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HERIOT-WATT UNIVERSITY

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I arrived in Heriot-Watt University Campus very early in the morning on April 8th 2013 for the first day of the two-day conference organized by the Institute of Mathematics and its Applications. The Institute organizes events throughout the year on topics ranging from Cryptography and Coding to Hydraulics and Fluid Dynamics. The conference I attended was on Mathematics in Finance with many prestigious speakers from abroad and from the UK, who were there to present their cutting-edge research and discuss their material with other experts and observers. As a Masters Student of Financial Mathematics at LMU, I had already attended several conferences to expand my vision and discover state-of-the-art research on topics of my interest. This conference was the last one I attended before I started writing my masters thesis. My preparation for the conference involved revisiting lecture notes on Financial Mathematics 2 and Financial Mathematics 3, which were both offered by the Working Group on Financial Mathematics at the Faculty of Mathematics in LMU. I was aware that the conference was going to involve topics beyond the reach of my previous studies, thus consulted the book by H. Föllmer/A. Schied, *Stochastic Finance,* 3. Edition, De Gruyter, 2011.

The very first session was by Bernt Øksendal from the University of Oslo. He presented his soon to be published work, "robust duality in finance". Prof. Øksendal applies convex duality theory to link two optimization problems. Under certain conditions, optimization of the expected utility of terminal wealth can be achieved by solving the equivalent dual problem, minimizing the expected value of dQ/dP over a family of equivalent local martingale measures. In the first problem, the terminal wealth is solved for admissable portfolios in a market with risky asset price process modelled as a semimartingale. Solving the first problem involved working knowledge in Lévy processes, and in-depth knowledge of Malliavin derivatives, which I did not possess at the time of the speech. Dual equivalence of the second problem under model uncertainty was elegantly put forth, although it was a bit difficult to follow at the time of the presentation. The application was much appreciated by experts in the audience, although others, including me, had to ask many questions to understand the material.

After this first session, parallel sessions were held on Risk and Solvency and Complex Systems. The audience had to choose between two sets of talks. I decided to participate in the first two talks on Complex Systems and subsequently in two sessions on Risk and Solvency.

The first talk on Complex Systems was on "Applications of Econophysics principles to determine stocks trends and strength" by Christoph Schmid from an advisory company, called IRISOS, based in Switzerland. In the speech, returns using a sequential algorithm working on econophysics principles was compared to information-driven and flow-driven trading strategies to identify leading stocks. Results shared with the audience indicate that the algorithm does indeed choose stocks with less variations. The algorithm allows for %3 less volatility when the investment period is limited to 90 days. Only results were shared in the presentation, although the paper itself detailed the method used in the study. The advisory firm in fact currently uses this algorithm as one of their trading tools.

The second talk on Complex Systems was on "Lévy Information and the Aggregation of Risk Aversion" by Dorje Brody and Lane Hughston. The authors address the relationship between risk, risk aversion and return when asset prices are modelled as processes that allow for jumps. Market risk aversion is an aggregation, in terms of an harmonic mean, of individual attitudes towards risk, which is defined as a pricing kernel for each individual. Authors prove that the market price of risk is the aggregation of such individual pricing kernels and each individual is positioned as a buyer or seller according to their pricing kernel with respect to the market kernel. A new information process was defined, and the final result is an arbitrage-free pricing method, obtained by using signal processing and pricing kernels.

After the coffee break, I moved on to the other room to attend the remaining two talks on Risk and Solvency.

The talk on "Optimal Capital Structure and Default Policy in an Integrated Model for Market, Credit and Liquidity Risk" was given by JProf. Dr. Eva Luetkebohmert-Holtz from University of Freiburg. Model Risk in this paper encapsulates Market, Credit and Liquidity Risks. While choosing its capital structure to finance its risky assets, each financial institution faces a choice of equity, short-term debt and long-term debt. Rollover risk is defined by the authors as the risk that equity holders will bear in case the short-term creditor will not renew the contract; exposing the institution to liquidity risk. Their maximization problem defines a barrier on equity holder's side, which allows the authors to find out market price for credit spreads and optimize capital structure for the firm. Not much time was left for questions before we moved onto the next speaker.

The next talk was related to risk measures, and was particularly compelling to me as I had attended a seminar on Risk Measures in the Winter semester. It was on "Measuring the Model Risk of Contingent Claims" by Prof. Dr. Natalie Packman from Frankfurt School of Finance and Management. With well-defined option prices, these authors compare different risk measures with respect to the value difference of the hedging portfolio for the pricing problem of a derivative. Then a hedging error is computed with respect to differences under various risk measures, namely value at risk and expected shortfall. They also use information criteria to compare their statistical results for model risk measures. This presentation was helpful on the second day of the conference when more papers on risk and solvency were presented.

The most interesting speech of the day was the plenary talk given by Prof. Dr. Philip Treleuven from the University College London. As the head of the Computer Science

department at UCL, he shared his goal of an integrated research environment at European level for research themes in finance. He argues that the amount of storage space needed for the data in consideration requires massive resources, so much so that no single institute or university can cope with it alone, but governments. Professor Treleuven compares his idea to the Hadron Collider in CERN in Geneva. His department saves and compiles data, but to no avail; even in very short periods of times like three days, they amass petabytes of data and are overwhelmed before posing any research questions. Prof. Treleuven also emphasized that about %80 of the trading activity consists of high frequency trading carried out by multiple algorithms and that there is virtually no research on how multiple algorithms react with each other. A European level institution for financial research could render scholarly work possible on stress scenario simulations for risk management research, on interaction dynamics for high frequency trading algorithms and also on some previously unexplained phonemena such as the Flash Crash of May 6th, 2010 when high frequency trading dragged the market down and brought it back up within 10 minutes with a trading activity of 600 billion dollars.

Risk research is alike the new Gold Standard, according to Prof. Treleuven, and it should be treated as such by large financial institutions and sovereigns. Prof. Treleuven treats high-frequency trading like the change from hand crafted production to mass production, and algorithms as the robots - machines that allow the shift in the mode of production. The question-answer session for this talk took quite a while since everyone was exuberated to discuss these ideas. Although everyone was spent and famished after long sessions of mathematical discussions, the talk ended 30 minutes later than initially set.

After the lunch break, the audience was brought together for yet another plenary talk, this time on "Which Mathematics for Financial Resilience?" by another UCL scholar, Dr. Dave Marsay. Dr. Marsay first argued that crises are almost completely defined by critical instabilities, and during crises three notions are present: diffusion, reaction and momentum. As such, loss of confidence and panic spreads quickly. For that reason, experiences of the past as well as models to treat previous situations can be very misleading. Moreover, most mathematical applications are focused on efficiency, but not effectiveness. Under efficiency concerns, the next crisis is likely to become a complex one, since it reflects the shortcomings of a system built up with efficiency concerns in mind at all levels. Thus, a different mathematics, other than the one conventionally used is required to cope with such a new crisis, Dr. Marsay argues. This talk was much appreciated by the audience, and a heavy Q&A session followed.

After this plenary talk, the audience was again divided into two different rooms for talks on Uncertainty and Credit Risk.

I stayed with the uncertainty session until the end of the day, and listened to talks on "Context-specific policies in ambigious regime switching environments" and "Optimal Investment-Consumption under regime-switching models", "Stability, Contingency and Ergodicity in Modelling Financial Markets" and "No Good Deals - No Bad Models". Among the four talks, some could not present the material over the time allotted, and some were not related to my interests. But the last one, "No Good Deals - No Bad Models" indeed was

thought provoking. The authors use some previously generated models to introduce a model uncertainty induced utility function, which allocates, as expected, greater weights to scenarios in which investors incur higher losses. The buy-and-hold strategy becomes a reasonable strategy when model uncertainty is taken into consideration in the utility function. The optimal level of utility is not set only for some prices, but two limits that are derived in the calculations serve as the good deal limits. It's a 60-page paper, and many researchers contributed to it.

The day concluded with poster sessions for junior researchers. Some masters students had applied to the Institute of Mathematics and its Applications to present their theses work as poster sessions.

The first talk of the second day of the conference was given by Prof. Dr. Damir Filipovic, who was the head of the Workgroup on Financial Mathematics at LMU before Prof. Dr. Francesca Biagini. His talk on " Scenario Aggregation for Solvency Regulation" offered a new approach for regulation in insurance industry. Prof. Filipovic developed the Swiss Solvency Test himself, and presented its uses in the industry at the beginning of his talk. He gave a timeline of events and emphasized that insurers buying assets without thorough risk assessment bursted with the dotcom bubble. Prof Filipovic then mentioned that The Swiss Solvency Test saved lots of effort during the 2008-2009 period. Right now internal models are encouraged and regulators have to check these internal models, which is a very heavy task, considering the scale of the industry. He mentioned stress scenarios to be aggregated for the capital requirements. Use of stess scenarios is a good chance for regulators for convergence of internal models. The model uses a loss functional defined on a universal sigma field and sample space (Ω, $\mathbf{F}$) and insurer specific P and L, that define the beliefs of the insurer and the internal model, respectively. In each case, regulator understands the loss functional $L(\omega)$, challanges the belief P, the distribution. A vector of target probabilities is defined, and a set of views are expressed on each side. Then, a Φ-divergence is used, with Φ as a convex function on Radon-Nikodym Derivative.

The model pays out in Capital Requirements: The stress test, view and my belief has a difference. With an optimization, each insurer solves for the distance between their model and the regulator. The insurer immediately has a benefit in adopting this new method for it allows for convergence to the model of the regulator.

Prof. Filipovic then discussed that Folk Theorem suggests that Value at Risk is more robust than expected shortfall, since quantiles are more robust than expectations. Yet, changing the metric implied that expected shortfall does not depend on the choice of quantiles and hence expected shortfall is more robust than Value at Risk, in this case.

Prof. Filipovic further argued that scenario aggregation is vital in risk-based solvency regulation. Current Swiss Solvency Test is subject to critical review. This minimum Φ-divergence approach is a coherent scenario aggregation method since it allows for:

- no penalty for conservative internal models,

- focus on tail events

- control over distance from internal model

- robustness of capital requirement

and pays out in capital requirements to the insurer.

After Prof. Filipovic's talk, parallel sessions started in two different rooms. I decided to take part in three of the sessions on "Systemic Risk" and the last session on "Risk and Solvency".

The first session on "Systemic Risk" was on "Derivatives and Credit Contagion in Interconnected Networks". In interconnected networks, investors trying to hedge their positions are subject to the default risk of the protection seller, while they buying protection. With credit default swaps, that counterparty risk is spreading out to other financial institutions. According to Prof. Kuehn from King's College London, banks are reluctant to offer credits to small and medium businesses, because it's problematic on the upper level, while they are insuring their risks. Loss distributions are likely to be wrong in detail, and banks, while expanding their books will lead to increased chances of running into large scale losses. Prof. Kuehn demonstrated the case of AIG's CDS exposure as one example of such a contagion besides proving his propositions.

The second session was an empirical study by employees from Borsa Istanbul, called "Analysis of Cross Correlations Between Financial Markets : Comparison Between Before and After the 2008 Crisis". Using random matrix theory, authors compare returns on the indices of eighty-seven financial markets from around the world. Eigenvalues of these cross-correlation matrices are tested against universal properties of random matrices to indicate that most of the cross-correlation stems from random effects. Once this is accomplished they compare their results to that of the period after the global crisis to find that in times of high volatility, glbal markets tend to act similarly, and randomness disappears. The presentation also included graphs that showed countries clustered according to their levels of collective behavior. Some of the graphs were generated by using minimum spanning trees. Among interesting results were large financial centers moving collectively, and geography being an important indicator, in the sense that investors living in similar regions tended to act together.

The last session I attended on Systemic Risk was about a talk on "Regulatory Capital Charges For Too Connected Institutions - A Copula Approach". This presentation attracted attention to its short-comings, and was heavily criticized by the audience. The presenter made serious mistakes regarding content and methodology and could not address the audience articulately. In fact, during the presentation the presenter tried to review some elementary notions like Brownian Motion, distribution functions and could not explain exactly why he was using Copula functions. The dispute continued until the lunch break and I missed the last session on Risk and Solvency before lunch.

After the lunch break was a plenary talk by Prof. Dr. Rama Cont from Imperial College London. The talk was on "Institutional Investors and the Dependence Structure of Asset Returns". It was another follow-up talk on systemic risk, and the discussion of contagion via

insolvency and contagion via illiquidity came up again. The interdependence of asset returns, according to Prof. Cont spreads out problematic part of portfolios, and the feedback effect causes a fire sales of assets. Regulators want macro-prudential mechanisms aimed at coping with dynamics of contagion. Moreover, Prof. Cont gave examples of cases when micro-prudential regulatory measures on institutional level failed repeatedly, such as on Black Monday event in 1987, dissolution of LTCM, and Quant Event of August 2007. Prof. Cont's co-author Lakshite Wakalath continued talking about the topic with a similar approach after Prof. Cont wrapped up his talk. At that point, some people left the room to attend the parallel session on Complex Systems, but I decided to keep listening to talks on Liquidity and Market Efficiency. Mr. Wagalath also gave specific examples for the study of spikes in volatility, during times of liquidation of large portfolios. These indicate that fire sales of assets in fact takes place collectively and cause massively similar movements in markets.

After "Fire Sales Forensics: Measuring Endogenous Risk", there was the talk on "Transaction Costs, market impact and derivative hedging" by Frédéric Abergel. The talk was on derivative modelling, with transaction and liquidity costs taken into consideration. With finite liquidity on demand side, market impact can be seen as the feedback on the market dynamics of the large trader's hedging strategy. The author offered a tractable joint-modelling of liquidity costs and market impact for derivative hedging.

In the very last session of the conference, Dr. Alexander Adamou from London Mathematical Laboratory talked about "Stochastic Market Efficiency". The difference between the classical efficient market hypothesis of this paper is that the author was able to come up with market data to support the hypothesis he put forth. After the short talk, the conference concluded.

In some cases it was difficult to follow the conference. Some presenters had very interesting pieces of work but they could not use their time properly, spending too much time with the introduction of the setting, instead of the methodology or conclusions. In some cases, the material was too heavy to understand in 30 minutes, especially some mathematical models were not easy to grasp for me as a second-year masters student. All in all, I had a final chance to discuss mathematical models before I finally set off to writing my own thesis and also to meet some highly renowned people in the world of theoretical finance, besides discovering the newest research horizons in the field. On a final note note, while writing this report more than a month after the conference, I personally discovered that by frequently asking questions during all sessions, I was able to increase and prolong my initial understanding of most of the material I was exposed to.