Paul Embrechts: Mathematics, Insurance, Finance >>>

Paul Embrechts

Interview of Paul Embrechts by Y.K. Leong

Paul Embrechts has made important and extensive contributions to insurance risk theory, quantitative risk management, mathematical finance and the modelling of rare events.

Embrechts had his undergraduate education at the University of Antwerp in Belgium and obtained his doctorate from the Catholic University of Leuven in 1979. Subsequently, he taught at Imperial College, University of London from 1983 to 1985, immediately after which he moved back to continental Europe where he established a long and distinguished career, first at University of Limburg, Diepenbeek (1985–1989) and then at ETH (Eidgenössische Technische Hochschule or Swiss Federal Institute of Technology) in Zurich where he is full professor of mathematics since 1989. He is the current Director of RiskLab-ETH, which was founded in 1994 as a virtual research cooperation and which he helped reorganize in 1999.

His scientific papers, both single-authored and co-authored, number more than 160 and have made important contributions to actuarial risk theory and risk theory in finance and to mathematical modelling in insurance and finance, in particular, modelling extremal events, econometric modelling, modelling dependence beyond linear correlation and modelling uncertainty in insurance and finance. He has co-authored a number of books and monographs, the most influential being *Modelling Extremal Events for Insurance and Finance* (co-authored with C. Klüppelberg and T. Mikosch).

He is a strong and active advocate of dialogue and interaction between academia and the finance, insurance and energy industries. In addition to serving on the editorial boards of a number of leading journals on finance, insurance and statistics, he has given consultative services to major financial institutions, insurance companies in industry and to international regulatory authorities in Europe and the United States.

Since 1987 he has been actively involved in numerous professional committees of scientific organizations such as Bernoulli Society, Institute of Mathematical Statistics, Foundation for Agency Management Excellence (FAME), Bachelier Finance Society and of universities and research centers in Europe. He has also been active in the organization of major conferences and scientific meetings throughout the world. He has held visiting positions in prominent universities and has been invited to give keynote lectures in many important scientific meetings and special lectures such as the Johann Bernoulli Lecture, Nomura Lecture, Hermann Otto Hirschfeld Lectures, Kuwait Lecture, Humboldt Distinguished Lecture Series, Radon Lecture and Patrick Poon Lecture. He has received honors from many professional bodies such as Institute of Mathematical Statistics, Institute of Actuaries, The Faculty of Actuaries, Belgian Institute of Actuaries and honorary doctorates from Heriot-Watt University, Catholic University of Louvain and University of Waterloo.

Embrechts is a member of the International Advisory Panel to the Risk Management Institute which was established in National University of Singapore (NUS) in 2006 with the support of the Monetary Authority of Singapore. He has close scientific associations and collaboration with the faculty of NUS. He was the Chair of the Organizing Committee of the program "Financial Mathematics" (2 November –23 December 2009), jointly organized by the Institute for Mathematical Sciences and the Risk Management Institute,

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NUS. On behalf of *Imprints*, Y.K. Leong interviewed him on 18 November 2009. The following is an edited and enhanced transcript of the interview in which he gives us a glimpse of the interplay between the abstract in mathematics and the reality manifested in insurance and finance. His ebullience and optimism in the power of the human intellect coupled with unwavering ethical principles in resolving real-life issues and improving the human condition is clearly felt in the interview.

Imprints: What was the topic of your PhD research? Who was your PhD supervisor?

Paul Embrechts: The topic of my PhD research was subexponential distribution functions; it's applied probability and essentially modelling of extremal events in insurance. My supervisor was Professor Jef Teugels from the Catholic University of Leuven. He's very well-known here in Singapore. He's the President of the International Statistical Institute (ISI) [(2009–2011)].

I: Did your PhD research have anything to do with your future work?

E: Oh, yes. From the start of my research — concentrating on the modelling of rare and influential events — "catastrophic risks" — was very much present in my work. So it led to applications to various fields including finance and insurance. In that sense it had a very strong influence on my later career.

I: You taught at Imperial College, London from 1983 to 1985 and then returned to Belgium. Did you ever consider going from London to the US where both the academic and financial attractions must have been irresistible at that time?

E: When I finished my PhD in '79, with my family I immediately went for a postdoctoral to London to work with Nick Bingham at Westfield College. In those days, Westfield College was part of the University of London and I was doing more mathematical research but still on extremal events. There I got an offer by the end of that year to go to the United States, to go to the University of Colorado at Fort Collins, then a world leading place in extreme value theory. For family reasons I did not accept; we had already two children at that time. Concerning the attraction of finance, indeed the United States had a lot to offer. You must, however, realize that my field of research together with specific applications was much more related to insurance. When it comes to insurance then Europe, especially the Continent, has much more to offer. The reason is that in the United States, and to some extent also in the UK, examinations and teaching are very much in the hands of the actuarial societies, the Society of Actuaries and the Casualty Actuarial Society in the US, or in the UK, the Institute and Faculty of Actuaries. On the Continent — Belgium, the Netherlands, Germany, Switzerland, etc, teaching is typically done at departments of mathematics, by their professors. As a consequence, we do more methodological mathematical research. We are also less dependent on the local actuarial societies, though we work together closely. So from the academic point of view, if you are interested in doing research in finance and insurance — for finance, yes, the USA in those days; for insurance, with a much stronger emphasis on mathematics, you came to Europe though, of course, several excellent centers exist outside of Europe. I remember, at Imperial College in those early days, I even started with some colleagues from other UK universities (Heriot-Watt, Edinburgh, Imperial College, City) meetings of lecturers in actuarial science. We brought together people with a common interest in the teaching of actuarial mathematics; we were very few in those pioneering days! Moreover, the stochastic modelling of extremes was also very strong in Europe, leading to an optimal combination for me.

I: But nowadays you are more interested in finance than in actuarial science.

E: Well, I'm still professor of mathematics, and as you know, ETH Zurich has a very strong department of mathematics. As professor of mathematics I'm responsible for teaching and research in actuarial mathematics. When I came to Zurich in '89, it was immediately clear to me that combined teaching and research in actuarial mathematics and mathematical finance would be very important going forward, like in industry, combining asset and liability management. So I started building up a research group both actuarial and

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finance centred, including the foundation of RiskLab in '94. Why '94? Because of the new capital adequacy rules for banks, the so-called Basel I and Basel II guidelines, the financial industry became increasingly interested in teaming up with academia. We started in the beginning with the three main Swiss banks, later expanded through Swiss Re, a reinsurance company. The key structure was a "triangle", the key concept "precompetitive research". The former refers to collaboration between academia, the financial industry and the regulators; the latter stresses that we wanted to do interdisciplinary research, the results of which would be available to all. In academia it is easy to say "We have to do interdisciplinary research"; it's much more difficult to actually do it. Modern academic establishment with all its indices and rankings is not really valuing that very highly. Publications in pillar-thinking top journals are asked for. Anyhow, in October 1994 we started RiskLab with the three players — academia, the financial institutions and the regulators. We roped them together and asked: "Ok, what do you think are important topics to do research on?" As a consequence we jointly came up with a number of topics which were of interest to the three groups. We at ETH looked for excellent students; industry collaborated and also financed the research. The combination worked. Many key ideas and results came out of RiskLab. If you look at the various professors at ETH, I am the one who concentrates most on insurance but, of course, now I also do a lot of research in the direction of finance applications. At heart however I remain an insurance mathematician.

I: So in that sense actuarial mathematics actually precedes mathematical finance.

E: Yes, by far. Many famous mathematicians worked on actuarial problems, including such names as [Carl Friederich] Gauss, Nicolaus Bernoulli, [Bruno] de Finetti, [Harald] Cramér, [William] Feller, [Ulf] Grenander. Becoming an actuary has always been a preferred profession for mathematicians. This was especially noticeable in Scandinavia and much related to problems in life insurance and pension funds. Later mathematicians became also sought after in non-life and reinsurance, and only more recently the banking industry entered the job stage. If, for instance, you look at the early editions of the *Journal of the Italian Actuarial Society*, you find fundamental probability papers by such mathematicians as [Francesco Paolo] Cantelli, [Andrey Nikolaevich] Kolmogorov, [Paul] Lévy. By the way, did you know that it was a Swedish actuary, Olof Thorin, who first proved that the lognormal distribution is infinitely divisible? This was published in the *Scandinavian Actuarial Journal*. Actuarial issues are of high relevance to society and we mathematicians have to get involved. I have told several presidents of ETH, "Switzerland has three important problems to solve in the future: social-insurance, social-insurance and social-insurance.", by social-insurance I mean life, health and pension insurance. No doubt the same holds true for Singapore.

I: I believe that Albert Einstein was reputed to have said that compound interest is the greatest invention of man. I wonder if that is true.

E: It is, indeed, generally accepted that in an interview he said something along those lines; we are, however, not absolutely sure. You know, Albert Einstein was a student at ETH just like John von Neumann.

I: Maybe he said in a joking manner.

E: Possibly, however the compound interest concept is a very important "financial force", just ask all those in serious debt.

I: The instruments of modern finance are abstract objects. Which three of these would you consider to be the most fundamental or most important?

E: I would say that the instruments of modern finance are real objects which are partly described by abstract theory. Let me try to give an answer to your question. The notion of (semi-)martingale and the link to the economic concept of no-arbitrage must come first. Through this link, mathematicians also make the notion of "there exists no free lunch" methodologically precise. Second, I would put the axiomatization of risk measures and the related mathematical description of such concepts as risk aggregation and diversification. Some of my more statistical research is related to the latter. As third I would add the various mathematical and statistical techniques

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for understanding and analysing model uncertainty. Especially concerning this third class of "instruments", here mathematics can, and should play an important role in clearly drawing the line for what can and, more importantly, cannot be achieved concerning pricing, hedging and risk management of complex financial and insurance products.

I: Is risk management a response to the challenges and issues of the stock markets of the 1960s and 1970s? Could you briefly tell us the objectives of risk management?

E: Whatever definition one takes, since the onset of mankind, risk has always been around. And consequently also the various ways in which society wanted to manage these risks. I will refrain from discussing risk from a historical perspective and concentrate on the 1960–70 period. On the more economic front, there were three important events: First, the various oil shocks in the '70s making energy a highly risky business; secondly, there was the end to the Bretton-Woods agreement of fixed exchange rates, and finally the surge in information technology (IT). The first two changes implied an increase in economic and financial risk, and hence triggered off the demand for products to hedge against these risks, the third, IT, made it all possible. I also would like to mention at this point the increased complexity of demands and products in the world of insurance, and this due to demographic and societal changes, the increased penetration of insurance in the overall population and the onset of discussions related to the environment.

As for your second question, risk management is, from a general point of view, a field that devises tools and techniques for channelling and transferring risks from those who do not want it to those who are willing (and hopefully are capable) to take it; for the latter, think, for instance, of an insurance company. This transfer should be done in a transparent and efficient way, embedded in a well-functioning political and regulatory environment. The field of risk management is (or, better, should be) holistic in nature. By this I mean that only in the rarest of cases should risk be seen as a singular issue devoid of any external influence. It is a highly interdisciplinary field.

I: The methods are very mathematical, not empirical or anything like that, isn't it?

E: That is not really true; it very much depends on the kind of risk management duty you are performing, and also to whom you are talking. Of course, if you are pricing and hedging a very specific complex derivative, like electricity swing options or interest rate swaps, then the underlying mathematics is non-trivial. In any case, also in this case you need data to verify the model chosen and calibrate that model to data, hence empirical analysis is very important. If, however, you perform your risk management duties as the Chief Risk Officer of a bank or insurance company, then technical issues are much less in the forefront; the more holistic, global economic and societal aspects enter more prominently. The underlying technical issues remain in the background. Reality will always find itself between these "extremes". Ideally one would have a well-balanced combination of both. It would be a mistake to swing too far away from the more mathematical, quantitative thinking, as much as it would be a mistake to forget about the so-called softer, qualitative side of risk management. And further, a crucial aspect of good risk management is clear, objective and open communication, also this to all types of audience: including the general public, politicians, the media, employees, etc. Especially at that level, mathematicians do not always score highly; we ought to train our students better concerning communication.

I: Are the products first formulated by mathematicians rather than by bankers?

E: Of course, mathematicians, or better, financial engineers, keep on inventing interesting constructions — you could call them products. For me such a construction is called a product if you sold more than one, say. I could give you examples of such "products" which were mathematically interesting, but did not find a market, or indeed were never intended to find one. I would say that the most interesting innovations and important products invariably come from industry, and not from a mathematician's mind. These products are often developed as an answer to specific demands from clients. Unfortunately, some parts of the banking industry more recently have been producing products which not only society did not really need, but more importantly turned out to be highly toxic for the worldwide economic system. It is exactly there that international regulation should step

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in. But likewise, mathematicians working in industry have to draw clear ethical lines not to be crossed when it comes to such product lines.

I: You once mentioned that applied finance and mathematical finance have diverged. Are their current differences essentially methodological or conceptual?

E: It's a remark that I made a while ago, well before the crisis. There is indeed less real contact between the two. And this may be a consequence of their perceived success. On the one hand, the financial industry felt that modern finance, not just mathematical finance, has tamed the credit markets, securitization being the magical word. And whereas these institutions still employ scores of scientists and engineers, including mathematicians, it was felt that the more methodological, mathematical research became less important. On the other hand, mathematical finance, as a subfield of mathematics, has reached a level of maturity as a field of research where progress can be made without worrying too much about reality out there. In a way one can compare this situation with mathematical physics where a lot of research can be carried out without worrying too much about experiments. On its own, this may not be too critical, as long as a sufficient number of intellectual bridges exist between the two worlds so as to keep on feeding academia with new, challenging and practically relevant research problems, and vice versa, academia can step in when it observes a violation concerning the underlying conditions needed so that some of its earlier research results can be applied. At RiskLab it is exactly this kind of bridge we try to maintain.

I: Do they talk to each other?

E: Several of us really try. The workshop here is a nice example where RMI (Risk Management Institute), IMS, industry and the Monetary Authority of Singapore exchange ideas. It is a nice example of the triangular dialogue I mentioned earlier.

I: Is it possible for a mathematical finance specialist to write papers without bothering about what happens outside?

E: From the point of view of scientific research, absolutely. I could give you several examples. Many brilliant students enter the field attracted by the beauty of (some) of the underlying mathematics. Numerous scientific developments in stochastics would never have taken place were it not for the initial questions asked by (applied) finance. In that sense, the issue is not too different from similar discussions around pure and applied mathematics, a distinction I personally do not like when it is pushed too far. At the end of the day, it often is a question of personality.

I: It seems that financial collapse could be caused by a panic response of investors which is more irrational than rational. Is there any attempt to incorporate some kind of human parameters into financial and investment models? In particular, have psychological methods or concepts been incorporated?

E: It is clear that, not just in the current crisis, people realize that there is irrationality in the market and that psychology and human behaviour play an important role. Some mathematical models are looking into that. One important branch of research is "model uncertainty". Let me be very clear on this: the mathematical finance research community is very well aware of the relevance of behavioural factors. Interesting recent research, also communicated at our conference at IMS, tries to capture these factors in precise mathematical language. That this is not easy, already [Isaac] Newton knew. After he lost about 2.72 million US$ (in today's money) speculating on South Sea Company stock, he said "I can compute the motions of heavenly bodies, but not the madness of people". In economics a whole field has been building up around behavioural finance. As mentioned before, I very much hope that both fields will meet up eventually. I expect that, within the next 5 to 10 years, there will be first practical models taking behavioural aspects seriously into account. The moving away from the efficient market hypothesis to the so-called adaptive (or alternative) market hypotheses is more a chance for mathematics than a threat. The same cannot be said for some fields of economics. For instance, mathematicians from day one in the '80s already looked at traders not as a homogeneous group but there are informed traders and there are noise traders. The resulting models very much depend on the balance or unbalance between the two.

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I: Apparently a 38-year cycle has been observed for the history of fluctuations. Do you believe there are definite cyclic patterns underlying financial and economic fluctuations?

E: The old wisdom, what goes up must come down, comes to mind. More seriously, I find it difficult to believe too strongly in theories of cycles. Also, cycles based on Fibonacci numbers are popular. Similar statements have been made about bubbles and financial crises; here it is about 7 years it seems. In the latter case it tells us more about how quickly people forget and how little we learn from past errors made. If you look in detail at what the exact claims are (like the 38-year cycle), how many years of data do you have? How can you statistically prove such a claim? Of course, statistical data mining, current availability of data and advances in related statistical research, coupled with modern computer technology, no doubt will lead to interesting findings. A possible example concerns the field of chartists or technical analysts.

I: Has the recent subprime financial crisis eroded confidence in mathematical finance? Has anything been done to restore this confidence?

E: If you read the media reports, or consider discussions with friends and colleagues inside and outside the university, there is indeed a feeling of that sort. First superficial media reports were keen to headline "How mathematics blew up Wall Street". Whereas such a title may be good for Hollywood, reality is far more complex. No doubt the ever growing complexity of financial products coming out of the financial engineering factories of investment banks grew increasingly distant from the underlying real economy, whatever the proponents of such product lines say. A particularly illuminating example is the so-called Abacus 2700-AC1 synthetic CDO product, of which one of the investment bankers involved with its construction is quoted to have said: "What if we created a thing, which has no purpose, which is absolutely conceptual and highly theoretical and which nobody knows how to price?". Here the classical rule should apply: "If you don't understand it, don't buy it, don't sell it!" Mathematicians will have to communicate better, both bank-internally as well as to the outside world, clearly stating where the limitations of our understanding of such products lie. We have to take our societal responsibility as academics seriously; this will gradually restore confidence.

I: Now the public is more aware that part of the blame is on rogue traders and rogue bankers rather than mathematics.

E: That is correct! Initial Hollywood fever has made way for a more realistic view on what went wrong. We should also not forget about the role politics played.

I: I think some of those people in the frontline don't really know what their products are.

E: Indeed, with some of the more complicated products, as briefly mentioned above, this is true.

I: Have methods of risk management been applied to evolutionary biology, in particular, about how epidemics spread?

E: I would say that it is more the other way around. I know of several applications of the spread of epidemics, say, to the modelling of credit markets. An example is the use of the Pólya-Eggenberger model. And just as an aside, George Pólya was a professor of mathematics at ETH (1914–1940); I still have his couch in RiskLab! Andrew Haldane, from the Bank of England is a great proponent of the use of ideas from evolutionary biology to finance. It is somewhat amusing that "the other Haldane", John Burdon Sanderson Haldane (1892-1964), was a pioneer of bringing quantitative modelling into biology and genetics. To take your question a bit more broadly: by now, quantitative risk management, as described in our 2005 book [*Quantitative Risk Management: Concepts, Techniques, Tools* (with A. J. McNeil and R. Frey)], is widely applied to such fields as environmental research, engineering and the medical field. Talking to scientists from those other fields, I always find it fascinating to try to understand the specificities of their risk management questions and techniques.

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I: You also have research interest in actuarial mathematics. Is it mainly confined to questions in insurance?

E: As I already mentioned before, in a way, insurance mathematics and its applications are my prime area of research. In actuarial applications, extremes often play a crucial role. Think for instance of catastrophe insurance or longevity modelling. Of course, insurance, by definition, interacts with many aspects of society, and as such is by nature multidisciplinary. A more recent phenomenon is the era of bank-assurance and alternative risk transfer. This concerns insurance risk transfer via financial markets. It is fair to say that, whereas the initial hype of industrial bank-assurance institutions is over, interesting cross-products between banking and insurance will always be there. Very often such products are born out of a societal need, like in the case of catastrophic events such as earthquakes and storms. The key word here is catastrophe bonds; these are bonds for which the coupon payment depends on the (non-) occurrence of a specific catastrophic event. I am convinced that worldwide we will see a U-turn from insurance holdings back to their main business, namely insurance. Many of my current students are increasingly in demand from insurance regulators and consultancy companies for the insurance industry; a trigger for this is the growing importance of the changing regulatory landscape. Often via these students interesting research questions come back to us.

I: I notice that in the recent crisis, one of the organizations that collapsed was an insurance company (AIG). With all their calculations, could they have avoided the collapse?

E: It is important to note that the company that created the problems was AIG-FP, where the final two letters stand for "Financial Products", a typical example for my remarks above. Without being able to enter into full detail, AIG-FP was involved with insuring complex credit instruments. It became very big on the so-called Credit Default Swap market. Like the banks with which it had all these deals, their modelling was far too rosy when it came to joint default modelling. I cannot believe that AIG-FB internally, many actuaries were involved. Together with Catherine Donnelly, I have written a paper on the topic: "The devil is in the tails: actuarial mathematics and the subprime mortgage crisis", it will appear in the *Astin Bulletin*, a leading actuarial journal. A copy can also be found on my webpage. The paper contains the full story from an actuarial point of view. The question, under which internal conditions they could have avoided the collapse is for me difficult to answer; no doubt, like so many of the other big players in the crisis, they were blinded by a perceived free-lunch on many of these instruments. The free-lunch turned into a very expensive lunch as soon as the market turned. And this turn came (a) very fast, and (b) with a massive size. All this has happened before with complex derivative positions, especially when one gambles with very high volumes, so-called high leverage. Brought back to its mathematical basics: non-linearity caused havoc!

I: You once mentioned something about the importance of managing large data and that this is a very important aspect. Can you say something more about this?

E: Statistics is a major scientific discipline that teaches us how to efficiently process, manage and analyse data. I am just back from a meeting with the National Science Foundation in Washington on the future of statistical science where we discussed "the next important areas of statistical research and applications". I was invited to present applications in finance and insurance. There is absolutely no doubt that the future belongs to the analysis of large, complex data structures. This may involve so-called "*n* small – *p* large" data structures and the related notion of sparsity, or data coming from large complex networks. The former relates to risk management questions involving thousands of factors, only a small proportion of which may be relevant. The latter (networks) relates to problems encountered in the subprime crisis like systemic risk. A key field is machine learning. Whichever problem area you prefer to study, the scientific developments within these fields are gigantic. It is no coincidence that some of the leading academic researchers in these fields were lured into joining hedge funds which are interested in detecting structure in massive financial data sets. In a sense, quantitative risk management will have to keep pace. The only way I can see this to happen is that we train our future generations of mathematicians, actuaries and risk managers so that they also learn about

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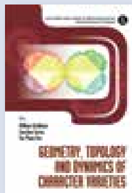
these new developments. This is a crucial task for all of us involved and, believe me, not a very easy one. Let me end with two statements I give my students on the way: (1) I tell them to be humble in the face of real applications. Here I typically quote from Shakespeare's Hamlet: "There are more things in heaven and earth, Horatio, than are dreamt of in your philosophy". And (2) in all circumstances I ask them to behave ethically, especially in the face of temptation, which surely will come.



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