

RESEARCH HEC



Michèle Breton:

- Full professor,
Quantitative Methods
in Management
- Director,
Master of Science Program
in Management

“The types of problems that interest me are always the ones that evolve over time, whether they concern decisions involving several participants trying to operate in an uncertain context – what is referred to as stochastic games – or dynamic management situations with or without the element of uncertainty. I also like it very much when there is a practical dimension: in what way can a particular optimization method be relevant and useful? How can a particular simulation help in coming to a decision? How can a particular mathematical model be applied to market analysis? No doubt this reflex is a remnant of my engineering training.”

(see p. 2)



Georges Zaccour:

- Full Professor,
Department of Marketing
- Director,
Doctoral Program
in Administration

“Game theory concerns itself with situations in which the actions of one player affect the gains of all the others. What these games have in common is interdependence. I try to understand the strategic behaviors of the players and to predict the outcome of the game using mathematical models. Numerous applications are possible: in politics, in economics, in marketing and even in biology. In many business contexts, whether these are cooperative or conflictual, there exist interdependencies in which game theory can be very useful. Along with optimization, it constitutes my primary field of interest.”

(see p. 3)

A FEW WORDS ABOUT THE INTERNATIONAL SOCIETY OF DYNAMIC GAMES

In 1984, a group of researchers organized the first international symposium on dynamic game theory in Haifa, Israel. Two years later, the group repeated the experience in Williamsburg in the United States, and then again in Antibes, France. As the event was generating a growing interest among academics from different countries and working in different disciplines, it was decided at the symposium held in Helsinki in 1990 to officially found a learned society. The idea was not to orient the group around a particular discipline, but rather to share a variety of experiences having one common point: the utilization of the same methodological framework, i.e., dynamic game theory. Since that time, the Society has met regularly once every two years in various parts of the world for a high-caliber conference open to all its members, alternating with smaller annual workshops to which participants are specifically invited. These meetings bring together economists, mathematicians or military strategists, specialists in finance, marketing or management, biologists, sociologists or political scientists. One can easily imagine the variety and the richness of the papers presented during the Society's meetings; it currently has over 150 members. Michèle Breton is an active member of this prestigious learned society. Georges Zaccour, who is also a member, sits on its executive committee. Together, they organized the sixth symposium in 1994, held in Saint-Jovite, Québec.

MICHÈLE BRETON: FROM A COURSING RIVER TO THE UPS AND DOWNS OF THE MARKET

“Models that are representations of real optimization problems in a real industry are the ones that truly interest me.”

Michèle Breton is not one to flit around. Since her days as a research assistant in the Industrial Engineering department of the *École Polytechnique de Montréal* and then as a young researcher during her doctoral studies at the *Université de Montréal* supervised by the renowned Professor Alain Haurie, she has always been concerned with getting a grasp of complex business realities using mathematical models in order to develop practical solutions for managers. Today, Professor Michèle Breton is a well-known researcher in dynamic programming and the Director of the Master of Science Program in Management at the *École des Hautes Études Commerciales de Montréal*.

Her recent work focuses on solving dynamic and stochastic problems, that is, the working out of solutions in complex situations and dynamic contexts. To explain the process, Dr. Breton uses the relatively simple example of managing a hydroelectric power station. “I first carried out some research at *Hydro Soft Energie*, now a part of *Hydro-Québec*, which specialized in the sale of optimization software for electricity generation. The aim was to develop mathematical models that would allow for maximum electricity generation while using as little water as possible.” Although they were quite complex, the models that she and her colleagues developed applied only to situations in which several of the main elements, such as turbine capacity, water level and demands, were assumed to remain constant. These models are now being used to optimize turbine functioning over short time periods.

But she felt the need to go farther. *La société Alcan* has recently given her that opportunity by asking her to conduct a study on how electricity generation can be optimized, taking into account factors that vary over time. This study focuses on a system consisting of several power plants, combined with an innovative application of dynamic stochastic

programming. “Variations in water supply have repercussions on the entire system. Delays, their impact on the other turbines, the effects of uneven electricity generation in one power plant on the outputs of other plants operating on the same river, unexpected events related to the seasons – snowstorms, heavy rains or droughts – and especially, the losses that power generation itself occasions, can all be included in the model.”

The model is original precisely because it can take into account losses caused by managers’ decisions, without detracting from the researcher’s main goal of optimizing electricity generation. “Losses are the results of a decision, but one which itself is inseparable from other factors that influence the system. We therefore need to develop optimization models that take into account the fact that a decision made by a manager – for example to use a particular turbine operating with a particular output – will have an effect on the losses of the power plant as a whole.”

Using a classic research approach, Dr. Breton dissected this complex problem by breaking it down into sub-problems, each of which was a challenge in itself. This process ultimately led to the modeling of uncertainty, which can deal with a longer time span. “The model allows managers of a power plant to decide, for example, to shut down a turbine for maintenance or to forecast the demand for electricity under changing weather conditions and to adjust the operation of all the turbines accordingly.”

Modeling uncertainty is a useful tool that can be applied in different sectors. For example, Dr. Breton is currently investigating the evaluation of options in the stock market. Contrary to simulation techniques which cannot take investors’ decisions over a specific time period into account, dynamic stochastic programming such as that used in the optimization of power generation can be applied to the evaluation of complex options. “The type of simulation that is currently being used for the evaluation of options cannot take into account decisions such as the exercising of options. This is where dynamic programming methods can be very useful to portfolio managers. They

are more expensive to operate than simulations, but when it comes to complex options, they are much more reliable.”

In collaboration with other researchers, Dr. Breton is also conducting more advanced research on “minimax” stochastic problems. This relatively new technique can be used by a decision maker who wishes to use a cautious strategy and guarantee the attainment of a particular objective, even under worst-case scenarios. The technique can also be used to carry out analyses of the sensitivity of decisions to probabilities established by the decision maker. In other words, the same mathematical tool can be used in very different areas, with unforeseen events over time representing the only common factor.

Since September 1999, Dr. Breton has been Director of the Master of Science Program in Management, commonly known as the M.Sc.; she was previously responsible for the financial engineering as well as the modeling and decision concentrations in this program. She also teaches in the new MBA - Energy program, whose students come in large part from the energy resources sector. The research she has conducted in various firms never fails to arouse the interest of her students. “When I teach students who have practical knowledge of what a power plant is, they inevitably want to know about the results of my research at Hydro or at Alcan. Some of them develop a real taste for it and want to find out more about a particular aspect; some even decide to enroll in the Doctoral program in financial engineering, in logistics or in operations research.” For Michèle Breton, it is of utmost importance that university teaching be nourished by leading edge research carried out in real firms.

Michèle Breton is a prolific researcher who has published three books and 37 articles in refereed journals. She has co-edited the proceedings of two scientific conferences on dynamic games and operations research, and she is the associate editor of two specialized journals in the field. She has also participated in over 60 funded research projects and presented 84 conferences and seminars

worldwide. Although her activities as researcher, professor and Program Director take up much of her time, Dr. Breton is always available to any student who has a question or who wishes to develop a deeper understanding of a certain aspect of his or her studies. If the student is registered in a course or a study program that is different from hers, so much the better. "If they come to see me, it is because they have a question related to

quantitative methods, they are interested in the subject, and they want to go further. It is unthinkable for me not to welcome them, especially since I love good questions and I am curious to see what other professors are doing."

Dr. Breton's ideas about teaching have evolved over the years. "I started to work here as a sessional lecturer. At the time I thought that in order to be a university professor, it was enough just to

teach. It was Alain Haurie who suggested that I do a Ph. D. under his supervision and that I do research. He introduced me to a subject that interested me, and since then I have always done research concurrently with my teaching. I learned to teach, to do research, to use my research to enrich my teaching and to love all of it. Perhaps some people are born with such an inclination, but as for me, I believe it is an acquired taste."

GEORGES ZACCOUR: FROM THE LOGISTICS OF CONFRONTATION TO THE GAME OF NEGOTIATION

"If Air Canada lowers its prices on its Montreal-Paris route, this decision will not only affect its own revenues, but those of Air France as well. Air France will have to respond in a strategic and calculated manner. Air Canada will react in turn, and so on. I am interested in understanding the strategic behaviors of the participants and in predicting the outcome of the game."

Over the last few years, Georges Zaccour's work has primarily focused on three domains: energy, environment and marketing. At first glance, one might be tempted to see this as a dispersion of efforts, but in fact there exists a single underlying thread directed at a multitude of applications. For Georges Zaccour's interest to be aroused, it is enough if a situation brings together "players" whose behaviors have an effect on the gains of their counterparts. Using mathematical models, he attempts first of all to understand the forces at stake and the latitude that each player possesses. Next, he tries to calculate the effects over time of a series of reactive behaviors and to measure the probability that a player will make a particular decision in response to a particular behavior, until an equilibrium point is reached. The measurement criteria take into account what each player can gain or lose as compared to the gains or losses of the other players.

One of his research programs focuses on the issue of cooperation and conflict in the management of distribution channels in which manufacturers and retailers are obliged to find a common ground. With a team of doctoral students and other re-

searchers, Georges Zaccour has tried to distinguish situations in which players will tend to cooperate from those in which they will establish a conflictual relationship. "The focal point of this program is to see whether it is possible to design mechanisms that lead to cooperation. If two partners play in a certain way, they will both improve their situation. If they play in another way, they will be headed for confrontation. What is interesting to look at in such a case is whether there are mechanisms that would encourage cooperation, and that would lead to higher gains for both parties."

The field of international negotiations regarding environmental issues is the object of another research program in which both doctoral students and other researchers are participating. The release of pollutants into the atmosphere concerns a number of countries. While these countries all want to lower pollution, they do not all view the problem from the same perspective, nor do they have access to the same tools with which to improve the situation; often, they do not even have the same interests at stake. Georges Zaccour immediately sees this as a situation where game theory may apply. The participants in the negotiations would need first to establish the nature of the common goal they are seeking, and then determine the way in which the countries concerned can divide up the costs of conservation. "While your aim may be to reduce world emissions of carbon monoxide by a certain amount per year, how will you decide that Canada should reduce them by so much, the United States by so much, Europe by so

much? Cooperative game theory provides precise parameters and objectives which can be used to work out satisfactory solutions for the countries concerned."

What makes this type of problem even more interesting for Georges Zaccour is that it requires constant readjustments over time. "Mechanisms must be found that can adapt to these changes. It's a little like a marriage: one signs a contract but after a certain number of years, the situation is no longer the same. You want the contract to remain optimal, but this means that continuous adjustments must be made over time. Game theory allows us to find mechanisms that guarantee that the players maintain cooperation to the satisfaction of all concerned."

In order for cooperation to exist, each individual party must anticipate the possibility of benefiting from it, failing which negotiations are broken off and no sharing is possible. One assumes that the players are capable of considering all of the options, are able to calculate what the outcomes might be for each option and to consequently develop the best strategy.

Georges Zaccour provides collective agreement negotiations as an example. "In union-management negotiations, the parties know what will happen if there is no agreement. Sharing the common wealth is always done with the point of no return in mind. If I am more dependent on you than you are on me, the way we agree to share our interests will reflect on this relationship." According to Georges Zaccour, game theory goes further than mere intuition in that it provides

approaches and models with which to analyze even the most complex of situations. “We can even take into account the degree of emotion or impatience by integrating it into each player’s utility function. A certain level of abstraction will always remain because we will never be able to include everything in a model. But if we can ensure that the model reflects a game situation relatively faithfully, we can suggest optimal strategies.”

Georges Zaccour sees very concrete applications of game theory in marketing. For example, competitive situations in the consumer goods market can give rise to promotional campaigns that will have an impact on the sales of an entire sector. Such a “game” can result in either a rather savage price war (as was the case with gasoline prices in Québec a few years ago), whereby all players can wind up losing, or in cartels, which are illegal in many countries, or in tacit compromises that permit a *modus vivendi* acceptable to all those involved.

Georges Zaccour recognizes that there will always be great strategists and brilliant managers capable of strokes of genius, who easily hold their own in situations where resources must be divided up, without having read even a single book on game theory. But in management schools today, researchers are attempting to provide future decision-makers with the conceptual tools that will give them an edge, ones that can be extremely useful in delicate competitive situations or negotiations. “Intuition, based in part on solutions successfully used in the past, plays a part in strategic behavior. But analytic tools can make a crucial difference when it comes to talks between seasoned negotiators. What we want to transmit in our courses are ways of thinking, not merely solutions.”

Georges Zaccour has edited nine books and published over 40 articles in peer-reviewed journals. He has presented more than 70 papers at conferences and colloquia devoted to game theory, marketing and operations research. He has produced five case studies on transportation in the petroleum sector and a number of pedagogic documents as well as a software package that evaluates oil pipeline investment projects. In 1994, he obtained the *prix Gaëtan Morin éditeur*, a prize that the École des Hautes Études Commerciales awards each year to its most promising researcher. Associate editor of two specialized journals, he also acts as an evaluator for a number of academic publications. He is affiliated with six research groups or learned societies, including the International Society of Dynamic Games, of which he is a member of the executive committee (see p. 1).

Since 1999, in addition to his activities as researcher and professor, he has also acted as Director of the Joint Doctoral Program at HEC. Georges Zaccour accepted this administrative position for a number of reasons. First, he himself is a product of this program, which was established 25 years ago. “When I was a student, I wanted to change some things about the program. As its Director, I now have the opportunity to do so!” The second reason he names is the long-standing tradition at the École des HEC according to which professors are duty-bound to accept administrative responsibilities on a rotating basis, even if they are more inclined toward research and teaching, as is clearly the case for Georges Zaccour. He also believes that in an institute of higher learning that teaches management, it is entirely logical for professors to take on managerial responsibilities from time to time.

Furthermore, given that researchers have natural affinities towards this program, one might suspect that this specialist in game theory sees it as potentially a strategic tool with which to further develop research at HEC.

It seems that Georges Zaccour is on the right track. Over the last several years, game theory has been appearing with increasing frequency on the curricula of management faculties and schools; some of these have even given their courses on game theory “star” status, particularly in the United States. Georges Zaccour believes that this tendency, which is occurring at both the Masters and Doctoral levels, in no way excludes more qualitative approaches, and this is one of the characteristics that he appreciates most about HEC. “Here, those in positions of responsibility are very respectful of the diversity of points of view. This is in fact one of the aspects of HEC that keeps many of my colleagues within its walls. In any organization, one must establish a certain strategic direction, but at the intellectual level, all doors must be kept wide open. This is what happens here, and from this point of view, it’s fantastic.”

Like many of his colleagues, Georges Zaccour thinks that the interest in research is acquired by mingling with masters in the field who have been able to communicate their passion and their own obsession with discovering things. “In order to be a good researcher, one has to work hard, but one develops the ability to do so if one is curious and determined. One must also have that passion to discover new ways of doing things. But if one’s interest is awakened from the start, research is something that can be learned and that can bring a great deal of satisfaction.”

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