The Mark H. A. Davis Festschrift: Stochastics, Control and Finance

Mark Davis has been associated with numerous major advances and has been influential to several generations of researchers working in the fields of stochastic analysis, stochastic contol and financial mathematics. On a personal level, Mark has been an inspiring teacher and mentor as well as a great friend and colleague. It is therefore with great pleasure that we write the foreword to this special issue of *Stochastics* comprising papers presented at the *Workshop on Stochastics, Control and Finance in honour of Mark Davis on the occasion of his 65th birthday* at Imperial College London, 12–14 April 2010[1].

After completing his BA degree in Electrical Engineering at the University of Cambridge, Mark pursued his PhD degree at UC Berkeley under the supervision of Pravin Varaiya. While at Berkeley, Mark had the opportunity to attend several influential courses, including his first-ever course in stochastic processes, given by Eugene Wong, and a course in probability given by Michel Loève. Indeed, this was a great period for stochastic analysis at Berkeley. Mark's cohort benefitted by the interaction with several distinguished visitors such as Vic Beneš and got access to ground-breaking works such as "On square integrable martingales" by Kunita and Watanabe before they were published. At the same time, researchers such as Thomas Kailath and Tyrone Duncan were just across the Bay at Stanford.

Mark's PhD thesis initiated the martingale theory of stochastic control. This would soon become one of the main methodological approaches that we currently have for the study of stochastic control and optimisation problems. In later years, Mark continued to work on several aspects of this theory, which has attracted the interest of numerous mathematicians, with Robert Elliott being among the first ones.

Returning from the States in 1972, Mark joined the Control Group at Imperial College London. The group had been created by John Westcott and David Mayne; Martin Clark was already there, while Richard Vinter joined in 1974. Several research visits were influential to Mark's academic development over the next two decades. Notable ones include his visits at Harvard with Roger Brockett in 1974, at MIT with Sanjoy Mitter in 1978/79 and in Vienna with Walter Schachermayer in 2000. His participation in a semester on control theory at the Banach Center in Warsaw in 1973 was another significant event during which he met Jerzy Zabcyk, Albert Shiryaev and several other mathematicians from Poland and Russia. In 1991, Mark spent six months at the University of Oslo visiting Bernt Øksendal, where he largely wrote his book *Markov Models and Optimization*.

After joining Imperial, Mark worked in several areas beyond the martingale theory of stochastic control. His research contributions have been so multifold and significant that going in detail through all of them would go way beyond the scope of this brief introduction. Therefore, we will suffice ourselves to just listing a few of them. The general theory of jump processes was one of the first areas that Mark contributed to, while his

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fundamental research on the development of pathwise nonlinear filtering theory was motivated by a basic observation by Martin Clark. Starting from a collaboration with Michael Dempster and Domokos Vermes on capacity expansion problems in production planning, Mark came up with the theory of piecewise deterministic processes (PDP). After the publication of his seminal paper in 1984, PDP's soon attracted most significant interest. In particular, their application to insurance was advanced by Paul Embrechts, who was at Imperial at that time. In the early 90's, Mark originated the deterministic approach to stochastic control by means of appropriate Lagrange multipliers. Some important aspects of this theory were studied in collaboration with Ioannis Karatzas and Gabriel Burstein, and were later taken up by Chris Rogers.

In the second part of the 80's, Mark developed a keen interest in mathematical finance. In his seminal paper with Andrew Norman, he derived a computable solution to the portfolio selection problem with transaction costs that has become one of the contributions that have shaped mathematical finance as the theory that we currently have. Mark made several further contributions to the theory of option pricing since then, with a notable one in collaboration with Thaleia Zariphopoulou. In the context of such applications in the area, Mark originated advances in the general theory of singular stochastic control in collaboration with Mihail Zervos.

In the early 90's, Mark's contributions to mathematical finance had received wide recognition in the academic community. At that stage, Mark started feeling that he had done as much in the field as he possibly could without any first-hand practical experience. It was at that time in 1995 that he received a telephone call from a head-hunter acting on behalf of Mitsubishi Finance (MF), which would later become Tokyo-Mitsubishi International (TMI). He took the challenge and became Director and Head of Research and Product Development at MF in London to run a group of around 6 PhD quants working on pricing models and risk analysis for fixed-income, equity and credit-related products. During his time in the City, Mark worked on several projects, including early models for credit derivatives, and came up with the "infectious defaults" model with Violet Lo.

Mark left TMI in November 1999 and returned to Imperial College London in August 2000 to build Imperial's Mathematical Finance group and programme. He launched the MSc in Mathematical Finance, originally designed by Terry Lyons, in that same year. He has been running the Mathematical Finance programme until recently. During this time, Mark has worked on numerous projects, including credit risk models with Giacomo Giampieri and Juan-Carlos Esparragoza, Malliavin Calculus with Martin Johansson, arbitrage conditions for option pricing with David Hobson and Jan Obłoj, interest rate models with Vicente Mataix-Pastor, and risk-sensitive asset management with Sébastien Lleo. Hosting the 5th World Congress of the Bachelier Society in 2008 with about 600 participants was amongst the highlights of this period.

So far, Mark has authored 5 books on stochastic analysis, optimisation and finance, and has written more than 100 publications listed in *Mathematical Reviews*. He was Editor-in-Chief of *Stochastics and Stochastics Reports* (1978-95), a founding co-editor of

Mathematical Finance (1990-93) and an Associate Editor of *Annals of Applied Probability* (1995-98). He currently is an Associate Editor of *Quantitative Finance* (since 2000) and *SIAM Journal of Financial Mathematics* (since 2009). Mark has been honoured by the award of the *Naylor Prize in Applied Mathematics* by the London Mathematical Society in 2002. He has been a Fellow of the Royal Statistical Society (elected in 1994), a Fellow of the Institute of Mathematical Statistics and an Honorary Fellow Institute of Actuaries (elected in 2001).

Outside academia, Mark has maintained a wide range of interests. Among them, his love of travelling and his involvement in music in the company of his wife Jessica have been harmonious signs and important reminders to everybody in his environment that academic life need not be dry, uneventful and lacking in sociability. We look forward to Mark's continued friendship as well as his future research contributions to our field!

Dirk Becherer
Giulia Di Nunno
Mihail Zervos
Harry Zheng

Berlin/London/Oslo, 19th September 2012

Mark H. A. Davis: Books

1. *Linear Estimation and Stochastic Control*, Chapman and Hall, London / Halsted Press, New York 1977.
2. *Lineinoe Otsenivanie i Stochasticheskoe Upravlenie*, Nauka, Moscow 1984 (Russian translation of *Linear Estimation and Stochastic Control* with revisions).
3. *Lectures on Stochastic Control and Nonlinear Filtering*, Narosa, New Delhi / Springer-Verlag, Berlin 1985.
4. *Stochastic Modelling and Control*, Monographs on Statistics and Applied Probability 24, Chapman and Hall, London, New York 1985 (with R. B. Vinter).
5. *Markov Models and Optimization*, Monographs on Statistics and Applied Probability 49, Chapman and Hall, London, New York 1993.
6. *Louis Bachelier's Theory of Speculation: the Origins of Modern Finance*, Princeton University Press 2006 (with A. Etheridge).

Mark H. A. Davis: Publications in Refereed Journals

1. Dynamic programming conditions for partially-observed stochastic systems, *SIAM J Control* 11 (1973) 226–261 (with P. P. Varaiya)
2. On the existence of optimal policies in stochastic control, *SIAM J Control* 11 (1973) 587–594
3. Information states for linear stochastic systems, *J Math Anal Appl* (1972) 384–402 (with P. P. Varaiya)
4. On the multiplicity of an increasing family of sigma-fields, *Ann Prob* 2 (1974) 958–963 (with P. P. Varaiya)
5. Nonlinear filtering with counting observations, *IEEE Trans Information Theory* IT-21 (1975) 143–149 (with A. Segall and T. Kailath)
6. The application of nonlinear filtering to fault detection in linear systems, *IEEE Trans Automatic Control* AC-20 (1975) 257–259
7. On stochastic differentiation, *Theory of Probability and its Applications* 20 (1975) 887–892
8. The separation principle in stochastic control via Girsanov solutions, *SIAM J Control and Optimization* 14 (1976) 176–188
9. The representation of martingales of jump processes, *SIAM J Control and Optimization* 14 (1976) 623–638
10. Martingales of Wiener and Poisson processes, *J London Math Soc* (2) 13 (1976)
11. Exact and approximate filtering in signal detection: an example, *IEEE Trans Information Theory* IT-23 (1977) 768–772 (with E. Andreadakis)
12. Optimal control of a jump process, *Z Wahrscheinlichkeitstheorie ver Geb* 40 (1977) 183–202 (with R. J. Elliott)
13. The general point process disorder problem, *IEEE Trans Information Theory* IT-23 (1977) 538–540 (with C. B. Wan)

14. A direct proof of innovations/observations equivalence for gaussian processes, *IEEE Trans Information Theory* IT-24 (1978) 252–254
15. Existence of optimal controls for stochastic jump processes, *SIAM J Control and Optimization* 17 (1979) 511–524 (with C. B. Wan)
16. "Predicted miss" problems in stochastic optimal control, *Stochastics* 2 (1979) 197–209 (with J. M. C. Clark)
17. Stochastic control by measure transformation: a general existence result, *Information Science* 21 (1980), 195–208 (with M. Kohlmann)
18. Functionals of diffusion processes as stochastic integrals, *Math Proc Cambridge Phil Soc* 87 (1980) 157–166
19. Capacity and cutoff rate for Poisson-type channels, *IEEE Trans Information Theory* IT-26 (1980) 710–715
20. On a multiplicative functional arising in nonlinear filtering theory, *Z Wahrscheinlichkeitstheorie ver Geb* 54 (1980) 125–139
21. Optimal play in a stochastic differential game, *SIAM J Control and Optimization* 19 (1981) 543–554 (with R. J. Elliott)
22. Factorization of a multiplicative functional of nonlinear filtering theory, *Systems and Control Letters* 1 (1981) 49–53
23. New approach to filtering for nonlinear systems, *Proc IEE* (D)128 (1981) 166–172
24. A note on a comparison theorem for equations with different diffusions, *Stochastics* 6 (1982) 147–149 (with L. I. Galchuk)
25. A pathwise solution of the equations of nonlinear filtering, *Theory of Probability and its Appl* (USSR) 27 (1982) 160–167
26. On a problem of D. R. Cox, *Ann New York Acad Sci* 410 (1983) 129–132
27. Piecewise-deterministic Markov processes: a general class of non-diffusion stochastic models (with discussion), *J Royal Statist Soc (B)* 46 (1984) 353–388
28. Optimal timing of capacity expansion, *J Economic Dynamics and Control* 10 (1986) 89–92 (with Z. Carvalhais)
29. Pathwise nonlinear filtering for non-degenerate diffusions with noise correlation, *SIAM J Control and Optimization* 25 (1987) 260–278 (with M P Spathopoulos)
30. Optimal capacity expansion under uncertainty, *Advances in Applied Probability* 19 (1987) 156–176 (with M. A. H. Dempster, S. P. Sethi and D. Vermes)
31. The martingale maximum principle and the allocation of labour surplus, *J Economic Dynamics and Control* 11 (1987) 210–217 (with G. Gomez)
32. Approximations for optimal stopping of a piecewise-deterministic process, *Math of Control, Signals and Systems* 1 (1988) 123–146 (with O. L. V. Costa)
33. Wiener space derivatives for functionals of diffusions on manifolds, *Nonlinearity* 1 (1988) 241–251
34. Anticipative LQG control, *IMA J Mathematical Control and Information* 6 (1989) 259–265

35. Impulse control of piecewise-deterministic processes, *Mathematics of Control, Signals and Systems* 2 (1989) 187–206 (with O. L. V. Costa)
36. On the minimum priciple principle for controlled diffusions on manifolds, *SIAM J Control and Optimization* 27 (1989) 1092–1107 (with M. P. Spathopoulos)
37. Strong consistency of the PLS criterion for order determination of autoregressive models, *Annals of Statistics* 17 (1989) 941–946 (with E. M. Hemerly)
38. Recursive order estimation of stochastic control systems, *Mathematical Systems Theory* 22 (1989) 323–346 (with E. M. Hemerly)
39. Portfolio selection with transaction costs, *Math of Operations Research* 15 (1990) 676–713 (with A. R. Norman)
40. Recursive order estimation of autoregressions without bounding the model set, *J Royal Statist Soc (B)* 53 (1991) 201–210 (with E. M. Hemerly)
41. A deterministic approach to stochastic optimal control with application to anticipative control, *Stochastics and Stochastics Reports* 40 (1992) 203–256 (with G. Burstein)
42. Reducibility and unobservability of Markov processes, *IEEE Trans Automatic Control* AC-37 (1992) 505–508 (with V. Lasdas)
43. European option pricing with transaction costs, *SIAM J Control and Optimization* 31 (1993) 470–493 (with V. G. Panas and T. Zariphopoulou)
44. A problem of singular control with discretionary stopping, *Ann Appl Prob* 4 (1994) 226–240 (with M. Zervos)
45. A note on super-replicating strategies, *Phil Trans R Soc Lond A* 347 (1994) 485–494 (with J. M. C. Clark)
46. The writing price of a European contingent claim under proportional transaction costs, *Computational and Applied Math* 13 (1994) 115–157 (with V. G. Panas)
47. A new proof of the discrete-time LQG optimal control theorems, *IEEE Trans Automatic Control* AC-49 (1995) 1450–1453 (with M. Zervos)
48. Permanent health insurance: a case study in piecewise-deterministic Markov modelling, *Mitteilungen der Schweiz Vereinigung der Versicherungsmathematiker, Heft* 2 (1995) 177–212 (with M. H. Vellekoop)
49. A target recognition problem: sequential analysis and optimal control, *SIAM J Control and Optimization* 34 (1996) 2116–2132 (with M. Farid)
50. A Markovian analysis of the M/D/1 Queue with finite buffer, *Proceedings of the Royal Society (A)* 453 (1997) 1947–1962 (with J. M. Howl)
51. A new order estimation technique for time series modelling, *IEEE Trans Automatic Control* 42 (1997) 402–403 (with W. X. Zheng)
52. A note on the forward measure, *Finance and Stochastics* 2 (1998) 19–28
53. A pair of explicitly solvable singular stochastic control problems, *Applied Math and Optimization* 38 (1998) 327–352 (with M. Zervos)

54. Pricing weather derivatives by marginal value, *Quantitative Finance* 1 (2001) 305–308
55. Infectious defaults, *Quantitative Finance* 1 (2001) 382–387 (with V. Lo)
56. Pricing, no-arbitrage bounds and robust hedging of installment options, *Quantitative Finance* 1 (2001) 597–610 (with W. Schachermayer and R. Tompkins)
57. Installment options and static hedging, *Risk Finance* 3 (2002) 46–52 (with W. Schachermayer and R. Tompkins)
58. Complete-market models of stochastic volatility, *Proceedings of the Royal Society of London (A)* 460 (2004) 11–26
59. A Hidden Markov Model of default interaction, *Quantitative Finance* 5 (2005) 27–34 (with G. Giampieri and M. Crowder)
60. Malliavin Monte Carlo Greeks for Jump Diffusions, *Stochastic Processes and their Applications* 116 (2006) 101–129 (with M. Johansson)
61. The range of traded option prices, *Mathematical Finance* 17 (2007) 1–14 (with D. Hobson)
62. Negative Libor rates in the swap market model, *Finance and Stochastics* 11 (2007) 181–193 (with V. Mataix-Pastor)
63. Risk-sensitive benchmarked asset management, *Quantitative Finance* 8 (2008) 415–426 (with S. Lleo)
64. Large portfolio credit risk modelling, *International Journal of Theoretical and Applied Finance* 10 (2007) 653–678 (with J. C. Esparragoza Rodriguez)
65. Informed Traders, *Proceedings of the Royal Society of London (A)* 465 (2009) 1103–1122 (with D. C. Brody, R. L. Friedman and L. P. Hughston)
66. Arbitrage-free interpolation of the Swap Curve, *International Journal of Theoretical and Applied Finance* 12 (2009) 969–1005 (with V. Mataix-Pastor)
67. Optimal investment under partial information, *Mathematical Methods of Operations Research* 71 (2010) 371–399 (with T. Bjork and C. Landen)
68. Impulse control of multidimensional jump-diffusions, *SIAM J Cont Opt* 48 (2010) 5276–5293 (with X. Guo and G. Wu)
69. Jump-Diffusion Risk-Sensitive Asset Management I: Diffusion factor model, *SIAM J Fin Math* 2 (2011) 22-54 (with S. Lleo)
70. Arbitrage bounds for weighted variance swap prices, *Mathematical Finance* to appear (with J. Obloj and V. Raval)