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Building bridges between Mathematics, Insurance and Finance

An interview with Paul Embrechts

Abstract:



Paul Embrechts is Professor of Mathematics at the ETH Zurich specializing in Actuarial Mathematics and Quantitative Risk Management. Previous academic positions include the Universities of Leuven, Limburg and London (Imperial College). Dr. Embrechts has held visiting professorships at several universities, including the Scuola Normale in Pisa (Cattedra Galileiana), the London School of Economics (Centennial Professor of Finance), the University of Vienna, Paris 1 (Panthéon-Sorbonne), the National University of Singapore, Kyoto University, was Visiting Man Chair 2014 at the Oxford-Man Institute of Oxford University and has an Honorary Doctorate from the University of Waterloo, Heriot-Watt University, Edinburgh, and the Université Catholique de Louvain. He is an Elected Fellow of the Institute of Mathematical Statistics and the American Statistical Association, Honorary Fellow of the Institute and the Faculty of Actuaries, Actuary-SAA, Member Honoris Causa of the Belgian Institute of Actuaries and is on the editorial board of numerous scientific journals. He belongs to various national and international research and academic advisory committees. He co-authored the influential books *Modelling of Extremal Events for Insurance and Finance*, Springer, 1997 [8] and *Quantitative Risk Management: Concepts, Techniques and Tools*, Princeton UP, 2005, 2015 [14] and published over 180 scientific papers. Dr. Embrechts consults on issues in Quantitative Risk Management for financial institutions, insurance companies and international regulatory authorities.

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1 The academic career

With this interview with Paul Embrechts, Professor of Mathematics at ETH Zurich, *Dependence Modeling* launches a new *Interview Article* series. Interview articles will be published on a semiannual basis (next in December 2015) and take the form of discussions with milestone personalities who played a fundamental role in the field of Dependence Modeling. We believe that students at all levels, teachers, scientists as well as practitioners can benefit from the following virtual meeting with Paul Embrechts, a very well known and influential personality in the world of Quantitative Risk Management. Besides summarising parts of his suc-

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successful career and personal experience, Paul Embrechts gives some valuable suggestions on how to succeed in academia and, at the same time, have a strong relationship and active collaboration with the world of regulation and industry. In the following, our questions to Paul Embrechts are written in bold-face.

Let's start from the beginning. How did you develop your interest in Mathematics? What did motivate you to start an academic career? Is there a particular moment in your life that you or your family identify as the one in which you decided or you turned out to be a mathematician?

I was raised in a family of five, my father was a policeman, my mother stayed at home for the children. Both had exceptional intellectual capacities but their talents were not at all allowed to flourish in those days. No one in the entire family went to university before me. Like for so many professional mathematicians, I was very lucky to have been taught by an excellent Mathematics teacher, Omer Weyenberg, at the secondary school I went to in Schoten, near Antwerp in Belgium. We were still taught classical Mathematics. The wave of “modern Mathematics”, in Belgium mainly driven by the efforts and energy of Georges Papy, came some years later. When it came, that wave hit Belgium particularly intensively. So during my secondary school days, we had no set theory, no group structures, nor precise definitions of functions and their properties, but still learned wonderful, be it somewhat classical Mathematics with lots of concrete problem solving. I recall that my teacher gave me some books where I could learn more “modern” Mathematics like group theory. So at the end of my secondary school, which I left ranked first (in those days, absolute ranking of pupils was still allowed), it was clear that I would either study Civil Engineering in Leuven or Mathematics in Antwerp. That it became the latter is a question of chance, like so often in life. One (financially) important aspect in those days was that I could stay at home while attending university. The mathematical culture shock came in my undergraduate years in Antwerp: it was as being lifted in a couple of weeks from the Greek world of Euclid in Alexandria to the world of Bourbaki in Paris. It was totally rewarding but initially very hard: those (very few) of us that survived learned a lot!

In your career, you held positions at various universities. What are the most important factors that have contributed to your career development? What was/is your “ideal” research environment?

At the (very small, since new) University of Antwerp we had a very theoretical curriculum, we essentially were given a Bourbakist training in Mathematics. A key figure for me in Antwerp (while I was already specialising in probability theory and actuarial mathematics) was Jean Haezendonck. In our last (4th) year we could choose any course anywhere, so together with a colleague of mine, we went once a week to Leuven to follow the course on Applied Stochastic Processes by Jef Teugels. Suddenly, probabilistic intuition entered the educational stage. So early on I sampled the importance of different academic environments. This combination of different types of teaching, research and skills still constitutes a hallmark of my own work. After my PhD in 1979 with Jef Teugels I spent a year with Nick Bingham at Westfield College London, followed by several years, in the end as tenured lecturer in statistics, at Imperial College. This early- to mid-eighties period at Imperial College was incredibly exciting. Let me just mention the name of D.R. Cox as a colleague. I basically met there every major statistician of the time and made numerous academic friendships which last till now. Mainly for financial reasons (for a lecturer with a family with then two, later three children, London is forbiddingly expensive) in 1985 we returned to Belgium, the University of Limburg. Finally, in 1989 I got the offer for a full professorship in (insurance) Mathematics at the Department of Mathematics of the ETH Zurich, an offer I and more importantly my family accepted. This was as successor of Hans Bühlmann. On learning this, a colleague from the Wharton School wrote to me congratulating and remarked: “These are some very big shoes to step into!” After 26 years at ETH, I can state that this comes very close to the ideal “research” environment, though I would replace “research” by the broader “academic”: total academic freedom but of course with a clear view (especially as an applied mathematician) on the societal responsibilities and duties we carry, little (if any) political interference, excellent students and colleagues and first class working conditions at all levels. I often say that I am fully treated as a professional and act accordingly.

Many researchers work in the same “small” field for their entire career. In your case, it seems that you have followed a long path from classical Probability Theory to Finance and Insurance (and back). How would you define yourself? A mathematician? An actuary? Or...?

And indeed you could throw in some statistics too: only last year I was, for instance, made a Fellow of the American Statistical Association. One point is clear, I call myself a *mathematician* and I also teach



Figure 1: Gerda and Paul, Oberrohrdorf (Switzerland), Christmas 2014.

my students to think and act as true mathematicians, also in practice! As my career path above describes, I have been very fortunate to have been able to work in several excellent institutions, having been exposed to different areas of Mathematics. As an applied mathematician interested in solving (or at least in contributing to the solution of) real life problems, this varied background is crucial. Of course as a research mathematician I have my basic research interests like in Extreme Value Theory (EVT) and Quantitative Risk Management (QRM), but applied problems are never far around the corner of my thinking. I try to bring this mathematical rigour into my actuarial work, either research-wise, through teaching and even via consulting. As such, both parts of “Actuarial (and) Mathematics” are highly relevant and important to me. I am also happy to see that through the numerous invitations I receive, both worlds, the actuarial one as well as the mathematical one acknowledge my contributions to the respective fields. Also, I feel fortunate that I have had the opportunity to build up this bridge function between serious (mathematical) theory and relevant applied problems. So you can call me a “bridge builder” if you like.

What role did your family play in your academic life?

Throughout, my family has been a tremendous support for me. At the same time, my research and the various related work environments very much contributed to finding our physical path through life. On this path we made many friends and had numerous wonderful experiences. Without that support, especially from my wife Gerda (see Figure 1), I would never have arrived at the academic point I stand now. At a moment of a difficult choice we had to make in our lives (related to a next career move, around 1985), Gerda said: “Your life belongs to academia, since that is where you will be most happy”. Perhaps she realised that through my teaching and research, I could really give something back to society. I am also sure that Gerda realises that some of my work is relevant for the outside world; she often witnessed this through numerous international academic invitations for talks and conferences. Only last year, she attended a talk I gave at the Federal Reserve Board in Washington and in the afternoon, while I was discussing with several FED economists, she was privately shown around the impressive FED building (see Figure 2).

2 Academia versus practice

While many researchers remain inside their little community, you spent a considerable fraction of your time convincing the financial industry and regulation to rethink and improve their risk management practice. How did this start? What is the actual state of interplay between regulation and Mathematics?



Figure 2: Paul Embrechts in 2014 in front of the FED building in Washington.

Here the answer is easy: the excellent academic ETH environment coupled with the intellectual as well as physical nearness of the financial and insurance industry in Zurich, including regulators, provide the ideal scene for fruitful discussions to take place. On a regular basis, former students or colleagues, now in industry, contact me for a lunch meeting in order to discuss issues; these can range from personal to professional. Moreover, I was able to have 20+ years of experience as an independent director at board level in banking and insurance. The combination of all this must be close to unique in the world, especially for a mathematician. On the regulatory side, the kick-off was October 7, 1994, the day we started our RiskLab as a precompetitive research centre interfacing between industry, academia and regulators. Together we strived (and still do so) to come up with open problems where input from all three sectors is essential. Last year we hence celebrated 20 years of RiskLab; as co-founder (together with my colleague Hans-Jakob Lüthi) and current director I am proud on what we have achieved. In many ways, RiskLab in Zurich is a blueprint for such collaborations. I personally find the actual state of interplay between Mathematics and regulation positive; examples of this I see in the discussions on the use of regulatory risk measures (Value-at-Risk versus Expected Shortfall, say) for the trading book, as well as the renewed interest in the possibilities and limitations for the quantitative modelling of Operational Risk. On the latter topic, and this mainly due to the mounting legal losses in the aftermath of the financial crisis, industry and regulators increasingly ask for our opinion.

Practitioners, regulators and researchers sometimes seem to speak three different languages. What does it take to be heard (and understood) by all of them?

Mutual respect! As mathematicians we first have to learn what the real practical issues are all about and not “charge in” with a big mathematical hammer asking where the nail is so that we can hammer it in. To my students I give the following advice: “Always be humble in the face of real problems” and quote Shakespeare’s *Hamlet* (1.5.167-8, Hamlet to Horatio):

“There are more things in heaven and earth, Horatio,
Than are dreamt of in your philosophy.”

Practice on the other hand also has to learn where the virtues of a mathematician lie: above all in the ability of being precise in the formulation of problems, the underlying conditions and possible solutions. Especially as a mathematician, it takes time to gain respect and understanding. This ultimate goal can only be achieved through excellent pedagogical communication skills. The extent to which the latter can be learned from experience or one is born with is a matter of intensive debate. To continue with the earlier mentioned bridge building metaphor: communication skills make the traffic flow more smoothly across that bridge between industry and academia.

How can we improve the mutual exchange of knowledge between academia and practice? In other words, why does it often take so long until research results are used by the industry?

This is an issue well beyond Mathematics as a discipline and is difficult to be answered in a couple of sentences. Ways in which we have been successful are for instance the creation of mutual contact platforms like RiskLab and our yearly Risk Day where academics and practitioners present recent results/issues to a broad (by now 300+) audience, including students. We also supervise a high percentage of our master theses, and in some cases doctoral theses, jointly with industry. Finally, as already mentioned above, I regularly meet (lunch, dinner, “just a discussion in my office”) with former students now in industry to keep my hand on the pulse of the market. Industry out there is not just waiting for us, we have to step out of our Ivory Tower and this often requires intellectual courage and typically will be time-consuming.

Are there counterexamples in which a research work entered immediately or was born in industry?

Of course there are, many. In my personal case I could give several examples related to the world of copulas, risk aggregation and the creation of specific financial derivatives. In the latter case, most of the interesting, successful products originated in industry. A further example is the creation of Quantitative Risk Management platforms in the mid-nineties in banks like JP Morgan; think of RiskMetrics and CreditMetrics.

Is it true that the perfect vita for a professor would include some years of experience in industry? How is it possible for a young researcher to achieve that in practice?

This question I definitely cannot answer with a “yes”. It so much depends on the field of research. Only in very few cases I would say that such a combination is warranted. For instance, at the moment I am chairing a committee for a new professorship in entrepreneurship (in a faculty away from Mathematics): in that case, practical experience is of course a plus, if not a must. But in the end it is always about finding the right balance. Overall, a vita for a professor is still very much, if not exclusively, judged on the basis of academic merit. In areas of research close to practice, like my own in Insurance Mathematics, there are various ways in which industrial experience can be brought into the curriculum. At ETH we do this by having several courses taught by former (mostly doctoral) students of ours, now working in industry. Some of these may eventually be given the status of adjunct professor. My advice to the young researcher remains: “Build up a strong academic vita with relevant university experience abroad”.

Are there “deadly sins” you repeatedly see in today’s risk management practice?

I would not use the word “deadly” here but rather “repeated”. All too often practice is too little aware of the constraints and conditions under which a specific Quantitative Risk Management tool can be applied.

Some areas of Quantitative Risk Management seem to be entirely theoretical or at least disconnected from reality. We refer, for instance, to the growing literature on stochastic processes used for financial pricing. Do you share this view?

This is more a question of evolution (call it “maturity”) both in academia as well as practice. QRM in the widest sense has evolved into an established academic subdiscipline of its own. It does not really need contact to industry anymore to flourish academically. That in such a context purely academic research is being pursued is fine with me. However likewise, parts of industry believe that more quantitative/mathematical thinking is not any more needed, “we know all and more would only harm”. Both situations I do observe. As should be clear from my answers above, I personally do not subscribe to these extremes. You also mention “the growing literature on stochastic processes used for financial pricing”. Here of course, industry is coming up with very challenging data structures and intricate products to be priced and hedged, think for instance of energy derivatives or products in use in the Life Insurance business. So having further developments at the more methodological level is surely called for.

Does the recipe for “the perfect paper” include more theoretical results or more applications?

In my world of applied (insurance) Mathematics it is clearly a question of balance. My recent papers often start from a concrete question in practice and then develop the mathematical (including statistical, numerical, software) tools to solve or better understand it. On the other hand, some of the papers I am most proud about are more theoretical. In several cases I first write a more methodological paper, mentioning the background from practice and then later may write a paper/report where we concentrate more on practical reformulations and/or offer several numerical or data based examples. This balance can very well be observed

in our QRM book with Princeton University Press, a revised edition of which appeared recently ([14]). My earlier, 1997 Springer book on EVT [8] tilts more towards theory, though we also got a lot of acclaim for it from industry. We even gave a one-week course on it for regulators at the Federal Reserve Bank of Boston.

Imagine that after your retirement in 2018 you start a second career as regulator. What would you like to see included in an upcoming “Basel X” or “Solvency Y” report your team is responsible for? You being a regulator: is this a realistic scenario?

Overall I would strive for a better balance between quantitative and qualitative approaches to risk management. Even as a mathematician, I feel that in some areas a kind of over-quantification has taken place. A typical example is the Advanced Measurement Approach (AMA), in its Loss Distribution Approach (LDA) Ansatz, to Operational Risk. The latter class is eminently important, look for instance at the recent, mainly legal losses. However, based on the amount and complexity of data available, a full LDA analysis and capital calculation at the required 99.9% yearly VaR level is methodologically well out of reach. We should have the courage to say so and act accordingly. For instance by going for lower quantile levels, say, and introducing scaling factors. Also, the Basic, or Standardized Approaches should not be disregarded too quickly, even for the so-called “more sophisticated banks”. Further, and not unrelated, the issue of model uncertainty should stay prominent. And finally, every time new guidelines are in the making, I would like to have a little task force in my group looking at ways one can arbitrage those new rules. Maybe if as regulators we don’t do so consistently, surely industry will and this with whole scores of quants and lawyers! I am not saying that the above breaks new ground, but as a new regulator I would offer time and energy towards finding solutions for these issues. However, in line with some of my answers before, I should perhaps first be given the time to learn “on (regulatory) site” before jumping in too quickly with my perhaps somewhat distant, even naive views on what needs to be done/fixed. Concerning whether I could see myself as a regulator: first of all, I always have had excellent contacts with insurance as well as banking regulators worldwide. For the most important ones I have given talks, even courses. And indeed interestingly, for Switzerland, I already have been approached officially twice for such a move: for the moment, time prevents me, but you were talking about 2018+, so who knows.

3 Dependence and Copulas

Among many things, you were perhaps the first one to put emphasis on financial applications of dependence (especially copulas): the famous RiskLab 1998 report. How did you find copulas – or how did they find you?

Copulas “found me” around 1995-6 in addressing a question from a local insurance company concerning the simulation of a bivariate insurance portfolio with given marginal distribution functions and prescribed linear correlation. A straightforward copula argument showed in their case that the model they were after does not exist. In those early days of QRM (recall that VaR was just born) other questions came about which clearly hinted at the fact that the financial industry had a very poor understanding of dependence. Even the omnipresent notion of linear correlation was badly understood. At the same time, other papers started to appear, mainly in the actuarial literature, stressing this malaise. For us a fundamental text was Harry Joe’s 1997 book [11]. We decided to write the 1998 RiskLab report with Alexander McNeil and Daniel Straumann: this paper [9] caused a landslide in dependence thinking. As we mainly saw this paper as a contribution to the “bridge building” alluded to above, we did not submit it to a journal; I did not want a referee or editor to change one word of it. It appeared in the end (2002) in a proceedings of a Newton Institute Cambridge conference, just to have it on record somewhere. But originally, the paper was conceived as a typical RiskLab contribution to the exchange academia-industry in the realm of financial risk management. By now it has been cited well over 2000 times, which is not bad for “just a report”. Till today, I am very proud of that paper.

Is there any copula model or any mathematician to blame for the financial crisis?

Absolutely not! Of course you are referring to the Gaussian copula exposed as the villain of the crisis in a 2009 Wired Magazine paper with the title: *Recipe for disaster: the formula that killed Wall Street* ([20], now

reprinted in [21]). It would take me too far to give all the (by now historical) details surrounding this discussion. In my 2010 ASTIN Bulletin paper with Catherine Donnelly *The devil is in the tails: actuarial mathematics and the subprime mortgage crisis* [4], most of the story can be found. Let me just say that, if the answer to your question were yes, then it would be very easy to fix the system, by now we know that it is not.

Roughly speaking, portfolio credit derivatives like CDOs make the abstract idea of “dependence” a tradable asset. These products (and their misuse) are often blamed to be responsible for the 2006+ financial crisis. To what extent do you agree with this criticism and why is it so complicated to understand (and work with) such products?

Once more, the above paper and the revised edition of our QRM book give full details on this. Books and scores of papers and reports have been written trying to answer your question. CDO-like products and their underlying insurance type deals, CDSs, surely have to take part of the blame. Whereas the original securitization ideas were perhaps fine, the hunt for return ballooned their market share so that around 2007 nominal values in such products reached astronomical proportions: CDOs (2-3 tri USD), CDSs (30 tri USD), OTC products (600 tri USD) and to put these (nominal) volumes into perspective, the world’s GDP at the time stood at about 60 tri USD; recall that 1 tri equals 10 to the power 12! Customers were tearing these products out of the hands of the investment bankers and banks were warehousing the perceived risk free upper tranches of CDOs in the billions of USD. As a result the banking industry eventually was long a catastrophic bond waiting to be triggered. The important downturn in the American housing market around 2006 provided that trigger. One should also state that (mainly American) politicians supported, even encouraged the growth of these markets and that public warning (given some laudable exceptions) was absent. So now again ask your question! Concerning complexity of products: this is surely true at the height of the bubble where products like CDO-squared and CDO-cubed were sold and where nobody had any idea how to price, let alone hedge them. The fall out of this madness we now witness in the large legal fines imposed on the investment banks that originated such products and the retail banks that put these products into client portfolios. At the moment of writing these lines, the largest such single fine stands at about 16 bi USD. Operational Risk casts its shadow on the market!

Could you design a financial product that allows to trade dependence that will be more sustainable than CDOs?

An interesting question I have not really been thinking about: I am sure that this is possible, as long as one steers away from the obvious construction errors from the past. For instance so-called correlation swaps are to be found in the market, but as far as I know, there is no standard way of pricing/hedging them. Also in insurance one notices more so-called multiline products or Alternative Risk Transfer products like double trigger CAT-bonds. In all of these cases a good understanding of the dependence properties of the underlying risk drivers is key.

In his quite controversial paper *Copulas: Tales and Facts* [15], Thomas Mikosch criticized the over/misuse of copulas. What is your opinion on this debate?

This really could be a completely new interview! First of all, at the time, not only Mikosch criticized copula-modeling. Others (personal communication) included Chris Rogers (Cambridge) and Darrell Duffie (Stanford), be it with different words/intensity, arguments or from different angles. I officially rejoined the journal discussion (*Extremes*, 2006 [5]) in reply to Mikosch’s comments, and hence do not really have to repeat my views here. Others immediately realized their importance: for instance Nobel Prize winning Robert Engle (NYU) gave our report to his then PhD student Andrew Patton (now at Duke) with the words: “Look into this for your PhD”. Similarly, for regulators, the “beyond linear correlation thinking” became very useful. As so often when science meets practice, the truth lies somewhere in the middle. Mikosch’s Hans Christian Andersen quote: “But he does not wear any clothes” stresses the fact that from a mathematical point of view, copulas have been around since the dawn of probability. The more statistical and numerical work at the time, and also now, was/is however very much novel and interesting. Crucially for me is that many problems from risk management practice come to us in a way that joint models are not at all available and copulas at least give us a first (perhaps not final) approach to come up with some models allowing for pricing or aggregation purposes. I specifically used the plural “models” as often I use copula modeling as a kind of dependence stress testing technique. Moreover, at the time we wrote our original RiskLab report, copula based thinking

opened many more applied researchers' and end users' eyes for the various pitfalls surrounding just-linear-correlation thinking. For that reason I often say that copulas are important for three reasons: "pedagogic, pedagogic and stress testing". By now, they have been seriously applied in every field of science I know. Anyone interested in these early day aspects of the story can consult my paper *Copulas: A personal view* [6]. But as I said, this discussion could easily turn into a new interview.

Is it more likely that Credit Suisse defaults within the next five years or that Belgium wins the Soccer World cup in this century?

As a Belgian (and now also Swiss) citizen I would put the last probability at 1!

Both (above) events refer to probabilities the market has an opinion on and different statistical tools exist to approach these questions. But which probability do you find the harder to compute?

I could hide my answer behind the intellectual backs of giants like Frank Knight and John Maynard Keynes and state that these events, to a large degree, defy precise quantitative assessment. Of course in the market information can be found, for instance in the case of Credit Suisse, through quoted CDSs or rating probabilities. UK bookies no doubt have bets on football championships but I would be surprised if they would exist so far out. The values of some of these estimates can be contested, to say the least.

Thinking about the financial crisis (but also statistics in medicine and big data issues in general): What responsibility do we have as researchers in (applied) Mathematics towards society?

This is a question dear to my heart. Already in my answers to some of the questions above I alluded to our social responsibility as academics. And I clearly say "academics" in general here. We have a moral obligation and a societal duty through the positions we hold as university professors. As applied mathematicians some extra aspects of the university-society interplay enter. For instance, in my case I was appointed as Professor of Mathematics, but with special emphasis on actuarial education and research. Also, my portfolio of academic duties includes the establishment and fostering of contacts with industry in the broadest sense on matters related to my position. It is absolutely clear that our society faces considerable challenges at the level of social insurance: life and pensions insurance, health and invalidity insurance and all these issues are further compounded by an increasingly inverting population pyramid as well as worldwide demographic redistributions of people and labour. In the face of these facts, as academics we cannot just stand on the sideline!

4 General perspectives about the future in our field

Looking backwards, what have been the most important contributions to the field of "Dependence Modeling" in the last 50 years?

If I take your 50 years literally, then we talk about post 1965, so for instance post Sklar's fundamental work in the fifties. For me personally, three names stand out: Harry Joe with his 1997 and 2014 books [11] and [12], Roger Nelsen's 1999 one [16] and Ludger Rüschendorf's 2013 *Mathematical Risk Analysis* [19]. All three scientists contributed considerably to the field of dependence modeling; their books summarise the work of so many authors I should have mentioned here. Another book, perhaps somewhat less well known to the typical financial risk manager, but which also shaped my thinking, is Bedford and Cooke (2001) [1]. Unfortunately, the modern world of QRM is much less aware of the fundamental contributions made to the field by actuaries. Let me single out one name here, Etienne De Vylder, a Belgian academic actuary who very early on (early eighties) brought me into contact with Fréchet-type problems (see for instance [3]) and their applications to insurance, finance and risk management. I cannot overestimate enough the importance of his views on our field.

A young researcher is about to start his PhD. What are the three papers/books which she/he must have read? Which areas of research are especially promising to investigate?

I personally would not want to put too much constraints on what a beginning student should read: let him/her read excellent Mathematics papers. From my own early days I recall with fondness and deep admiration the following three:



Figure 3: RiskLab excursion 2014 on the Klausenpass (Switzerland).

1. The magical first volume of Theory of Probability and Its Applications (TPA) containing the fundamental papers by Yu. V. Prokhorov [18] and A.V. Skorokhod [22] on the convergence of stochastic processes;
2. L. Breiman's 1965 *On some limit theorems similar to the arc-sine law* (also TPA, [2]), and
3. J.W. Pitman's 1974 *Uniform rates of convergence for Markov chain transition probabilities* in the Zeitschrift für Wahrscheinlichkeitstheorie und Verwandte Gebiete, ZfW for short, [17].

Paper 2. was closely related to my research at the time and 3. opened my eyes to the beautiful probabilistic method of coupling for proving limit theorems. Till today I sense the pleasure I felt at the time reading the above papers. It is exactly this nostalgic feeling I would hope my students carry along on their academic path. Allow me two comments at this point: I recently was invited to a conference in memory of Yu. V. Prokhorov at Moscow State University, a memorable event where I could meet many of my Russian (former Soviet) mathematical colleagues and friends. And concerning ZfW: few of the younger readers of your journal will know that ZfW is now called Probability Theory and Related Fields (PTRF): I always was against the name change. A brief comment on promising fields: keep your eyes open for relevant developments in statistics, numerics and operations research!

You advised many PhD students and PostDocs who made a successful career in academia. What are the three most important things a young researcher should keep in mind to succeed in academia?

Indeed I have been very fortunate with about 30 young people in each category. A typical Swiss phenomenon is that about 80% of my PhDs went into industry whereas for my PostDocs it was the other way around, 80% went into academia. Answering your question about "succeeding in academia": surely the family situation has to fit in with a developing academic career, especially as longer stays abroad coupled with not particularly high beginning salaries are the norm. Further, it is important to get acquainted early on with all major aspects of academic life, these include, besides the obvious teaching and research, other duties on the (inter)national academic scene which constitute good academic citizenship. Finally, being an academic in whatever university environment (and I was both at very small institutions as well as at world class ones) you must realise that it is your personal involvement that will finally contribute to your institutions' success.

What are the three most important things an established professor should do?

Strive for world class, frontline research, teach with passion and be willing to take on important administrative duties within wider academia in general and your university and department more in particular.

Is there something in particular that the scientific community needs nowadays?

We need to be freed from the excessive ranking mania and from the ridiculous mapping of academic achievements to some numbers. Key performance indicators may be *the* thing in the (financial) industry, their use within a university environment I personally find out of place.

It is a common saying that a scientist gives his best before the age of 40. Do you agree with this statement or what do you consider the “golden age” for being a researcher in Mathematics?

This is indeed widely quoted for (pure) Mathematics, though one always finds notable exceptions. A wonderful current example is the recent, remarkable work [23] of Yitang Zhang (born 1955!) on the twin-prime problem. In applied Mathematics this is somewhat different: here practical experience plays a very important role and this typically accumulates with age. I very much feel this in my own case. In many ways I feel that I am doing my best work now. Interestingly, at the Prokhorov conference mentioned above, one of the older Russian probabilists, after my talk, congratulated me in that way. Let me however stress that I personally not at all like this division between pure and applied mathematics.

You are close to retiring: What will you miss most of your job?

Indeed I (have to) retire at the age of 65 in July 2018, after 29 years as ETH professor. Perhaps you will have to ask me that question again after my retirement. We as university professors are in the unique, even enviable position of being able to maintain some kind of professional life. We may well lose financial support and/or full office space, but research does not halt at that age; the mind keeps on functioning. Likewise, all (inter)national contacts remain, so I expect still to do both research and give seminars and talks. The day-to-day contacts with administration and students will of course diminish. Whereas I may not lament the former (though ETH’s administration must be the best and most supportive in the world), I surely will miss the latter. How much so remains to be seen.

On a lonely island, which mathematical book would you take?

I am glad that you ask for a book, not for a copula: I mention this as many times I asked this question, kind of “tongue-in-cheek”, with “copula” inserted for “book”, in talks I gave. You ask me for a Mathematics book: the most worn out book in my (extensive) library is William Feller’s Volume II, *An Introduction to Probability Theory and Its Applications* (1971) [10]. I take this one, if only for nostalgic reasons.

Important mathematical results are eternal; but the half-life time of scientific papers (in the sense of being read) is rather small. Which of your publications will still be read in 50 years?

I expect that my 1979 ZfW paper [7] will still be read, as well as the 1998 RiskLab report [9] on properties and pitfalls of linear correlation. Most of my more recent work, however, I expect to survive through our EVT and QRM books.

Mention at least one research paper in your field that you did not write but you wish you had written.

The coupling (hence probabilistic) proof of Blackwell’s Renewal Theorem by Torgny Lindvall (*Annals of Probability*, 1977, [13]). I was two years into my PhD and had started to look into the problem. For most of my more recent work in QRM I felt that I had the edge with respect to timing as well as with respect to coming up with new ideas. Here my nearness to practice played and still plays a crucial role.

How does it feel having a co-authored book as the standard textbook on risk management used in the world? Did you ever have to sign a copy?

I think that both the EVT [8] as well as the QRM [14] book have become standard textbooks. With the QRM one, we essentially established a new field. We do indeed get many very positive reactions on both and I could tell you many anecdotes related to these textbooks. Once my co-author Thomas Mikosch placed our (voluminous) EVT book on the top of a blackboard preventing it from constantly moving upwards. On a visit to NYU, at the invitation of Nobel prize winning Robert Engle, my wife Gerda was shown around the Engle’s flat by his wife and noticed a copy of our QRM book on his desk. My favourite picture of the QRM book is of a former PhD student Robert Salzmann reading it sitting half-way up in the Dead Sea. But I want to stress the very important “co-authored”. Indeed both books were written together with former PostDocs: Claudia Klüppelberg and Thomas Mikosch for EVT and Alexander McNeil and Rüdiger Frey (shown in Figure 4) for QRM. In both cases, the books emerged after we taught the respective topics for some years both at ETH and at summer schools of the Swiss Association of Actuaries. For the latter, in the case of a course on QRM, a further interesting photograph exists having 100 copies of the textbook lined up like domino stones . . . during the financial crisis the stones indeed tumbled. To your final question: indeed we were asked on several occasions to sign our books. This was/is invariably gratifying. At such moments I strongly feel that my academic contributions have not been in vain.

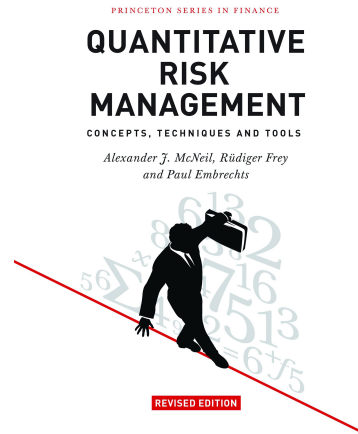


Figure 4: (From left to right:) Paul Embrechts, Alexander McNeil and Rüdiger Frey, the authors of the book *Quantitative Risk Management: Concepts, Techniques and Tools - revised edition* in 2014 at the Kruger Park (South Africa). The book, published by Princeton University Press, June 2015 [14], is one of the most widely used textbooks in Quantitative Risk Management and has also been translated into Japanese.

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