

Alain BENSOUSSAN

Curriculum Vitae

The University of Texas at Dallas
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Birth Date: 5/12/40
Birth Place: Tunis, Tunisia
Citizenship: French

TRAINING

- Ecole Polytechnique, graduated in 1962. (Master Degree: Mathematics and Sciences)
- Ecole Nationale de la Statistique et de l'Administration Economique, graduated in 1965. (Master Degree Economics and Statistics)
- PhD in Mathematics, 1969, Paris: Identification of parameters and filtering
Advisor: J.L. Lions

DISTINCTIONS AND AWARDS

- SIAM – W.T. & Idalia Reid Prize, 2014
- Fellow AMS, 2013
- Fellow SIAM, 2009
- Member of the French Academy of Sciences - 2003, Correspondent Member 1986
- Legion d'Honneur (Officier) - 2003
- BundesVerdienst Kreuz (Officier) – 2003
- NASA, Distinguished Public Service Medal – 2001
- Ordre National du Merite (Commandeur) - 2000
- Member of the French Academy of Technology, 2000
- Member of the International Academy of Astronautics -1999
- Member of Academia Europae 1985
- Fellow IEEE - 1985
- Von Humboldt Prize - 1984

PROFESSIONAL CAREER

- Ashbel Smith Professor, since September 2009; Distinguished Research Professor, School of Management, University of Texas at Dallas, August 2004, September 2009
- Chair Professor of Risk and Decision Analysis, Graduate School of Business, Polytechnic University of Hong Kong , from January 2009 to December, 2012
- Chair Professor of Risk and Decision Analysis, Department Systems Engineering and Engineering Management, City University of Hong Kong, since January 2013
- WCU (World Class University) Distinguished Professor, Graduate Department of Financial Engineering, Ajou University 2010 – present
- Director, International Center for Decision and Risk Analysis, School of Management, from September 2004
- Associate then Full Professor at the University Paris-Dauphine, from 1969 to 2004
- Emeritus Professor at the University of Paris Dauphine, from 2004

- Part time Professor at the Ecole Polytechnique Paris from 1970 to 1986
- Part time Professor at the Ecole Normale Supérieure Paris from 1980 to 1985
- On Leave at the European Institute for advanced Studies in Management, Brussels, as Professor from 1971 to 1973, then as Director from 1975 to 1977.
- Chairman of the Mathematics Department of the University Paris Dauphine, from 1975 to 1977.
- President of INRIA, Institut National de Recherche en Informatique et Automatique, from 1984 to 1996.
- President of CNES (Centre National d'Etudes Spatiales), French Space Agency, from January 1996 to February 2003.
- Chairman of ESA Council (European Space Agency) from July 1999 to July 2002

SCIENTIFIC RESPONSIBILITIES

- Associate Editor-in-Chief Journal of Mathematical Finance, since 2011
- Member of the Advisory Board of Texas Institute of Science since 2009
- Co Editor in Chief of Risk and Decision Analysis (IOS Press), since 2008.
- Member of the Board of "Fondation du Risque" since 2004
- Editor-in-Chief of Asymptotic Analysis Journal (IOS Press), since 1999
- Member of the Editorial Board
 - ⌚ *Applied Mathematics Letters*
 - ⌚ *Communications in Applied Analysis*
 - ⌚ *Journal of Applied Mathematics and Optimization*
 - ⌚ *Kybernetes*
 - ⌚ *Management Science and Financial Engineering*
 - ⌚ *De Gruyter Series in Nonlinear Analysis and Applications*
 - ⌚ *International Journal of Financial Studies*
 - ⌚ *Journal of Risk and Financial Management*
- Chairman of AFIRST, Franco-Israeli Association for Science and Technology from 1992 to March 1999.
- Vice Chairman of the IFAC "Mathematics of control" Committee from 1978 to 1981.
- Member of the organizing Committee of the IFAC World Congress (1981).
- Member of the selection Committee for the session Control Theory and Optimization, International Congress of Mathematics, Helsinki 1978 and Chairman for the same session, Warsaw 1982.

DESCRIPTION OF MANAGERIAL RESPONSIBILITIES

I have had important managerial responsibilities in France in parallel with my activity as a researcher. Two of the main responsibilities were my successive roles as President of INRIA and then President of CNES (staffed by approximately 2500 people each).

1 -BEFORE MY RESPONSIBILITY as PRESIDENT of INRIA

At the University, I was chairman of the mathematics department for 2 years (1975-1977) and chairman of the CEREMADE (applied mathematics research laboratory of the University Paris Dauphine) for another 2 years (1973-1975). This involved supervising teaching and research programs, looking for new teaching and research staff, and managing corresponding budgets. From 1977 to 1979, I was Director of EIASM, the European Institute for Advanced Studies in Management in Brussels. I had previously been one of the first two French faculty of this newly created institute (1971- 1973). This institute was created with the help of the Ford Foundation and was part of an initiative of several European organizations to

strengthen research and advanced training in Management throughout Europe at a time when very little existed. My presence was justified by the fact that I was one of the few European applied mathematicians interested in quantitative management and by the active role of my university in the creation of this institute.

As Director of EIASM, I implemented a new strategy to counter the unfortunate, but inevitable, scarcity of resources common to international organizations born at a period of prosperity and in a specific context of justification that becomes less present after several years. From a full staff faculty (which is very costly), I turned to the concept of a scientific network. While this was an original idea at the time, it continues to be used by the European Community (which used it to initiate a European Research Program in 1983) and has been the core of the European research area since its inclusion in the 6th framework program. Keeping this concept operational till now has permitted EIASM to survive and to play an active role in unifying the European scientific community in Management.

Needless to say, I gained experience in an international scientific environment, bridged cultural gaps, and negotiated budget issues with several organizations of different countries. At the same time, I was not, being a mathematician, among the most representative of the field. I successfully used this drawback as an asset by remaining neutral among all the active members of the community (not so many at the time) and introducing the spirit of a research-oriented director to a domain in which this was not the traditional flavor in Europe in those days.

2- RESPONSIBILITY as PRESIDENT of INRIA

I was appointed President of INRIA on December 18, 1984. This appointment is made by two Ministers, the Minister of Science and the Minister of Industry. This position is held in renewable 3-year terms. I accomplished 4 mandates (or 12 years).

When I left INRIA in 1996, there were around 1500 staff members, half of which were full-time civil servants. The budget exceeded 100 M\$, which included 20% of owned resources (not governmental subsidy), and it was located in 5 campuses: Rocquencourt, Sophia-Antipolis, Rennes, Nancy and Grenoble, plus a few people scattered elsewhere (namely, in Toulouse). Today, INRIA continues to flourish and has become one of the most famous research institutes in information technology and control in the world.

The following is a brief description of accomplishments which took place during my presidency from 1984 to 1996.

The main responsibility of INRIA is to bridge the gap between Fundamental Research in Computer Science, Control, Scientific Computing and the real needs of industry in both the information technology industry, as well as, in economic sectors using information technology. Although not a university, INRIA has a fundamental role in training, and contained around 500 student members among its staff at the time. Between 1984 and 1996, INRIA nearly doubled in size (growing from 3 to 5 campuses), and put forward an active strategy of transfer by getting contracts with industry and actively encouraging spin-off companies. (Around 20 spin-offs were created in 10 years, which represented the creation of 800 high tech jobs).

INRIA has been very present on the international scene, not only by the reputation and visibility of its staff, but also by many important international agreements, including an agreement with NSF and the opening of a center in Moscow, the Lyapunov Institute, in cooperation with Moscow State University. A spectacular illustration of this presence is the creation under the sponsorship of MIT and INRIA, of the

International World Wide Web Consortium, which gathered approximately one hundred organizations (mainly industries) from America, Europe and Asia.

An additional important initiative was the creation of ERCIM, European Consortium for Informatics and Mathematics, in 1989. ERCIM grew from three founding organizations (INRIA in France, GMD in Germany and CWI in the Netherlands) into a consortium of fourteen European National laboratories and Research Organizations in information technology and control, and today contains many more.

Being President of INRIA means being both Chairman of the Board and Director of the Institute. It involves supervising the scientific orientations and the strategy of transfer and international cooperation. The President has to deal constantly with ministries and local authorities, with industry representatives and with academic institutions. He has a wide range of action, provided he can be convincing internally about the objectives and externally about the achievements of the institute.

Due to the role of INRIA, I have been appointed as member or chairman to numerous committees, boards, and scientific councils of organizations playing a national or an international role. This increased my knowledge and experience of the scientific and industrial environment and allowed me to promote the realizations of the institute.

In addition, I had to become a generalist in the field of information technology and understand the main scientific and industrial issues. I wrote several synthesis reports, some of which I used to present lectures to an audience of non-specialists (i.e. scientists of other disciplines or decision makers from industry or government) and to define the position of INRIA on main issues of concern.

3- RESPONSIBILITY as PRESIDENT of CNES

I was appointed President of CNES, the French space Agency, on January 31, 1996, and elected Chairman of the Council of the European Space Agency for a three year term on July 1st, 1999. My term with CNES was renewed through February of 2003. CNES is the French space Agency as well as a centre of excellence for technology. It represents 2500 persons, including the space port of Europe in Kourou, French Guyana.

The responsibility of the President concerns defining the strategy and orientations of the Center, in particular, the reinforcement of the European cooperation and international programs. Space is a strategic issue in the construction of Europe. As such, I dealt often with industry. One of the important tasks related to the position concerns the European space programs and the restructuring issues, both in industry and in the public sector. More than for INRIA, political aspects impact considerably the activity of CNES. In addition, the culture is completely different from that of a research organization. This environment gave me exposure to new kinds of problems and challenges.

Such a position involves also extended international contacts with the main agencies worldwide, NASA, Rosaviakosmos, CSA (Canada), ISRO (India), CSNA (China), NASDA (now JAXA) (Japan). For my role in this capacity, the NASA Administrator awarded me the distinguished public service medal. I initiated the strategic plans of CNES, positioning the Agency in respect to both the European Space Agency and industry.

More importantly, this position gave me experience outside the pure research establishment. I learned a lot from two serious failures of the launcher Ariane 5. The first one was the maiden flight a few months after I was appointed President, and the second one was in December 2002. This is where I really felt the importance of Risk Management in the context of innovative projects. Besides the passion for space matters, I got from CNES the motivation for my present orientation.

In 2005, I participated to the international commission set up by JAXA to define a new orientation, structure and organization for the Japanese Space Agency.

4 -RESPONSIBILITY as DIRECTOR of ICDRIA

Coming back to the Academic life after I left CNES in February 2003, I decided to devote my time to develop risk and decision analysis as a comprehensive discipline encompassing all possible aspects of uncertainties both technical and managerial. After one year at my University, I decided to move to the U.S. to take on new challenges. I joined the University of Texas at Dallas, in July 2004.

The International Center for Decision and Risk Analysis (ICDRiA) was established in the School of Management of the University of Texas at Dallas in August 2004. The center's mission is to develop research in Risk Management and Decision Making in industry or in relation to security issues. This is a fast growing field with a strong interdisciplinary flavor. The goal is to build in a few years a full program of education and applied research in this domain.

ICDRiA has now three main orientations: Strategic and financial risks, operational risks and information security.

To date, I have obtained support from both Europe and the US which includes grants from ESA (European Space Agency), EADS (European Aeronautics Defense and Space Company), French Ministry of Research, CEA (French Atomic Energy Agency), NSF (2grants as P.I. and one as co PI), and TARP (State of Texas Advanced Research Program). I also obtained a grant from a Canadian Company BlueLine/Rediform. .

I have recently obtained support from EDF (Electricite de France) and CEA and a MURI (DoD Multidisciplinary University Research Initiative) project. The grant with EDF runs from 2011 to 2014 and is devoted to uncertainties related to alternative energies, namely wind power production. The original grant with CEA in 2004 has been renewed from 2011 until 2014. This research involves risks related to the behavior of mechanical structures subject to vibrations. I am also part of a MURI grant managed by my colleagues from the computer science department.

5- INTERNATIONALIZING of ICDRIA

In 2008, I was contacted by the Hong Kong Polytechnic University (PolyU), in relation with the special program of World Class University put in place to attract foreign scholars and boost research. I was appointed Chair Professor of Risk and Decision Analysis at PolyU under a three-year contract that began in January 2009. It has been extended for one year in 2012. The agreement stipulated that I may ask for a no-pay leave of absence of six months per year to visit the University of Texas at Dallas (UTD). My understanding was that I should use this position to favor an extensive cooperation between UTD and PolyU in my field of research and beyond if possible. Therefore, I worked to open a PolyU component of the International Center for Decision and Risk Analysis (ICDRiA). However, opening a branch of ICDRiA at PolyU has turned out to be a more complex matter than expected. This endeavor was considered as creating a new research center, a heavy operation in the PolyU organization.

In 2009, I was contacted by Ajou University in Korea. Ajou University was competing in a program set up by the Korean government to create clusters of excellence in specific domains and boost the research activity and visibility of Korean universities worldwide. Ajou University won the competition in the field

of Financial Engineering. It was an opportunity to develop active networking and complementary activities on a multilateral basis.

To take advantage of the opportunity while avoiding barriers related to creating new research centers, ICDRiA signed an agreement with existing centers within PolyU and Ajou to develop activities in common. The natural partners were the C.Y. Tung International Center for Maritime Studies (ICMS) at PolyU and the World Class University (WCU) Project in the Graduate Department of Financial Engineering at Ajou University. A trilateral agreement was endorsed by the Deans of the respective schools, and we started a process of exchanges in an international context.

Ajou University hosted a symposium July 8-10, 2010, "Optimal Control Theory, Financial Mathematics and Financial Engineering." The outcome has been a very active participation of Chinese, Japanese and Korean scholars in Economics, Finance and Mathematics. The quality of this participation has been outstanding, both in terms of new methods and in terms of new research opportunities. Within PolyU, an important side effect has been the cooperation between the Mathematics Department and the Faculty of Business. To the best of my knowledge, cooperation was very limited in the past and has now taken a greatly increased tempo. Now, we must look to the example of some Chinese Universities, like Shandong and Fudan, in which the cooperation is intensive. The economists know the relevant mathematical tools, and the mathematicians have a deep knowledge of the real problems.

Another important event has been to organize an International Research Forum. The Forum was supported by the three partners of the trilateral agreement, as well as, France (College de France and INRIA), China (Shandong University), and the U.S. (New York University). The Forum took place in December 2010 and has been very successful. Scientifically, we have many outstanding contributions which have been published in special issues of the journal *Risk and Decision Analysis*. At the same time and in close cooperation with the Forum, the department of Applied Mathematics held an International Conference on Applied Statistics and Financial Mathematics, with most sessions in common.

Following the strategy of developing synergetic activities, I tried to take advantage of my activities in the field of wind energy. From the contacts with Electricité de France we had data on wind turbines and wind velocity. Thanks to Professors T.L. Yip and John Liu from ICMS, we were able to obtain similar data for the wind power station of HEC (Hong Kong Electric Company) installed in Lamma Island. We had also some contacts with China Power International Development Limited but no cooperation yet.

I hired a Research Assistant from France and invited two scholars from France. Forecasting is a key issue since profitability cannot be obtained on a purely commercial basis and requires significant investment from the tax payer. While the environmental advantage of this energy creates public support, the tax payer cost must be minimized. Having the most accurate forecast of expected energy production is of crucial importance.

I discovered the Mutual Insurance domain at PolyU with Professor John Liu. This domain is directly linked to the way Maritime Transport Operators fulfill their insurance needs. I supervised a student of Professor Liu, who has now completed his PhD. It turns out that a better understanding of mutual insurance has attracted the interest of Koreans, and we now join expertise in analyzing various aspects of this important domain in the context of Kong Kong economy.

Concerning technical risks and my activity with CEA in France, I would like to mention that one of my interests stems from contacts with the Civil Engineering Department of CityU. In general, the research addresses the risk of breakdown of buildings and constructions subjected to earthquakes. This research ultimately leads to a global risk assessment since the costs trigger the decision. I have published several papers in this domain. It is interesting to notice that the mathematical models present similarities with

those of failure of firms. The civil engineering term “risk of ruin of structures” is reminiscent of the term “risk of ruin” in economics.

To take advantage of international opportunities, I have been in touch with ODDO Options. ODDO is a very successful French bank specialized in trading options and known to be “Market Makers.” ODDO has chosen Hong Kong to expand activities in China and Korea and are eager to work with me to be connected with an Academic environment in Hong Kong. In fact, they recruited my post-doc and we are going to start an active cooperation involving a colleague from PolyU who moved last year to H.K. Chinese University. This colleague and another colleague from the mathematics department of PolyU are co-PI of a GRF grant I received and for which I am P.I. This grant, in the amount of HK\$1.2 M, will begin next year and span three years.

I also got a grant on the Hong Kong-Germany cooperative research program. This grant was awarded for two years and allows cooperation with colleagues from Bonn University. While the financial aspect of this grant is limited to travel support only, it is highly significant and contributes greatly to the international impact of my activities in Hong Kong. A German grant has followed and will permit me to continue the research through new visits to Bonn.

6- JOINING the CITY UNIVERSITY OF HONG KONG

Beginning 2013, I joined City University of Hong Kong. I am presently affiliated to the department SEEM, “Systems Engineering and Engineering Management” It is in the College of Science and Engineering. That is a new and interesting environment, and I keep contacts with the College of Business. I have been involved in new proposals related to high speed trains and to nuclear reliability. I also obtained the signature of an agreement between the City University of Hong Kong and the University of Texas at Dallas. This creates a new framework, which has to be worked out. In particular, cooperation on Systems Engineering and Management, between the Colleges of Engineering and of Business of the 2 universities is the primary objective.

DESCRIPTION OF THE RESEARCH WORKS

1. INTRODUCTION

I had the luck to begin my research at the same time space activities were boosting control activities. I was thus trained in Control Theory. My main field of expertise consists in connecting methods from Analysis and Stochastic Processes in view of solving concrete problems of Applied Mathematics, and in Control arising in Engineering, Economics and Management. In the course of my scientific career I have supervised around 25 PhD students. I describe my activity before I joined the University of Texas at Dallas (UTD), the research activity I have been pursuing since I joined UTD, and, finally, the activities at Polytechnic University of Hong Kong, till I left it at the end of 2012.

2. RESEARCH ACTIVITIES BEFORE I JOINED UTD

STOCHASTIC PARTIAL DIFFERENTIAL EQUATIONS

I was among the early initiators of the theory of stochastic PDE in the sense of Ito. I worked in particular, alone or in cooperation on stochastic monotone equations, stochastic Navier-Stokes equations, stochastic variational inequalities, and on stochastic inertial manifolds. This theory has found some of its most interesting applications in the study of nonlinear filtering theory, where the work of my former student PARDOUX is a reference. Note that numerical resolution is now within reach, which elicits this field of research to be quite active and quite useful for applications.

FILTERING AND CONTROL OF STOCHASTIC DISTRIBUTED SYSTEMS

These problems have been at the origin of my research. In particular, my thesis (under the supervision of J.L. LIONS) was devoted to Kalman filtering for linear systems with white noise inputs on both time and space. My main contribution was to make use of the theory of cylindrical measures of Gelfand Vilenkin and L. Schwartz. This permits a rigorous approach to a large variety of problems, provided the model is linear. In particular, I was able to apply these techniques to a bi-dimensional model playing a role in image processing or the problem of optimal location of sensors.

Some nonlinear problems can be also considered, basically using fixed point theory in connection with the results on linear systems. In the problem of control, I contributed strongly to the theory of necessary conditions and to a rigorous approach of Dynamic Programming via nonlinear semi-groups. The main field of application concerns the stochastic control of systems with partial information, which naturally has a huge domain of applications. This has led to the flourishing theory of stochastic-forward-backward differential equations, introduced by my students E. PARDOUX and SHI-GE-PENG. It has had many applications in finance and stochastic control.

OPTIMAL STOPPING, IMPULSE CONTROL, VARIATIONAL AND QUASI VARIATIONAL INEQUALITIES

I discovered, which is now standard and broadly used, that variational inequalities correspond to the dynamic programming treatment of optimal stopping, and then solved, with J. L. LIONS, the impulse control problem, via a new theory called the theory of quasi -variational inequalities. This has initiated a long and fruitful cooperation on this topic with J.L. LIONS and many colleagues and students. Many applications of this theory concern old and new problems of Operations Research and Management, in particular, in Inventory Theory. However, this mathematical framework is also extensively used in mechanics and physics to model plastic behavior and frictions. In fact, I use it in my current research supported by CEA and NSF.

REGULARITY of NONLINEAR SYSTEMS of ELLIPTIC and PARABOLIC PDE and APPLICATIONS

Stochastic Nash differential games lead to systems of elliptic and parabolic PDE. The regularity of solutions is extremely important for obtaining a Nash point. This has motivated a longstanding cooperation with J. FREHSE, one of the worldwide specialists of the regularity of elliptic systems. I have also solved with him the ergodic case, which even in the case of one equation was open in its full generality. We are presently using these methods to solve problems related to Mean Field theory. This domain is very important in physics as well as economics.

ROBUST CONTROL and RISK-SENSITIVE CONTROL

My interest for this domain stems from its connection with the field of Risk sensitive stochastic control. In fact, I first solved with J. VAN SCHUPPEN the problem of finding a sufficient statistics (of the same size as the state, which was an open problem) for the LEG (Linear Exponential Gaussian) control. Later,

in cooperation with J. BARAS and R. ELLIOTT, for the partial information case, and H. NAGAI and J. FREHSE for the full information case, I contributed several results to justify some earlier formal treatment. The connection between robust control and risk sensitive control can be best seen through small noise introduction and singular perturbations. This is a field of very active research worldwide due to the broadness of the applications and the use of many mathematical techniques.

EXACT CONTROLLABILITY

After the introduction of the HUM method by J. L. LIONS and its' use by many authors, I became interested in developing a general theory of exact controllability for infinite dimensional systems, where the dynamics is driven by a skew-symmetric operator. In this way, one can unify most of the existing results concerning wave equations, Maxwell equations, ...

HOMOGENIZATION

Initiated by the probabilistic interpretation of homogenization, my interest in this domain has widened into an important cooperation with J.L. LIONS and G. PAPANICOLAOU, where we have developed many general approaches to this very fruitful theory. Later, I considered the homogenization of Bellman equations with L. BOCCARDO and F. MURAT, and the case of random homogenization with G. BLANKENSHIP.

REGULAR and SINGULAR PERTURBATIONS

Homogenization can be viewed as a particular situation of singular perturbations. However, many other situations can be considered. It was natural for me to be interested in their application to Control theory, both deterministic and stochastic, and, in the latter case, with full or partial information. Many particularly useful results can be obtained in the case of partial information in that one can derive approximate but accurate finite dimensional feedback laws, yet the optimal one is infinite dimensional.

PROBLEMS in OPERATIONS MANAGEMENT, FINANCE AND ECONOMICS

Since Control Theory has a lot of applications in many areas of Quantitative Management, I have cooperated with several specialists of the field to obtain the solution of concrete problems. I have developed first the applications of Control Theory to inventory and production systems (see in particular my books). Then I worked in Finance since the mid-eighties. I have been working in the design of complex options with M. CROUHY and D. GALAI. Later on, with my student H. Julien, I investigated models of options for incomplete markets, where the incompleteness arises from "frictions" in the management of portfolios. Another approach to this problem has been developed jointly with N. TOUZI and J. L. MENALDI, using penalty approximations and viscosity methods.

3. RESEARCH ACTIVITIES SINCE I JOINED UTD

Since I joined UTD, I have been working mostly on Operations Management, Economics and Risk and Decision Analysis.

OPERATIONS MANAGEMENT

The bulk of the research concerns stochastic models with partial information. For this research, we formed a team with S.P. SETHI, M. ÇAKANYILDIRIM and Ph.D. students and received NSF support.

Little has been done in this field, and we have developed a substantial theory. I have been also working on maintenance problems, on s,S policies, on service constraint models and on lead time problems.

ECONOMICS AND FINANCE

I have worked with S.P. SETHI in models of Economic Growth developed by K.J ARROW and al., taking into account population growth. We are also working on extensions to take into account healthcare. With J. KEPPO and S.P. SETHI, I have obtained results on models of consumption-investment with inflation and incomplete information.

INFORMATION SYSTEMS

I work also with colleagues from the Information Systems group of the School of Management and the Computer Science department of the School of Engineering. We have obtained results on several models to define optimal levels of protection in information systems. I participate here to large contracts funded by DOD and NSF, where my colleagues from Computer Science are involved. Among the topics which have been considered, that of botnets and assured-information systems have been the major ones. More recently, I worked on modeling expansion of a new technology like Cloud Computing.

RISK AND DECISION ANALYSIS

My major objective since I started my activity at UTD concerns the development of Risk and Decision Analysis as a Science. The importance of Risk Management is stressed in all contexts now—from security against terrorism and protection against natural hazards to operational and financial risks in industry.

But Risk Analysis is far from being recognized as a science in the academic environment. One difficulty is that it is addressed in different contexts. In Engineering it relates to reliability theory and quality control in industry as well as to the treatment of the ruin of structures in the context of civil engineering. Probabilistic risk assessment brings new elements in engineering research, in relation with the study of systems (Systems Engineering).

In Economics and Management, Risk Management has been developed mainly in finance and insurance. Economics provides some theoretical background for the concept of risk as pertains to individuals, teams and competition. My strong belief is that these developments are building blocks of a general theory, which deserves to be considered as a science.

My approach so far has been to prepare an appropriate education program on which research can be developed. One of the major tasks is indeed to show that generic concepts are available for the treatment of risks. Once this is done more focused aspects can lead to a very fruitful research. A key direction is that of *real options*, which connects finance methodology to a lot of other situations.

My publications in this area are so far limited to lecture notes and presentations to conferences, as far as the general aspects are considered. I have publications in more specific aspects described below, particularly in the domain of real options.

4- RESEARCH ACTIVITIES SINCE I JOINED POLYU

MUTUAL INSURANCE

This domain has been developed since I joined Poly U, where I have learned about it. It is applicable in the context of Maritime insurance. Impulse Control has been used with two band levels, improving results available in the literature with application to Cash Management. We have connected impulse control to singular control in a way which is new. We have also shown that the splitting method, widely used in Numerical Analysis can be efficiently used in this context. It is not very well known in the Operations Research literature. Not only has it allowed new proofs of theoretical results, but also very efficient algorithms.

With Korean colleagues, we are now considering the impact of Moral Hazard in Mutual Insurance.

REAL OPTIONS

This domain is one of my major domains presently. Investments for very large, innovative, risky and costly projects cannot be decided simply using traditional approaches, like NPV (Net Present Value) or DCF (Discounted Cash Flow). A new theory is in full development, which tries to mathematically model the need of flexibility in particular. I have been working on the incomplete market set-up for real options as well as competition aspects. More recently, more sophisticated models including switching have been studied with new results.

A new orientation concerns connections between real options and the famous problem in economics related to capital accumulation. This one goes back to Arrow's theory of growth. I am working on a unifying theory for these two research topics, considered as separate in the literature.

STOCHASTIC VARIATIONAL INEQUALITIES AND MECHANICAL STRUCTURES

With the support of CEA and NSF, I am working extensively in the domain of mechanical structures subject to vibrations. I discovered that Stochastic Variational Inequalities, which I developed many years ago in an a theoretical context, are the right tool to model the behavior of dynamical systems whose state can go from elastic to plastic phase and accumulate fatigue. This research has led to many interesting directions in applied mathematics (invariant measures, partial differential equations with nonlocal boundary conditions, and control theory) as well as in applications (understanding short and long cycle behaviors of the state of the system, understanding results of Monte Carlo simulation, and computing critical excitation).

ADVANCED INVENTORY THEORY

This is the topic of my new grant obtained with the General Research Fund in Hong Kong. A book has been published in 2011. I also intend to work on new inventory type of problems motivated by stocks and options market makers decision making. I am continuing on inventory problems with partial information, where the information is the stock-out time, with learning possibility.

ALTERNATIVE ENERGIES

I am currently involved in an active research related to wind energy. This research is supported by a grant from EDF (Electricité de France). I feel confident that this research can be of interest to industry in the U.S. as well as in China. My major orientation so far is in forecasting the annual power production of a windmill. The various categories of uncertainties impact directly the decision-making, since the profitability of a project may be in jeopardy. In fact, I have seen that the current practice neglect essential sources of uncertainties and risk.

MEAN FIELD THEORY

This theory, which originated in physics for many years, raised a lot of interest recently in control and economics. The main idea, coined “Mean Field Games” is to model an infinite number of players with common behavior by a representative agent. However, the dynamics and the objective of this representative agent incorporate a term, the mean field term, which average all the similar dynamics and actions of the very large community. It is similar to the idea of a particle, moving in a medium made of similar particles, but there are the decision-making aspects in addition. With J. Frehse I am considering Nash games with mean field effect. With P. Yam I am considering linear quadratic differential games with mean field effect. An interesting application of this theory is to handle control problems with cost functional, for which Dynamic Programming approach does not apply.

The three of us have completed a Springer Brief providing a comprehensive approach to all concepts and methods. This will be published in 2013. Effective October 1, 2013, NSF – National Science Foundation has awarded me a grant to support my continued research into this area. See “Grant Activity” below

5- RESEARCH ACTIVITIES SINCE I JOINED CITYU

PRINCIPAL-AGENT CONTRACTS IN SUPPLY CHAINS

Supply chain management is much more driven by setting best possible contracts between manufacturers and suppliers. Principal-Agent contract theory is an important domain of research covering economics and management science, addressing the issue of asymmetry of information, moral hazard, and incentives. It is a major framework to consider contract engineering needed in supply chain management. With Ozalp Ozer at UTD, I have developed a theory connecting inventory theory with principal-agent theory. In this framework, the inventory manager does not sell directly; he contracts a retailer who has better knowledge of the market. There is asymmetry of information, and the manager’s problem is to design a contract which guarantees the retailer with a certain level of inventory (or production), while obtaining from him that he reveals his information on the market.

PRICING AND INVENTORY MANAGEMENT

The problem of jointly defining the dynamic pricing of a product and the inventory management is a complex problem, for which only limited results exist, although interesting conjectures can be made. I have started to work on this problem, motivated by questions from Professor Yan, Dean of the College of Business at City U. In fact, the motivation goes much beyond and concerns also competition in pricing. Game theory has not been considered in the context of inventory management. So it is a brand new topic, full of challenges.

MEAN FIELD TYPE CONTROL

This problem has similarities with Mean field games, but is different. It is a control problem, or a calculus of variations problem, for a non classical evolution dynamics; the Mc Kean-Vlasov dynamics. We have provided for this problem a Hamilton-Jacobi-Bellman theory, which is original and is promising. It leads already to interesting problems in the case of linear-quadratic control problems.

TIME- INCONSISTENCY

The standard Dynamic Programming theory leads to time consistent solutions. Indeed, the optimal control is obtained through a feedback depending only on the current state. So if the problem starts at any time and with any initial value, the feedback remains the same. This very important property is related with Markov properties. It does not carry over in non Markov situations. Nevertheless, some ideas have been proposed to address the issue of obtaining time-consistent solutions in non Markov situations. The concept of solution has to be modified. We have obtained with Phillip Yam some results in that direction.

TEACHING ACTIVITIES

Doctoral Students: I have been the advisor of the following Ph.D. students in France.

J. P. Quadrat, M. Robin, A.Sulem, J.L. Menaldi, M. Goursat, E. Pardoux,
P. Nepomiatschy, C. Le Marechal, J.M. Proth, P. Bertrand, F. Delebecque,
C. Picard, P. Mesulem, C. Julien, D. Potier, J. Thepot, F. LeGland, D. Chaplais,
C. LeGuay, R. Sentis

They are well established professionals in industry or in the academic community (in France, one is in the U.S.).

Since my arrival at UTD, I have partly supervised several students. I have been in the Thesis Committee of Q. Feng and have been the advisor of Ruixia Shi and the co-advisor of Ashuman Chutani, who have obtained their PhD in 2009 and 2010 respectively. I have supervised Laurent Mertz, who got his PhD in December 2011. I have been also co-adviser of Laser Yuan, who got his PhD in January 2009. I have supervised Meng Li, with S.P. Sethi. He has got his PhD in July 2013. I am currently co-supervising Shaokuan Chen. I have been in the committee of Zhou Wei. I am also co supervised Zhongfeng Yan, who got her PhD in Shangai in June 2013.

I have supervised partly Lama Moussawi. I have supervised several Post Docs: Andrew Royal, Ioane Muni Toke, Celine Hoe, Arash Komae, Nadir Farhi, Benoit Chevalier-Roignant, (all supported by grants).

CLASSROOM TEACHING

Since my arrival at UTD, I taught the following courses:

Ph.D Courses:

- Advanced Topics in Inventory Management
- Differential Games
- Advanced Risk Analysis

MBA and Master Courses:

- Risk and Decision Analysis
- Quantitative Introduction to Risk and Uncertainty in Business
- Introductory Math Finance

I created all courses except one. In the course Risk and Decision Analysis, I provided training on the simulation software @ Risk.

In PolyU, the position has been purely a research one, so I hold research seminars.

At CityU, I have initiated a new course (PhD and Master level)

- Estimation and Control of Random Dynamical Systems

GRANT ACTIVITY

Science of Cyber Security: A Data Driven Approach

Bhavani Thurasingham, Co-PI: Letifur Khan, Murat Kantarcioglu, Kevin Hamlen, Alain Bensoussan

NSA – National Security Agency – Lablet Program

Sub-contractors: University of Maryland, Baltimore County, Purdue University

5 years: Start, February 1, 2014

\$3,170,000.88

Proposal Submitted – November, 2013

TWC Medium: Collaborative Incentive Compatible Privacy Preserving Data Analytics

Murat Kantarcioglu, Co-PI: Alain Bensoussan

NSF – National Science Foundation – SaTC Proposal

4 years: Start, September 2014

\$621,285.15

Proposal Submitted – October, 2013

Mean Field Games, Mean Field Type Control and Extensions

Alain Bensoussan

NSF – National Science Foundation

3 years

\$512,809.05 – *revised to \$339,572 – awarded on September 17, 2013*

Mean Field Theory, Stochastic Control and Systems of Partial Differential Equations

Alain Bensoussan, Phillip Yam

RGC- Hong Kong

3 years, July 1st 2013- July 1st 2016

HK\$ 423,562-

Advanced Inventory Theory

Alain Bensoussan, Cedric Yiu

RGC- Hong Kong

3 years, July 1st 2011- July 1st 2014

HK\$ 1,052,000

EADS Industrial Strategy Development

Alain Bensoussan

EADS North America, \$256,000 October 1, 2004-February 28, 2009

ESA Risk Management Study

Alain Bensoussan

European Space Agency, \$98,536 November 1, 2004-October 31, 2006

Research and Consulting in Risk Management,

Alain Bensoussan

FX-Counsel, \$115,870 January 1, 2005 – Dec. 31, 2006

Seismic Risk and Elasto-Plastic Oscillators Modelling,

Alain Bensoussan

French Atomic Energy Agency (CEA), \$337,328 June 1, 2005 – May 31, 2010

Inventory control with Partial Observations and Inspections

Alain Bensoussan, Metin Cakanyildirim, and Suresh Sethi

National Science Foundation, \$200,000, July 1, 2005 – July 31, 2008

Forecasting of Demand with Optimal Ordering.

Alain Bensoussan, Metin Cakanyildirim, and Gergely Turi, (R.A.).

Blueline/Rediform Corp., \$70,000 December 1, 2005 – Dec. 30, 2006

Statistical Updating Methods in Risk and Decision Analysis: Applications to Supply Chains

Alain Bensoussan

Texas Higher Education Coordinating Board, \$79,000 May 15, 2006-January 31, 2009

New Stochastic Processes, Partial Differential Equations, and Control problems Arising in Models of Mechanical Structures Subjected to Vibrations

Alain Bensoussan and Janos Turi

National Science Foundation \$320,520 August 15, 2007 – July 31, 2011

ESA Risk Management Study

Alain Bensoussan

European Space Agency (ESA) \$30,442 May 1, 2008-April 30, 2009

Water Resources Development

Alain Bensoussan

The University of Texas at Dallas, \$45,000 September 1, 2008-August 31, 2009

Windmill Productivity Modeling

Alain Bensoussan

Electricite de France (EDF), \$192,052., February 1, 2011- November 30, 2013

Seismic Risk and Elasto-Plastic Oscillators Modelling,

Alain Bensoussan

French Atomic Energy Agency (CEA), \$225,000 July 1, 2011 – December 31, 2013

LIST OF PUBLICATIONS

BOOKS

- *Filtrage Optimal des Systèmes Lineaires* (Dunod, 1971).
- *Management Application of Modern Control Theory*, (North Holland, 1974), with G. HURST & B. NASLUND.
- *Applications des Inéquations Variationnelles en contrôle Stochastique*, (Dunod, 1978), (English translation: *Application of Variational Inequalities in Stochastic Control*, North Holland, 1982), with J.L. LIONS.
- *Asymptotic Methods in Periodic Media*, (North Holland, 1978), with J.L. LIONS & G. PAPANICOLAOU. Published online by Elsevier in 2011
http://www.elsevier.com/wps/find/bookdescription.cws_home/504844/description#description
- *Stochastic Control by Functional Analysis Methods*, (North Holland, 1982).
- *Impulse Control and Quasi-Variational Inequalities*, (Dunod, 1982), with J.L. LIONS, russian translation, 1987.
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- *Perturbations Methods in Optimal control*, (Dunod-Gauthier Villars, 1988).
- *Stochastic Control with Partial Information*, (Cambridge University Press, 1992).
- *Representation and Control of Infinite Dimensional Systems*, (Birkhauser 1992) Vol. 1, with G. DA PRATO, M. DELFOUR ET S.K. MITTER.
- *Representation and Control of Infinite Dimensional Systems*, (Birkhauser 1993) Vol. 2, with G. DA PRATO, M. DELFOUR et S.K. MITTER.
- *Regularity Results for Nonlinear Elliptic Systems and Applications*, (Springer 2002), Applied Mathematical Sciences, Vol. 151, (Springer 2002) 443 p. with J. FREHSE.
- *Representation and Control of Infinite Dimensional Systems*, 2nd Edition, (Birkhauser 2006) with GIUSEPPE DA PRATO, MICHAEL C. DELFOUR and SANJOY K. MITTER.
- *Dynamic Programming and Inventory Control* (IOS Press 2011) Vol. 3 Series: Studies in Probability, Optimization and Statistics.
- *Asymptotic Analysis for Periodic Structures*, AMS Chelsea, with J.L. LIONS and G. PAPANICOLAOU. Reprint. 2011
- *Mean Field Games and Mean Field Type Control Theory*, Springer Brief (Oct 31, 2013) with J. FREHSE and P. YAM, ISBN: 978-1-4614-8502-0
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EDITED BOOKS

- *1st, 2nd, 3rd, 4th, 5th, 6th, 7th, 8th, 9th International Conference on Analysis and Optimization of Systems*, (Springer Verlag, Lecture Notes, 1974, 1976, 1978, 1980, 1982, 1984, 1986, 1988, 1990), with J.L. LIONS.
- *Applied Optimal Control* (North Holland, 1978), with P. KLEINDORFER & C. S. TAPIERO.
- *Stochastic Optimal Control and Applications*, (North Holland, 1980), with P. KLEINDORFER & C. S. TAPIERO.
- *Mathematical Techniques of Optimization, Control and Decision*, (Annals of the CEREMADE), (Birkhauser, 1981), with J. P. AUBIN & I. EKELAND.
- *Handbook of Mathematical Modeling and Numerical Methods in Finance*, 15(1) (Elsevier, 2008) with Q. ZHANG.
- *Real Options, Ambiguity, Risk and Insurance*, Studies in Probability, Optimization and Statistics, V.5, (IOS Press, 2013) with SHI GE PENG, JAE YOUNG SUNG

JOURNAL ARTICLES & PROCEEDINGS

1967

- Une méthode d'Identification de Valeur Initiale, *C.R.A.S. Paris*, t. 265, Nov. 1967, pp. 724-727.

1968

- Sur l'Identification des Systèmes Aléatoires, *C.R.A.S. Paris*, t. 266, Série A, Juin 1968, pp. 1229-1232.
- Sur l'Analogie entre les Méthodes de Régularisation et de Pénalisation, *R.I.R.O.*, 2e année, No 13, pp. 13-26, 1968, with P. KENNETH.

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- Identification de Systèmes Gouvernés par des Equations aux Dérivées Partielles, *Computing Methods in Optimisation Problems*, Academic Press, N. Y. 1969, pp. 25-34.
- Contrôle Optimal Stochastique de Systèmes Gouvernés par des Equations aux Dérivées Partielles de Type Parabolique, *Rendi Conti di Matematica*, (1. 2) Vol. 2 Series VI, Rome 1969, pp. 135-173.
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- Identification et Filtrage, *Cahiers de l'IRIA* No 1, Feb.. 1969, pp. 1-253.

1970

- Approximation des problèmes de contrôle optimal, *Cahiers de l'IRIA*, No. 2, 1970, pp. 104-172, with A. BOSSAVIT & J. C. NEDELEC.
- Statistical problems in Hilbert spaces, application to filtering theory in, *Kybernetika*, Prague 1970, pp. 270-279.
- On the best linear feedback for systems governed by differential operational equations, *Symposium on Optimization*, Springer Verlag, Lecture Notes in Mathematics, Berlin 1970, pp. 53-57.
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1971

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- On the approximate Kalman-Bucy filter, *Proceedings of the Hawaii Conference on System Science*, Hawaii 1971, pp. 462-46
- Filtering theory: a comparison between lumped and distributed systems, Memoria de la Conferencia Internacional sobre sistemas, *Redes y Computadoras*, Mexico 1971, pp. 160-163.

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1972

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- Optimization of sensors location in a distributed filtering problem, *Stability of Stochastic Dynamical Systems*, Springer Verlag, Lecture Notes in Mathematics, No 294, Berlin 1972, pp. 62-84.
- Equations aux dérivées partielles stochastiques non linéaires, *Israël Journal of Mathematics*, 11(1), 1972, pp. 95-129, with R. TEMAM.
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- On the filtering theory for some stochastic distributed parameter systems, Nov. 1972, with J.L. LIONS.

1973

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- Sur quelques phénomènes asymptotiques stationnaires, *Note C.R.A.S. Paris*, t. 281, Juillet 1975, pp. 89-94, 21 with J.L. LIONS et G. PAPANICOLAOU.
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- Sur les temps d'arrêt optimaux et les inéquations variationnelles d'évolution, *Note C.R.A.S. Paris*, t. 280, Série A, 21 Avril 1975, pp. 989-992, with J.L. LIONS.
- Sur les méthodes de décomposition, de décentralisation et de coordination et applications, dans *Méthodes de Décomposition*, edited by J.L. LIONS et G. MARCHUK DUNOD, Paris 1975, Tome 2, with J.L. LIONS et R. TEMAM.
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- An Analytical Approach for the Growth Rate of the Variance of the Deformation Related to an Elasto-Plastic Oscillator Excited by a White Noise, with Laurentz Merta, Sheung Chi, Phillip Yam – *submitted to SIAM/SIAP on November 25, 2013*

Working Papers

- Differential Games with Mixed Leadership: The Feedback Solution with SHAOKUAN CHEN and S.P. SETHI.
- Unemployment Risks and Optimal Retirement in an Incomplete Market with BONG-GYU JANG, and SEYOUNG PARK
- Real Options in a Stackelberg and a Pre-emption Game with a Geometric Brownian motion Stochastic Demand with S. HOE and D. DILTZ.
- Renewal and Ergodic Property to the solution of a Stochastic Variational Inequality with Jumps with L. MERTZ.
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- Feedback Solution in Linear-Quadratic Stackelberg Differential Games with S.P. SETHI
- The Maximum principle for Stochastic Global Stackelberg Differential Games with S. CHEN and S.P. SETHI