it is a very difficult question because it is not that far away from ethics. I think it's very good for science, and also, the risk management world is really looking at the question of ethics much more carefully.

I know about this in the modern world of insurance and finance. And I can give you several examples there, but I mean, in all these discussions, we can talk about longevity, discuss longevity in the books. Investigate people living longer and longer lives and how ethical it is—we expect to invest a lot in that part of research in, let's say, baby food, to mention as an example. So if there are social values for each individual, together with a sufficiently broad group of people that are not just trained scientists, you must be able to find a solution; the best solution doesn't exist.

And where do you find the most significant examples of this cooperation happening?

Pandemic

Again, the pandemic. That's why people can buy the book. If they only read the chapters with the examples we discuss in the book at the beginning of the first chapter and analyze the data later, they'll have learned a lot. So this is what is happening. In the medical field around coronavirus, it happened too late. Many, many reactions to the virus, political reactions, were based in epidemiology, virology, and biology, which is fine. It was clear that too little input came from psychology, sociology, and so on. Much too late. So there it happened too late.

IPCC

I would say the environmental arena. If you look at the IPCC reports, there is a lot of cross collaboration there, but on the other hand, it also depends very much on the democracy you live in. There are countries where it is naturally built in that we have a coherent, much brotherly support political system. Switzerland, let's say —we have different political parties, but we have decision-making where all the parties are involved. In contrast, you have countries where it is more dogmatic.

Political landscape

So if it is in the first one, you will much more readily arrive at a solution supported by different areas - think of social insurance. Sending viable pension plans. If that already is based on a broader political landscape where there are specialists, actuarians, statisticians, or whoever, that is already a good thing. It is more difficult in countries where we don't have such a broadly supported system. That's what we now see in the US. Democrats and Republicans are so opposed in decision-making, making it difficult to find a coherent solution.

References

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