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MICHAEL TAKSAR MEMORIAL ISSUE

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MICHAEL I. TAKSAR

MICHAEL I. TAKSAR, 1949 -2012

Michael I. Taksar was born on September 9, 1949, in Moscow, Russia. His mathematical abilities revealed themselves quite early, when he was a student in the special high school in Moscow organized in 1964 by Eugene Dynkin for mathematically inclined children. In 1966 he became a student at the Faculty of Mathematics and Mechanics of the Moscow State University and in 1971 he graduated from it with an MSc degree in Mathematics (Probability Theory and Mathematical Statistics). After the graduation from the University, he worked as a Research Scientist at the Central Institute of Economics and Mathematics of the USSR Academy of Sciences until 1977. In 1978 Michael Taksar emigrated to the United States and in 1979 he received his PhD in Mathematics (Probability Theory) from Cornell University in Ithaca, NY.

His career as an applied probabilist in the US began when he became an Assistant Professor at the Department of Operations Research at Stanford University (1979-1984). He worked as Associate Professor at the Department of Statistics at the Florida State University, Tallahassee, from 1984 to 1987. In 1987, he received a position of a Full Professor at the Department of Applied Mathematics at the State University of New York at Stony Brook, from which he moved to the Department of Mathematics of the University of Missouri, Columbia, in 2002. In all the Universities he worked, he created around himself an atmosphere of fruitful work marked by remarkable achievements.

Michael Taksar's early research was guided by his PhD advisor, one of the founders of the theory of stochastic processes, Eugene Dynkin. As one of the members of "Dynkin's school", Michael Taksar belongs to the group of mathematicians whose research during the last 2-3 decades provided substantial influence on, and in certain respects determined, the current shape of Applied Probability. He gained his reputation in the communities of applied probabilists and control theorists because of his ability to perform a deep analysis of the mathematical problems he worked on, brilliant command of advanced mathematical techniques and an elegant, highly professional style of his papers and presentations.

One has to emphasize three groups of Michael Taksar's results, or three directions of his research that are extremely important. Michael Taksar is known to control theorists as one of the founders of singular stochastic control. This theory has applications in various fields, and in particular it is indispensable in some aspects of financial economics dealing with continuous-time dynamic investment problems. The pioneering paper in this direction co-authored by Michael Taksar is one of the most cited publications in the field.

The second group of Michael Taksar's results, which has been the main focus of his work during the last one or two decades, is related to both Mathematical Finance and Insurance. It combines the ideas of controlling risk with portfolio optimization and dynamic investments. In this field, Michael Taksar with a team of co-authors from various countries obtained profound and extremely valuable results. A characteristic feature of these results is that they are of theoretical importance, and at the same time, have a strong applied direction. They lead to explicit formulas, ready for computations, and give direct answers to questions that are of interest to both theoreticians and practitioners.

The third direction of research on which Michael Taksar focused during the last two decades was related to stochastic models in mathematical economics. He made substantial contributions to the development of stochastic models of dynamic economic equilibrium taking into account local interactions among economic agents. Here, he pursued a novel approach involving non-classical stochastic control schemes for random fields on directed graphs. Another topic he was interested in was the application of the ideas and results of the theory of economic growth (von Neumann-Gale model) to the modeling of financial markets with frictions – transaction costs and portfolio constraints.

Michael Taksar could not only work very successfully as an individual researcher, but he also possessed outstanding abilities to work in interdisciplinary environments, organizing and directing a team of scientists with the view to achieving a common goal. His co-authors in recent years (more than 10 top-level applied probabilists from various countries as well as scholars from engineering, actuarial science, finance, management science, etc.) had quite different abilities and backgrounds, but in collaboration with Michael, their research has led to a series of closely interrelated results that constituted a self-contained and complete theory. This rare and valuable combination of an individual mathematical talent and abilities to organize and lead a team of scientists distinguished Michael Taksar among many other researchers with comparable mathematical strength.

Michael Taksar was a brilliant lecturer, always working thoroughly on the presentation of the material he taught. His lectures will be remembered forever by the young people whom he introduced to Applied Probability and Mathematical Finance. His PhD students will be always grateful to Michael for help in making their own first steps in research.

Michael Taksar was an outstanding mathematician and a man of a generous spirit, taken too early, sorely missed by those who knew him, and gratefully remembered.

Alain Bensoussan
Igor V. Evstigneev
Mogens Steffensen

June 2013

MICHAEL TAKSAR IN THE MEMORY OF HIS FRIENDS

Søren Asmussen

My memory of when I first met Michael is quite vague. Probably at meetings in the 1980s and 90s. I had certainly been aware of his work in stochastic control and he of my interest in insurance related problems. Accordingly, we got together more seriously in the mid 90s and worked out our first paper on dividend strategies in risk models. Very little had been done on control in insurance then, though by chance Shiryaev and Jeanblanc independently wrote a closely related paper at about the same time. For my part, this collaboration also served as a tutorial in stochastic control given by one of its masters.

This collaboration continued over the years. A main part was Michael's collaboration with my PhD student Bjarne Højgaard, where Michael in reality served as supervisor for large parts of Bjarne's thesis. This resulted in a series of papers by the two and later in one written by all three of us, published in Finance and Stochastics 2000 and treating the important excess-of-loss reinsurance scheme. In this collaboration Michael once more taught me some lessons, not least on how to solve differential equations that appeared unaccessible by my modest skills.

Michael has visited me both in Aalborg and Lund, and most recently two times in Aarhus. The last visit was in 2011, where motivated by control problems we got intrigued by the largely open problem on how to model portfolio characteristics as functions of the premium charged by the insurance company.

The project quickly turned out to contain a fair amount of economics ideas, and by good fortune we got Bent Jesper Christensen from the Aarhus economics department involved. We had a number of very fruitful and inspiring meetings on this, resulting in a conglomerate of ideas from all three of us. However, when Michael left Aarhus, the paper had still open problems and remained dormant until we received the sad news of his death. A new breakthrough came in the last months of 2012, and we are extremely glad that as a tribute to Michael we can contribute to this volume by the final version of the paper to which Michael brought so much in its early stages.

My memories of Michael are not only professional. Also as a person, he was far from ordinary. I remember his cocktails, where an important ingredient was the special Japanese melon liqueur he carried in his suitcase while traveling the world. And my wife has vidid memories of the dancing lessons he gave her in our kitchen. He will be remembered and missed.

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Alain Bensoussan

Michael Taksar, a Respected Scholar and a Great Personality

I have not written papers with Michael, but I have known him for long. Of course, I knew his remarkable work. It turned out that from 2009 to 2012, he was visiting the Hong Kong Polytechnic University, in which I had a position. This gave us the opportunity to know each other better. We had several dinners together, and I could learn more about his personal life. I keep the memory of a very profound and sensitive person, with deep thoughts and exceptional intellectual skills. It is so sad that this personal relation has been interrupted abruptly. Of course, the loss for applied mathematics, probability, mathematical finance and insurance is dramatic. He will remain in my memory as he will in that of all his friends.

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Abel Cadenillas

I saw Michael Taksar for the first time when I was a PhD student at Columbia University and Michael was invited to give a talk in a seminar of the Department of Statistics.

After completing my PhD, I read some of his papers and met him at some conferences. I developed an admiration for his outstanding and innovative work on stochastic singular control and its applications. In particular, Harrison and Taksar (Mathematics of Operations Research 1983) and Taksar, Klass and Assaf (Mathematics of Operations Research 1988) are classical papers of this literature.

In the late nineties, Michael became interested in insurance problems and I became interested in stochastic impulse control and its applications. Asmussen and Taksar (Insurance: Mathematics and Economics 1997) and Jeanblanc-Picqué and Shiryaev (Russian Mathematical Reviews 1995) are the pioneering papers on the application of stochastic control methods to optimal dividend policy problems. During a visit to the University of Alberta, Michael proposed to join forces to study the joint optimization of the dividend and risk policies of a firm taking into account taxes and fixed administrative costs. I was flattered by this opportunity to work with him. Our results (joint work with Tahir Choulli and Lei Zhang) led to the paper Cadenillas, Choulli, Taksar and Zhang (Mathematical Finance 2006), which studies the dividend optimization problem for a financial or insurance firm which can control its business activities, simultaneously reducing risk and potential profits. The management of the firm also controls the timing and the amount of dividends paid out to the shareholders. The objective of the corporation is to maximize the expected total discounted dividends paid out until bankruptcy. Due to the fixed administrative costs, the resulting mathematical problem becomes a mixed classical-impulse stochastic control problem. We solve this problem explicitly and construct the value function together with the optimal policy.

Michael was very generous to share his knowledge with younger researchers. The academic community has lost an outstanding researcher and a great person.

Igor V. Evstigneev

Michael Taksar in My Memory

Michael and I met for the first time at the age of 16, when we were both high school students. We graduated in the same year (1971) from the Faculty of Mathematics and Mechanics of Moscow University and became members of Eugene Dynkin's research group at the Academy of Sciences in Moscow. Michael emigrated to the US in 1978 and became the first PhD student of Eugene Dynkin at Cornell, while I was his last PhD student in Moscow.

In our youth, we did not communicate with each other frequently: it seemed that we had absolutely different characters, general tastes and interests. In the late seventies and eighties, when Michael worked in the US and I was a "senior researcher" in the Academy of Sciences in Moscow, we were hardly aware of each other's existence. Our paths crossed again in 1992 in Bonn, where I spent two years (1991-93) as a visiting professor at the research center at the Economics Department of Bonn University headed by Werner Hildenbrand and Michael visited that center for one month in the summer of 1992. At that time, Bonn was a focal point for research in Mathematical Economics, attracting people eager to work in Hildenbrand's group from all over the world.

Having met after so many years in a fruitful research environment, we discovered that we spoke a common mathematical language, had a considerable intersection of research interests and saw promising topics for a fruitful collaboration. This was not surprising as we had a similar background and the same scale of academic values: Dynkin's style of research in the field, combining an excellent mathematical level with a deep understanding of key modeling aspects, has always been a dream reference point for both of us.

The summer of 1992 became the starting point for our long collaboration, which resulted in numerous joint publications. We worked at the interface of Mathematical Economics and Finance, applying the modeling frameworks developed in the former (von Neumann, Gale, Dynkin) to the modeling of financial markets. In a series of papers (1994-2009), we developed models of large economies with locally interacting agents, based on a control theory for random fields on directed graphs. We had a whole range of plans for further joint work, which were destroyed by the sudden and unexpected death of Michael in February 2012.

I clearly remember our phone conversation on Thursday 9 February 2012 (Michael was at his home in Missouri, and I was in Manchester). We discussed a couple of projects extending to a rather distant future, and Michael, who had just returned from a long chain of sabbatical journeys, sounded relaxed and calm, as if looking into the future with certainty and optimism. And a few days later, on Sunday 12 February, I learned of his sudden death from his wife...

As I have said, Michael and I learned to appreciate each other and became friends in fact a quarter of a century after we had met for the first time. We had joint NSF projects in the framework of which I visited Michael first at Stony Brook and then in Missouri. I remember the beautiful scenary of Long Island, where I spent two springs, 1999 and 2000, and the warm atmosphere of Michael's home. Looking into the past, it comes to my mind that I have never had such a reliable and responsible friend as Michael – a friend who always kept his word, in small and large, and who was always even and calm in his

friendly relations. I tried to reciprocate in return to the extent I could – who knows to what extent successfully…

Michael Taksar, a beautiful mind and a faithful friend, will forever remain in my memory.

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Yuri Kifer

During 1967--1970 Misha Taksar and myself together with several other undergraduates of MechMat faculty of Moscow State University participated in E.B.Dynkin's seminar were we learned various issues in probability and analysis while some of us produced in this framework their first research papers. One of the topics was what is now called Dynkin's games which found their place both in Misha's and my research. My only working collaboration with Misha occured when E.B.Dynkin suggested to us to translate (for the Russian periodical of translations called Matematika) recently appeared (and later became famous) paper by H.Kunita and S.Watanabe, On square integrable martingales, Nagoya Math. J., 1967. The articles for Matematika were not intended to be only automatic word by word translations but could include comments, corrections and more references added by translators who thus were supposed to be experts in the field, and so this offer was rather flattering for two undergraduates who just recently learned the notion of martingales. After a lot of work and many arguments due, in particular, to our less than perfect English we produced a translation which appeared in Matematika in 1971.

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Jose-Luis Menaldi

I had the opportunity of meeting Michael in several occasions and the pleasure to work with him (and Maurice Robin) on singular control problems. There were several projects after this one, but not all of them were actually completed. Certainly, I keep the memory of Michael's amazing skills in probability and I remember some of his ideas or comments always complementing our vision of particular issues with the "what if ..." and the arguments thereafter. In my view, he was a scientist with a wide mathematical culture and a very pleasant personality.

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Maurice Robin

Michael and I met in several occasions at SUNY and at INRIA and we had the opportunity to work, together with Jose-Luis Menaldi, on singular control problems. It was more than twenty years ago, but I remember Michael's amazing skills in probability and the interest I had in our discussions. I keep the memory of Michael as a scientist with a wide culture and a very nice colleague.

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Suresh Sethi

Michael Taksar, 1949-2012

Michael Taksar was an accomplished mathematician, a friend, and a colleague. Our research collaboration began over 25 years ago when I met him at an INFORMS (formerly TIMS/ORSA) meeting, during which we discussed some open research issues and decided to work together. What a fateful decision that was! Over the years I invited Michael to visit me at University of Toronto and University of Texas at Dallas, and I visited him once at Florida State University. Our collaboration resulted in over 25 co-authored papers and a book titled *Markovian Demand Inventory Models*, co-authored by myself, Michael Taksar, and Qing Zhang, and published by Springer in 2010. My joint work with Michael has been in the areas of Mathematical Finance, Operations Management, and Operations Research.

In the late 1980s, I introduced Michael to Mathematical Finance. Our first paper on the topic was to introduce non-terminal bankruptcy in the consumption-investment problem. The paper titled, "Optimal Consumption and Investment Policies with Bankruptcy Modeled by a Diffusion with Delayed Reflection," was presented at the 25th IEEE CDC in Athens, Greece in 1986. The journal version of the paper appeared in *JOTA* in 1992 with the title, "Infinite-Horizon Investment Consumption Model with a Nonterminal Bankruptcy." At that time, we also noted errors in the famous 1971 Merton paper and published, "A Note on Merton's 'Optimum Consumption and Portfolio Rules in a Continuous-Time Model'," in *Journal of Economic Theory* in 1988. Subsequently, I co-authored several other papers on the topic with Michael, which can be found as chapters in my 1997 Springer book *Optimal Consumption and Investment with Bankruptcy*.

Another early work with Michael Taksar was related to hierarchical manufacturing systems. A seminal paper on the topic is Lehoczky, J.P., Sethi, S.P., Soner H. and Taksar, M.I., "An Asymptotic Analysis of Hierarchical Control of Manufacturing Systems under Uncertainty," *Mathematics of Operations Research*, 1991, which was presented earlier at the 27th IEEE CDC in Austin, TX in 1988. Later, our joint paper titled, "Capacity and Production Decisions in Stochastic Manufacturing Systems; An Asymptotic Optimal Hierarchical Approach," won the second prize for the Best Paper Award presented at the Third Annual Meeting of Production and Operations Management Society, held in Orlando, Florida in 1992. My work with Michael and others forms the basis of my 1994 Springer book *Hierarchical Decision Making in Stochastic Manufacturing Systems*, co-authored with Qing Zhang.

During the last several years of his life, Michael worked full throttle in actuarial science, published a number of influential papers, and became very well established in the field. Our 2002 joint paper, "Optimal Financing of a Corporation Subject to Random Returns," published in *Mathematical Finance*, has played an important role in this development.

Some of Michael's idiosyncrasies that I remember fondly are: his liking of soups, particularly miso soup, which he would unfailingly order with almost every dinner that I ate with him, his interest in the art of paper folding (origami), and his extreme dislike of the Soviet system that would form a part of many discussions with him.

Michael Taksar was kind-hearted, hard working, and full of passion. In him, I lost a dear friend and an esteemed colleague, and our research community lost a great scholar.

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Mogens Steffensen

Michael Taksar visited Copenhagen for half a year in 1999 during my PhD studies. We shared the interest in applying stochastic control methods to insurance problems and we discussed intensively various problem formulations and the structure of their solutions. The discussions continued at SUNY at Stony Brook where I spent 3 months as visiting PhD student. There he offered willingly his precious time on shaping my understanding of the applicability of stochastic control to insurance mathematics. Although we never wrote papers together, he influenced heavily my patterns of thinking during those years. Since then I enjoyed meeting and chatting with him at conferences around the world as well as in Copenhagen where he came back a couple of months in 2005. Even more because of friends and collaborators in other parts of Denmark, Michael appeared to like the country, and I am proud to having taken part in his long-lasting relationship to the country.

Privately, he showed me the same hospitality as he did professionally. In Stony Brook he invited me to cocktail parties at his home and shared his many-faceted history with me. Although I was not even formally his student, he showed interest in my person and my works enough to be remembered for the rest of my life. Something that he did not have to do. And this is also what made him a great scientist: Doing, being interested in, and sharing so many things he did not have to. His generosity and intellectual capacity will inspire me forever.

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Allanus Tsoi

Professor Michael Taksar joined the Department of Mathematics at the University of Missouri in Columbia, Missouri, in the year 2002. He became a leader and an icon in the area of mathematical finance and actuarial research in the department, and will remain and be remembered as a founder of the actuarial program in our department.

I first came to know and meet Michael personally through some conferences in mathematical finance held in the USA, Hong Kong and Australia. He first impressed me as a very serious person, not only during the time when he spoke in mathematics and insurance, but also when he was telling a joke. In many occasions I had trouble in deciding whether to laugh deliberately or not.

Michael's research has been a prominent influence on mine. His ideas on controlled diffusion and actuarial applications have made great impact on my research on white noise, filtering, and mathemartical finance. Michael was also a good teacher of Shangzhen Luo, a student of mine, who has been a faculty at the University of Northern Iowa.

Michael's research status has been prominent internationally. He was well recognized in North America, in Europe, in Asia including Hong Kong, as well as in Australia. In Hong Kong he was a good friend of Xunyu Zhou and Yailiang Yang, two leading figures in mathematical finance and actuarial mathematics.

Michael was active, not only in research and guiding graduate students, but in administration as well, in the campus level as well as in the departmental level. His

decisions were crucial in setting up both the undergraduate and graduate programs in actuarial mathematics at our university.

I enjoyed the privilege of being a member of the thesis committee of his students. One of his last Ph.D. students, Dany Bassil, has been working in Chicago and doing very well.

On the romantic side, Michael was a good dancer. Not only did he exhibit his dancing DNA's during many departmental parties, he was also an active member of a local dancing club to the least.

Michael was a tea lover. There were times during the starts of Fall Semesters when I went to his office and enjoyed tea breaks and listened to his opinions on how certain difficult matters should be handled.

Michael will always be remembered as a precious consultant of mine.

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George Yin

Remember Michael

Michael Taksar was a dear friend and a great colleague. I first met him in 1991 at the University of Toronto. He gave a talk there, while I was taking a one-term sabbatical leave.

Later, we saw each other often at conferences and workshops. My favorite memories were the longest time that we spent together at Warsaw Airport. Both of us left for a conference on stochastic control held at the Banach Center. We booked the same KLM flight from Warsaw to Amsterdam and arrived at the airport at the same time. We were told that some part of the KLM jet was broken. Instead of getting it fixed using the local resources, KLM contacted the Amsterdam hub. Somehow, the decision was to wait for an incoming flight to bring the needed part. So we were stranded there. This gave us an excellent opportunity. We chatted on a wide variety of topics from research to real life. It was a lot of fun. The KLM in-bound flight finally arrived. Time seemed to fly rather fast; and we did not realize that 8 hours had passed.

Later on, one of my students worked on problems arising in insurance and risk theory. Naturally, we looked into the literature and studied the work of Michael. In the paper with Højgaard, Michael examined the problem of an insurance company that tries to optimize the actuarial value of the dividends paid out to stockholders until the ruin time. Meanwhile, the company has an option to reduce the risk exposure through cheap reinsurance with the same safety loading as the one of the company. Insightful closed-form solutions were obtained. In their paper entitled "A diffusion model for optimal dividend distribution for a company with constraints on risk control," Choulli, Taksar and Zhou considered optimal control of business activity to find an optimal dividend distribution scheme for a corporation with a liability stream, and with lower and upper constraints on the business activity. Their work paved a way

for considering more complicated problems. We have gained much insight from studying Michael's work.

Michael's passing is a great loss to the mathematics, insurance, and control systems communities. We lost a great mind and very good friend. It is with great sadness that we pay tribute to Michael and celebrate his life at this moment. Even though Michael may be gone, his work will influence us and the scientific community forever. He will live in our memory forever.

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Xunyu Zhou

Michael Taksar's untimely death was really a shock to me. I first met him in 1995, and was often intrigued why he did not appear to age over the years. He was always energetic, with a sharp mind and keen eyes on new research problems. Then suddenly I received the sad news, alas, a cruel reminder how stochastic life can be.

Our first encounter occurred in 1995, when he visited me at the Chinese University of Hong Kong for 2 months. During his visit, he introduced me into the area of mathematical insurance. We put forward a model of an insurance company that could choose a reinsurance policy to manage the risk exposure, and at the same time strategically implement a dividend payout policy in order to maximise the long term value of the company. We formulated the model as a mixed regular-singular control problem for diffusion processes. Employing stochastic control and the theory of Skorokhod's problem, we were able to characterise the risk control and dividend policies explicitly. The paper, entitled ``Optimal risk and dividend control for a company with a debt liability", was published in *Insurance: Mathematics and Economics* in 1998. It has attracted a considerable amount of follow-up researches in the area.

Since then Michael had visited me in Hong Kong many times, in 1996, 1998, 1999, and 2004. It was such an intellectual fun working with Michael, who possessed both sound economic intuition and rigorous mathematical power, a rare quality for people working in the area of mathematical finance and insurance. The collaboration had been fruitful: we had proposed and solved a number of significant problems along the line of our first joint paper.

While most people dislike the humid and hot weather in Hong Kong, Michael liked it very much because it was reminiscence of his favourite weather in Florida where he lived for several years. Indeed he always chose to visit Hong Kong during summers, when many local people, me included, wanted to escape. It goes without saying he was also a fan of the Hong Kong cuisine, so much so he brought over his family a number of times to taste it. I still remember he insisted taking me to dinner the evening before he left Hong Kong every time, proudly declaring it ``*our* tradition".

I also visited him once at Stony Brook, staying with his family in his beautiful house. There I discovered that Michael was a master in making cocktails with vodka. The cocktails he made were stimulating and refreshing. It was such a memorable scene that we sat in his lounge with glasses of *his* cocktails, talking about anything from history to mathematics.

Our field has lost a great mind, and I have lost a friend and colleague. Michael will be remembered, both as a scholar and a wonderful man, for the long time to come.