LABEX MME-DII :

Economic and mathematical models of dynamics, uncertainty and interactions

Description of the research projet and member research centers.

Contents

1. SCIENTIFIC DESCRIPTION OF THE RESEARCH PROJECT 1
2. PARTNERSHIP 11

1. SCIENTIFIC DESCRIPTION OF THE RESEARCH PROJECT

The scientific project of MME-DII pursues two major research objectives. The first one is to develop innovative fundamental models of economic behavior. The second one is to apply these models to various economic and social problems. The first objective occupies a central position in the MME-DII project and is centered on interactions between mathematicians, economists and physicists. It is described in Part I below. Applications are covered in Part II.

PART I: CORE MODELS OF INDIVIDUAL BEHAVIORS AND INTERACTIONS

I-A. Models of uncertainty and decisions

Uncertainty is a pervasive aspect of economic life. Economic agents evolve in an uncertain environment, where they make crucial decisions without knowing *ex ante* the future consequences of their decisions. Part of this uncertainty is idiosyncratic and markets have a crucial role to play in diversifying these risks. However, aggregate uncertainty is often important and may have significant effects on the well-being of individual agents. Understanding how modern societies are affected by uncertainty requires improved models of individual decisions under risk, as well as better stochastic models of aggregate uncertainty. These topics are at the heart of this research axis.

1- Models of individual choices

Individual decision under uncertainty is at the core of many models in economics and finance. Both in applied academic work and in practical applications, the reference model in this field remains the expected utility theory (EUT) (von Neumann and Morgenstern, 1944; Savage, 1955). The prevalence of this model is striking, given its empirical failure revealed and emphasized by the famous Allais (1953) and Ellsberg (1961) paradoxes. These paradoxes have triggered a vast theoretical literature offering alternative decision-making models. Several researchers in THEMA and LEM have made significant contributions to these debates. However, no dominant model has yet emerged. The objective of the research projects, in this field, is to develop new models of individual behavior that combine theoretical innovation, empirical accuracy and tractability.

Among the various topics that will be investigated, research will in particular explore models of decision making under ambiguity. The notion of ambiguity has been introduced by Schmeidler (1989) to designate situations of unknown risk (uncertainty about the probability distribution governing the outcomes) as opposed to (known) risk. Situations of deep uncertainty (as occurring e.g. in the issues related to climate change) typically entail this form of ambiguity. To quantify uncertainty, it is necessary to develop measures similar to those under risk, but emphasizing low-probability extreme-outcome events. To understand individual behavior under uncertainty, it is crucial to model the process of belief formation under ambiguity, i.e., how decision makers use and aggregate objective yet imprecise information into subjective beliefs. More fundamentally, this raises the issue of the value of information to economic agents. While this notion is well understood in a Bayesian framework, this is no longer the case in more general models.

In sufficiently complex environments, ambiguity can give rise to indecisiveness. Models of incomplete preferences can be used to capture agents, who are rational and consistent as long as they can rank alternatives, but are subject to psychological biases when indecisive. This analysis bridges the gap between the ultra-rational economic paradigm and empirical reality, while conserving tractability and empirical testability.

This analysis delivers policy implications related to information provision by central authorities and provides guidelines for the creation of institutions governing the flow and quality of information.

Highly relevant for the modeling of “individual” preferences is the so-called collective model of choice. Many economic decisions are embedded in particular social contexts and involve several individual agents, in a way that cannot be satisfactorily modeled by the standard microeconomic approach. Household decisions offer a good example. Recent research has focused on decision-making resulting from household members' interaction. This context raises a number of issues that are usually neglected in the more traditional literature and that will be investigated in the project. Research topics include: the nature of the goods consumed (public or private), altruistic attitudes, cooperation and balance of power within households, derivation of testable restrictions of the collective model, and identification of the structural determinants of choices and behaviors.

These different topics are highly cohesive and lend themselves to research at the interaction of several research programs. For instance, research will be conducted at the intersection of collective decision models and decision theory, focusing on household decisions under risk. The approach will combine microeconomic modeling and a behavioral approach, in an empirical project that is closely connected to the research conducted in mathematical finance and risk management, which is developed below.

While this program on the modeling of individual preferences is largely theoretical, it is connected to several empirical projects in experimental economics. Such projects, whose objective is to empirically elicit key features of individual behaviors, preferences and strategies, have been and will be conducted on a variety of topics including cooperation within couples, couples’ preferences under risk, trust building when hiding behind probabilities or coordination games. These projects will greatly benefit from the current development of a laboratory facility, at ESSEC, for experimental behavior analysis.

This research agenda is of course strongly connected to the research in mathematical finance discussed below but other connections can be underlined. First, the development of adequate models requires a mastery of advanced mathematical techniques (convex analysis, lattice, probability theory, functional analysis). Second, there is also room for conceptual exchange. For instance, Billot plans to transpose concepts borrowed from quantum physics, such as simultaneous plurality and counterfactuality belief formation, within an Aumann-Bacharach model of belief formation.

2- Stochastic processes for economics, finance and risk management

Assessing the consequences of uncertainty for individuals and societies also requires adequate models of the underlying stochastic processes. Several researchers in the MME-DII project, in AGM, LAGA and MODALX are focusing on the study of these processes, in particular their asymptotic properties, and their applications to economics, finance, risk management and physics. Here, we briefly mention the most salient ones.

- *Random walks* are one of the founding subjects of probability theory. Research will investigate the behavior of pure random walks, as well as several generalizations such as random walks in

random environment or non-Markovian models involving memory of the past trajectory (cooky random walks, reinforced random walks).

- *Continuous-time diffusions and Markov processes* also have numerous applications. One of the main issues of this field is the evaluation of the rate of convergence to equilibrium. Research will focus in particular on diffusion processes and jump processes in both reversible and non-reversible settings, as well as on self-interacting diffusion processes. Research in probability will also explore fundamental properties of coalescence and fragmentation models.

Applications of these models to mathematical finance are potentially numerous. Before turning to their discussion, it is worth stressing that there also exist very strong interaction potentials in other fields of economics as discussed in the next section.

In mathematical finance, stochastic processes find direct applications in portfolio valuation and option theory. Several researchers in THEMA, ESSEC and LAGA are involved in this field that lies at the intersection of economics and applied mathematics and began with *the theory of speculation* (Bachelier, 1900). Option pricing and hedging theory have been intensively developed from the seminal Black and Scholes (1973) and Merton (1973) formula. Since the fundamental theorem of arbitrage-free pricing (Harrison and Kreps, 1979), the main mathematical tools used in this research field are the stochastic calculus and the martingale theory.

Advances in this research area require the combination of three main ingredients: more relevant models of individual preferences under risk; more accurate, yet tractable stochastic processes to capture market uncertainty and dynamics; more realistic models to quantify main financial risks (credit, market, and operational risks). Research conducted in this area in MME-DDI will incorporate all these aspects. Next, we provide some flavours of the type of research that will be conducted.

New developments in portfolio choice theory are required to better account for investor attitudes towards risk and uncertainty. This can be done by introducing richer models of individual preferences in optimal portfolios models. One example could be to introduce progressive random utilities in pricing theory or to study portfolio optimization, in a Tversky and Kahneman framework, with rank-dependent expected utility and/or with ambiguity. Such problems are connected to the developments of the previous block. They are also connected to the new stream of *behavioral finance*, which seeks to provide experimental foundations to models of individual preferences under uncertainty. The notion of "forward utility" (Musiela and Zariphopoulou, 2002) offers yet another example of the type of extensions that will be conducted.

Another line of research is the incorporation into portfolio optimization models of more relevant stochastic models, in particular for continuous time processes. This draws heavily on advanced probability theory. It also makes use of advances in estimation procedures and adapted numerical methods. Another example of research interactions between probability theory, mathematical finance and econometrics is credit risk management, which is at the basis of the recent financial crisis. Besides continuous time processes, a complementary approach will be developed based on general point processes, which represent a useful method that takes risky asset fluctuations into account. They allow for instance to involve exogenous factors such as macroeconomic variables. Note also that such processes are crucial to deal with insurance problems, in accordance with Solvency II (EU directive that codifies the EU insurance regulation).

Research will also be undertaken to better take into account salient features of the organization of financial markets. Among these features, it is important to model the existence of transaction costs and liquidity constraints. Short-selling constraints offer another example. The relevance of such a topic is further enhanced by projects aimed at introducing a tax on financial transactions or regulating sales. Adequately incorporating such constraints in optimal portfolio models requires adequate mathematical tools from functional analysis, convex analysis, and stochastic control.

To summarize, the research program in mathematical finance and risk management conducted under MME-DII will present a balanced combination of mathematical sophistication and economic innovation conducted jointly by specialists in stochastic calculus, finance experts and economists. This represents in our eyes a valuable specificity of the project, compared to the research programs in finance of several concurrent research centers, in particular in mathematics.

3- Statistics and econometrics

Adequate statistical methods are essential for the identification and validation of relevant models for stochastic processes. Such methods will be extensively studied by statisticians taking part in the project.

A large part of the research program in statistics will focus on the stochastic dynamics of time-series processes. These processes are highly relevant in most economic and financial applications. At the center of the research program in statistics conducted in MME-DII, lies the issue of time dependence. This encompasses many forms of dependencies in discrete time series (when observations are made according to discrete epochs like years or seconds, as in the case of time indices, e.g. stock exchange, meteorological data), continuous time processes, random fields (for instance in the case of observations of geographic data or observations linked through graph relations) or space-time processes (i.e. combining geographic and time observations as in the case of fish in the sea). Adequate models of dependence are required, in particular to properly model the occurrence of extreme risks, conditional on current conditions. An immediate next step, following the development of adequate models, is to work out the required tools of statistical inference.

Two concurrent approaches can be followed for analyzing time dependence. The first one assumes a non-stationary time process. The second approach develops an analysis of dependence within the context of stationary time-processes. Both approaches lead to different inference problems and both will be investigated. Work on this topic will greatly benefit from previous extensive research conducted by researchers in AGM, MODALX and LAGA. For instance, Doukhan has focused on dependence in stationary processes, including weak dependence, heavy tailed times series and long range dependence.

The research projects that will be conducted in statistics will cover estimation problems pertaining to both discrete and continuous time-processes:

- For discrete processes, estimation problems that will first concentrate on the estimation of measures of dependence (e.g. Markov structure estimation; semiparametric estimation of the Hurst coefficient of long range dependence, inverse problems). Weak dependence also raises non-standard estimation problems, such as the estimation of the limit variance or the estimation of quantiles for specific statistics of interest. These different issues can be analyzed in terms of sub-sampling techniques. Bootstrap methods are of particular relevance in this context. Sparsity is another research area, for instance in data analysis when the sample size is much smaller than the dimension of the data.
- Estimation issues for continuous processes include goodness of fit tools for diffusion processes, and non-parametric estimation problems for multi-dimensional diffusion models. Specific estimation problems will be addressed in the context of Lévy-diffusions and the so-called Lévy-flights. Extensions of estimation to other continuous time models are an essential objective for future researches.

Besides estimation problems, the analysis and application of advanced time-processes requires innovative techniques. For continuous data problems, numerical solution techniques have become an essential tool and require the development of new algorithms, such as Monte-Carlo (MC), quasi-MC or randomized quasi-MC. Developing relevant simulation techniques for rare events is another important and challenging topic that will be investigated.

Applications of these researches to estimation problems are numerous, in particular in finance and in forecasting in general. Several researchers, in particular at THEMA and ESSEC, have focused their research on estimation problems encountered in financial econometrics. A thematic cycle is being organized on “Non-stationarity in statistics and risk management”. The cycle's detailed program is provided in the appendix. This cycle demonstrates the important interaction potential between statisticians, economists and finance specialists on this topic. More generally, it is a good illustration of the way research interactions will be fostered within MME-DII.

Beyond the specific estimation problems discussed above, more general synergies between statisticians and applied economists should also be stressed. Many researchers, in particular at THEMA, develop applied empirical research and resort to a wide range of econometric methods (panel data, qualitative variable, duration and count data, estimation by simulation, instrumental variables, program evaluation, etc, in a parametric and non-parametric perspective). Stronger

integration of the research of applied econometricians and statisticians will undoubtedly boost the techniques used in econometrics and stimulate research on new estimation problems. In particular, the strong development of computers and more recently of cloud computing has made possible the exploitation of huge databases in various scientific areas such as genomics, ecology, food security issues or finance, where high frequency analysis has proven to be crucial. Statistical learning methods, random matrices, analysis in large dimension, or multifractal analysis witness a strong interest in order to understand mathematically these huge sets of data. The LabEx MME-DII has a research expertise in such domains and will contribute to the dissemination of relevant material for future researchers and R&D stakeholders in economics and finance.

I-B. Models of interactions and dynamics

The second research axis focuses on the development of core models of interactions and coordination of heterogeneous agents, in a dynamic environment, which represents a central topic in economic analysis.

1- Models of individual interactions

Coordination of interacting agents is a dominant topic in economics. Traditional models offer polar descriptions of interactions. On the one hand, general equilibrium theory offers a very rich setting that has been applied extensively but interaction is summarized by a price vector and ignores strategic interactions. On the other hand, the generic normal form game explicitly accounts for strategic interactions but most economic applications rely on additional stringent assumptions, imposed by tractability issues (small number of players, symmetry, homogeneous agents...). The objective of the research on interactions conducted in the LabEx is to develop new models of interactions that address the shortcomings of standard game theory models.

Emphasis will be put on the modelling of strategic interactions among heterogeneous agents. In most existing models analyzing the coordination of economic agents, the information and behaviour of a large population of agents is summarized by “simple” mathematical objects (like the average signal observed by agents or the average action played). To further study coordination issues in games, there is a need to develop models where the information and behaviour of agents is described by more sophisticated mathematical objects (like distributions of actions) and to analyze the dynamics of such objects.

Research will first focus on agents’ coordination in games. The key issue addressed is how agents end up (or not) interacting in a “satisfactory” way (from the perspective of both the players and the social planner). A first example of such models is given by global games that have received significant attention recently. This approach seeks to extend the standard framework of interactions by incorporating small degrees of uncertainty in the players’ decision problem. The study of these games needs considerable exploration. A related topic is the impact of strategic uncertainty in dynamic and static games, where uncertainty refers to other players’ behavior and not the fundamentals. The question here is to understand the conditions allowing for a correct prediction by every player of other players’ behavior. Dynamic game models also deserve specific attention because they allow for repeated interactions, learning, experiments, and communication over time among other features of economic relevance. Although there is already a huge literature about learning, many questions are still open. In particular, dynamic global games have so far only been developed in very restrictive settings (since it is particularly difficult to describe the evolution of the information structure in these games). More generally, asymmetric information introduces some heterogeneity that cannot always easily be incorporated. To handle this, many models use shortcuts such as assuming that there is a “representative agent” or that a given player reacts to the mean action of others. Breaking some of these technical limitations will allow to better understand the interplay between private and public information, and the interaction between fundamental and strategic uncertainty.

A complementary approach will focus on situations in which interactions extend beyond the realm of a small set of well-identified strategically interacting entities. A promising model of interactions is offered by the theory of mean-field games (MFG, Lasry and Lions). This theory provides an innovative framework by combining tools from statistical physics and dynamic control theory for modelling strategic interactions among large sets of agents. In this approach, the strategy of each agent

is influenced by the distribution of positions and strategies of other players (i.e. the mean field), and in turn influences the mean field. These models involve a wide range of mathematical tools (stochastic control, stochastic differential games, existence and stability of solutions of deterministic partial differential equations). Until now, these models have been developed mostly by mathematicians. Potential economic applications are manifold, in a variety of fields such as the labor market, portfolio management, the oil market, academic production, etc. The development of these applications and relevant extensions of the basic model is one of the research fronts that will be explored in MME-DII, in particular in CEPN, LAGA, AGM and THEMA.

Models of game theory have long been a privileged area of interactions between mathematics and economics. The challenge of developing increasingly complex and yet tractable models makes the collaboration of economists and mathematicians even more necessary. For instance, mathematical models developed to study convergence in repeated interaction systems- a topic that is well studied at AGM- appear highly relevant for the study of coordination dynamics. Further insights can also be gained from models developed in physics to describe the behaviour of large sets of interacting particles. Besides the example of mean-field game theory, applications of other models to economics can be fruitfully explored. The Ising model, and its numerous extensions, offers a rich framework that allows modelling of local and global interactions. This appears particularly relevant for modelling issues such as social interactions, the formation of preferences or the diffusion of norms, to name just a few applications. This model, however, has been little explored in social sciences.[1] Other models of interest in this area include Poisson Point Process and percolation models which represent challenging and competitive topics in modern probability. Physicists and probabilists of the MME-DII partners have considerable expertise in these models, which represents a precious asset for developing alternative interaction frameworks.

2- Optimization and applications

The development of new models, in economics and finance, often raises challenging mathematical problems that reach well beyond the standard tools of the economist's toolbox. Very often, these problems involve complex and non-standard optimization programs that need to be solved in order to derive theoretical results. Complementarities between economists and mathematicians in this domain are strong. On the one hand, economists may largely benefit from the expertise of mathematicians. On the other hand, economists may help define interesting modeling problems.

A significant share of the research programs of AGM, LAGA and MODALX in partial differential equations (PDEs) is connected to optimization problems. Researchers in these teams have developed outstanding expertise in fields such as control theory, calculus of variations, ergodic theory and stochastic processes. Combination of the methods of control theory and probability on one side and homogenization techniques on the other has produced some remarkable insights in the theory of turbulence. Variational techniques have been developed and successfully applied in many problems like the existence of ground states or more general equilibrium or steady states. Many aspects of the linear and non-linear analysis of PDEs are also investigated, including existence, stability, and control of solutions for stationary and evolution equations. While most of these topics have been investigated with applications to physics in mind, the room for economic applications is considerable and will be explored in the MME-DDI project. In particular, it will be applied to the real option analysis, which is the modern tool in corporate finance theory to handle investment choices of firms (Dixit and Pindyck, 1994).

Optimal transportation models offer a very good example of the type of interactions that MME-DII may foster. Optimal transportation represents a very active field of research in mathematics.[2] It lies at the interface of the fields of optimization, partial differential equations, and dynamical systems in finite and infinite dimensions. Initially developed by Monge (1746–1818), the basic problem of optimal transport is to find the optimal plan for transferring mass from a set of origin locations to a set of locations. Such plans turn out to be generated by solutions to suitable PDEs.

[1] One of the rare exception, in a simplistic framework, is the Schelling model of discrimination.
[2] The Fields medal award to C. Villani is partly motivated by his research in this field.

Applications of optimal transport theory to economic problems are multiple. In general terms, the mapping of arrival and destination points studied by optimal transport theory is very similar to the pervasive problem of matching in economics. Classical examples include the matching of workers with heterogeneous skills to firms with heterogeneous characteristics on the labor market, and problems of assortative mating on the marriage market. Analyzing the process of matching is a key step toward understanding the functioning of markets and, in the examples given, the dynamics of social and economic inequality. In economics, matching models have gained popularity over the last two decades but the theoretical framework developed so far is still restricted to very specific cases. Typical models can only be solved in the case of one-dimensional heterogeneity, transferable utility and under the assumption of no informational friction. Optimal transportation theory offers powerful tools to solve optimal matching in more general cases. Furthermore, studying the inverse problem may help identify the matching constraints at work.

Optimal transport can also be applied to contract theory in a multidimensional setting for problems such as optimal taxation, nonlinear pricing, optimal regulation of natural monopolies. A key feature of such problems is that the implemented allocation should be incentive compatible: no agent type should wish to select an outcome that is intended for some other type. In the one-dimensional case, the literature assumes the Spence-Mirrlees condition, which allows to fully characterize the implementable allocations using only local incentive compatibility constraints. These constraints imply the monotonicity of the decision variable with respect to the agent's unobservable type. The original complex maximization problem then melts down to a straightforward optimal control program. However, many applications involve multidimensional heterogeneity (e.g., multi-product nonlinear pricing, multi-product monopoly regulation, multi-characteristic optimal income taxation). In this case, a condition such as the Spence-Mirrlees condition is meaningless as there is no simple complete ordering of a multidimensional Euclidean space. Substantial technical difficulties have limited the scope of the problems solved by economists until now. A few pioneers, however, have made inroads (Rochet and Stole, 2003, and the references therein). Remarkably, it can be shown that an incentive compatible allocation is the solution of an optimal transportation problem between the set of types and the set of implemented decisions.

Applications of optimal transportation theory to economics are still in their infancy (Ekeland, 2010 and references therein) but they represent a promising field of interactions between economists and mathematicians. The team gathered under the MME-DII project is in a good position to stimulate the development of such applications. On the economics side, the research topics outlined above occupy a central place in the research agendas of THEMA and ESSEC. On the mathematics side, some researchers in MODALX are already active in the field of transport theory and the research programs of AGM and LAGA offer a strong interaction potential for the hiring of a specialist of optimal transport theory. One of the research chairs in MME-DDI will be opened on this topic.

3- Models of aggregate dynamics

Macroeconomic dynamics studies the evolution of aggregate economic variables (e.g. capital, employment and consumption) over time. The need for relevant general equilibrium models of aggregate dynamics appears particularly acute in the globalized and financialized economy. On the one side, markets are increasingly connected and a partial equilibrium view turns out to be misleading. On the other side, it is urgent to understand the transmissions mechanisms between the financial sphere and the real economy.

Dynamic (Stochastic) General Equilibrium (D(S)GE) models offer the reference framework for research in this area. Current models suffer a number of important limitations. Individual and informational heterogeneity is not sufficiently taken into account. Market imperfections and, in particular, credit market imperfections are not sufficiently microfounded. Strategic interactions between agents are left aside.

The limitations of available model affect both their ability to explain aggregate dynamics and their capacity to provide good forecasts and inform economic policy. To a large extent, these limits mirror the limitations of theoretical models of individual behavior, interactions and coordinations, discussed in previous sections of this scientific project. But they also reflect mathematical limitations to the resolution of adequate models. Hence, the development of new models of aggregated economic

dynamics requires combining innovative economic theory with adequate mathematical instruments. Research in this area in particular will bring together researchers from EPEE, THEMA, AGM and LAGA.

A first area of research will concentrate on the development of models that take into account the heterogeneity in agents endowments and preferences as well as in firm's technologies. Individuals are also heterogeneous with respect to information. More informed individuals may extract a rent that is inefficient from a social point of view, for instance on financial markets. Models incorporating such heterogeneity are necessary to explain macroeconomic volatility, to model the trade-off between inequality and growth or to assess impact of globalization on welfare. From a mathematical point of view, to prove the existence of a general equilibrium with heterogeneous agents requires more sophisticated fixed-point arguments (Le Van and Vailakis, 2003). The bifurcation analysis is also non-standard because of the role of the initial distribution of wealth (functional analysis and the theory of global bifurcations are required to address this issue). Furthermore, solving DSGE models numerically with heterogeneous agents requires sophisticated approximation methods, especially when the economy is disturbed by aggregate shocks.

A second area of research will be the introduction of financial imperfections in DSGE models. Current models of credit markets imperfections (asymmetric information and financial constraints) are crude. The same holds for the bubbles in GE models (Tirole, 1985; Weil, 1987). The frontier of contemporary models is to incorporate bubble formation in a Ramsey model with and without borrowing constraints (Bosi). The challenging points from a mathematical point of view are the application of non-standard topological arguments (Gale and MasColell or Florenzano fixed-point arguments). In such frameworks, the first welfare-theorem no longer applies and the standard Negishi technique no longer works. Concerning the bubbles in Ramsey models, a key point is to try to provide better characterizations of the transversality condition. Concerning the modeling of the financial markets imperfections, a challenging issue is the introduction of incentive constraints in a DGE framework.

A third research area will answer the need to introduce more strategic interaction between agents in DGE models. In the real world, agents are not simply price-takers but take in account also the behavior and the best reply of the others. A synthesis between the general equilibrium and the game theory, and new concepts of Walras-Nash equilibrium are required. Strategic interaction can also help to better understand how players react in the financial markets and contribute to understand herd behaviors and speculative attacks. From a mathematical point of view, standard fixed-point arguments à la Brouwer-Kakutani are no longer useful to prove the existence of a strategic DGE (strategic Ramsey). One needs new tools such as supermodular games, lattice theory and Tarski fixed-point arguments. These new tools will be explored, at the frontier of economics and mathematics.

PART II: APPLICATIONS

The relevance of the innovative models of uncertainty and interactions developed in part I largely relies on their ability to shed light on the key economic and social issues of our time. Economists involved in the project, in particular in THEMA and ESSEC, have a long experience in applied research that combines relevant theoretical models and econometric tools to explore a variety of topics in economics and finance. Given space constraints, we only emphasize here two domains of applications: finance and risk management, and public economics. Furthermore, it is only possible in each case to give a flavor of the research that will be conducted. Both domains require a combination of models of decision and uncertainty and models of interactions and dynamics. They demonstrate the relevance of the applied research that will be conducted in MME-DII, ranging from the development of practical tools with direct applications in market finance to the *ex post* evaluation of public intervention.

II-A. Applications to finance and risk management

1- Financial engineering

Research in financial engineering will consider relevant extensions of portfolio optimization to a variety of new problems, using the tools developed in axis I-A. A first investigation will consider

portfolio strategies for long-term horizons where interest and inflation rates should be considered as stochastic. Applications will also be conducted to examine the benefits of portfolio diversification, for instance in real estate, commodity markets or foreign investment. The incorporation of constraints such as portfolio insurance or other constraints deriving from market regulations[3], introduced to improve investors' protection will also be more precisely analyzed. Research will also consider the development of long-term portfolio management tools that may take into account different economic factors, such as those reflecting macro-economic scenarios. This would offer institutional investors a way of interconnecting macroeconomic forecast, often produced internally by their forecast division, with portfolio allocation models.

2- Risk measure and management

Risk management and risk regulation are other important topics in applied finance that will be investigated. The inadequacy of the risk management models developed in the 1990s has been revealed by the recent financial crisis. In particular, the crisis has revealed their inability to adequately account for market frictions, liquidity problems, contagion effects due to risk interdependence, discrete-time rebalancing portfolio… This led to an inadequate assessment of risks. Risk management is tightly connected to risk regulation, through international standards, such as Basel 2 and 3, that aim at preventing major bank collapses and guaranteeing economic stability, by requiring rigorous risk management and capital protection. Assessing the impact of these regulations at the micro-level also requires accurate models of risk, together with suitable mathematical tools and relevant financial economic models. This is obviously a privileged and high-stake domain of applications of the models of section I-A. Research will seek to provide new and improved (theoretical) risk measures and to develop adequate statistical tools for the empirical assessment of these risk measures.

3- Strategic interactions in financial markets and contagion models

From a more analytical perspective, new research is also necessary to better understand coordination and interdependencies between agents on financial markets. A most striking form of these interdependencies is given, in the evolution of stock prices, by the dramatic episodes of bubbles and crashes that are mostly determined by expectations on future behavior. Understanding the conditions of emergence of such phenomena and the room for preventive regulation is still largely an open issue. Similarly, contagion and the diffusion of financial default is an important area of investigation. Both issues are an important domain of application of the models of global and local interactions that will be developed under axis I-B.

4- Corporate finance

A third direction of research deals with corporate finance issues. In addition to the real option theory already mentioned, several topics will be investigated. Elaborating on the acknowledged divergence of objectives between shareholders and managers, a first project will examine the role of large shareholders in corporate governance. If size of ownership plays an important role, the nature of the shareholder is another important feature that will also be investigated in future research. The second important source of conflicts of interests in firms is between shareholders and creditors: Firms might take unjustified risks which may in turn negatively affect their borrowing capacity and jeopardize good investment projects. This calls for an investigation of the financing constraints faced by small and medium enterprises (SME) and how they affect firm performance. Of related interest is the role of credit ratings agencies and firms' credit quality in an international trade context. A last important topic of corporate finance is the influence of bankruptcy laws on performance, the occurrence of bankruptcies and their outcomes.

II-B. Applications to public economics

The applications of core models to public economics offer an integrated approach of public intervention, from normative analysis of collective decision procedures to the empirical evaluation of policy interventions in various fields such as taxation or industrial policy.

1- Social choice

[3] See for instance the EU directive entitled "Markets in Financial Instruments Directive" (MIFID).

Policy intervention requires the definition of collective objective functions, which aggregate individual preferences, and collective decision mechanisms. Following on the seminal work of Arrow (1951), the analysis of these mechanisms has received considerable attention in the social choice literature. This literature is tightly connected to the analysis of decision under risk, as illustrated by Harsanyi's model of impartial observer. Although the properties of several collective preference aggregators have been well studied, existing research is often unable to provide guidance to public decision in situations of deep uncertainty. This is an important area of future research. Investigating the aggregation properties of voting procedures and exploring issues of strategic voting are other topics of political and social importance. These issues can be adequately tackled using developments in models of interactions. "Large" games, where each agent interacts with a large and uncertain number of other players offer an example in the case of strategic voting. These applications closely echo the topics of research conducted by researchers of MME-DII.

2- Implementation

An important problem in public policy - that involves a combination of strategic interactions modeling and optimization problems - is the issue of implementation and mechanism design. The objective of mechanism design is to understand how a player (the principal, for instance a government) can lead the other players to act in a certain way or to reveal their private information by having them playing a game with well-chosen rules (which is the "mechanism designed" by the principal). At the heart of mechanism design theory are incentive constraints: rational players must be given appropriate incentives to play in an appropriate way. Several researches of MME-DII are investigating these issues and considering various extensions: situations of collusion between agents; situations where the social planner is uncertain about the relevance of his representation of the agent's behavior or information; design problems, where the rejection of the mechanism does not end the strategic interactions between the potential participants of the mechanism. This research program has direct application on topics such as fiscal and competition policy.

3- Taxation and redistributive policy

A large amount of research projects will be devoted to the analysis of fiscal and redistributive policy, which represents both a major field of public intervention and an important topic of public economics. This research program will mainly investigate the properties of different tax policies in terms of their distortionary and redistributive effects and seek to design optimal taxation schemes. Research on indirect taxation will seek to extend the reference framework offered by the Ramsey (1927) taxation rule in order to incorporate several key aspects of current fiscal debates, in particular the EC constraints on applicable indirect tax rates. Research on income taxation will seek to define optimal tax schemes in situations where, contrary to the Mirrlees framework, agents differ in several relevant dimensions. Estimation of household response to fiscal policy is also a crucial issue in order to assess the effectiveness of various fiscal policies and requires a combination of taxation theory and microeconometric tools. Measuring the redistributive effect of taxes is also an important concern from a social and political perspective. In this respect, attention will also be devoted to policies aiming at equalizing opportunities across individuals. This reaches beyond the realm of pure fiscal policy and also involves educational and health policy.

4-Industrial regulation in open economies

A last domain of policy intervention that will be explored is competition policy and industrial regulation. Research will focus on how market structure, in a general sense, including in particular industry composition and firm's internal organization, is affected by all sorts of market constraints including market size and degree of competition, market regulations, as well as social and geographical constraints. This important issue can be dealt with from a variety of approaches. Competition policy represents a first natural approach in industrial organization and strongly emphasizes the conditions for achieving efficient regulation. However, the question of market structure and industry organization is a particularly salient issue in two other important contexts. The first one is the case of developing countries, where firm organization and industry structure will be influenced by a variety of market constraints in a way that may condition development prospects and industry dynamics. The second one is the case of industry structure and specialization in the context of open economies taking part in international trade. These two connected issues cannot be dealt with in

isolation, given the importance of international trade in economic development. The objective of this research is to offer an integrated approach of economic development, firm organization, industry structure and market regulation in an open economy. Shedding light on these issues requires the development of relevant models at the intersection of industrial organization, international trade and macroeconomics that are tightly linked with the different models explored in section I.

2. PARTNERSHIP

Composition of the partnership

Research center	*Affiliation*	*AERES evaluation*	*Number of researchers and graduate students involved in the project*
THEMA research center (laboratoire Théorie économique, modélisation et applications, UMR CNRS-UCP 8184)	Université de Cergy-Pontoise and CNRS	**A+**	**47 researchers** (inc. 8 ESSEC faculty) 24 PhD students
AGM research center (laboratoire Analyse, Géométrie, Modélisation, UMR CNRS-UCP 8088)	Université de Cergy-Pontoise and CNRS	**A+**	**30 researchers** 17 PhD students
LAGA research center (laboratoire Analyse, Géométrie, Applications, UMR CNRS-UP13 7539)	Université Paris 13 and CNRS	**A+**	**21. researchers** 16 PhD students
MODALX research center (laboratoire Modélisation aléatoire EA 3454 UP10)	Université Paris Ouest la Défense	**A**	**17 researchers** 4 PhD students
ESSEC research center	ESSEC Business School	not available	**18 researchers** (of which 8 THEMA members) 15 PhD students
LPTM research center (laboratoire de Physique Théorique et Modélisation, UMR CNRS-UCP 8089)	Université de Cergy-Pontoise and CNRS	**A**	**12 researchers**
LEM research center (laboratoire d'Economie Moderne, EA 4442,)	Université Panthéon-Assas	**A**	**9 researchers** 1 PhD student
CEPN research center (centre d'économie de Paris-Nord, UMR CNRS- 7234)	Université Paris 13 and CNRS	B	**13 researchers** 15 PhD students
EPEE research center (centre d'Etudes des Politiques Economiques, EA 2117)	Université Evry Val d'Essonne	B	**11 researchers** 6 PhD students

- *THEMA*

THEMA is a research center in economics, finance and management jointly operated by UCP and the CNRS. It was founded in 1993 and became a CNRS "UMR"[4] in 1997. Today it gathers a total of 61 permanent faculty members affiliated with UCP, the CNRS or ESSEC, 47 of which are involved in the project. THEMA rapidly emerged as one of the major research centers in economics in the greater Paris area. THEMA was graded A+ by AERES. According to various rankings, THEMA ranks in the

[4] UMR stands for unite mixte de recherche (*i.e.* joint research unit) and is the highest degree of involvement and recognition for a CNRS research center.

top five among research centers in France.[5] THEMA is characterized by a large degree of international openness. One third of its faculty held a position or was trained in a foreign university. THEMA faculty has collaborations with various academic institutions in Europe and North-America.

Several THEMA faculty members received a scientific distinction that rewards their academic excellence and testify to their strong research potential. R. Renault (industrial organization) and A. Lefranc (labor and public economics) are junior fellows of the Institut Universitaire de France (IUF). THEMA gathered a total of four IUF members over the last 10 years. A. Guerdjikova (microeconomic theory) was awarded a *Chaire d'excellence junior* by ANR. Two past members of THEMA were awarded the CNRS silver and bronze medal (Forges and Koessler) for their contributions in theoretical microeconomics.

Over the last five years, THEMA researchers have been involved in eleven research projects funded by the ANR, or similar projects. There are currently four distinct ANR being conducted in THEMA: TRANSINEQ (Lefranc), ITACE (Belan); TIPI (Donni); SOLITER (Martin). THEMA researchers have also recently been involved in two large-scale integrated European project funded under the FP6 and FP7 schemes.

The scientific production of THEMA mostly consists in research, applied and theoretical, leading to publication in peer-reviewed international journal of the highest standards. The last four-year inventory of publications, undertaken for the period 2005-2008 counted a total of 276 refereed journal publications, 48 academic books or contributions to books and 173 working papers. This publication record corresponds to a period when THEMA faculty included only 40 members. Over the recent years THEMA researchers recently have published in high-ranked generalist and field journals (AER, ReStud, JET, REStat…).

The research conducted at THEMA covers all fields of economics but reveals a strong emphasis on microeconomic modeling and applied econometrics. The research program in economics is structured around the following research axes: theoretical microeconomics; industrial organization; public economics; labor economics; international trade and development. THEMA also develops a strong research program in finance. Two specificities are worth mentioning. First, research in finance is strongly connected to the research conducted in economics, e.g. in financial market microstructure and in decision theory. Second, research also includes a program in financial econometrics, with researchers like A. Heinen and J.-L. Prigent who develop specific tools for the analysis of financial time-series, in order to shed light on portfolio optimization and risk management issues.

Given its research agenda, THEMA occupies a central position in the economics and finance research program of MME-DII and will contribute to all research axes.

The complementarities of the research conducted at THEMA with that of other research partners within the LabEx project are strong. In particular, most of the research conducted at THEMA relies to various extents on mathematical modeling. Beyond this overall mathematical common ground, several specific research areas at THEMA would greatly benefit from the enhanced integration with the researchers in mathematics that the LabEx aims at achieving. This is particularly the case in mathematical finance – for which important collaborations already exist – and game theory which has traditionally been a major field of interaction at the frontier of mathematics and economics. Other application field of mathematics is the analysis of economic equilibrium in dynamic models and decision theory, optimal transport theory.

THEMA is also deeply involved in higher education, in particular at the master and doctoral level, and gathers every year about 25 students conducting a PhD at THEMA. It has also initiated the development of interdisciplinary training programs in economics and mathematics.

- *AGM*

AGM (Analyse, Géométrie et Modélisation) laboratory is an UMR of CNRS and UCP dedicated to research in pure and applied mathematics with emphasis on Partial Differential Equations, Analysis,

[5] in particular Kalaitzidakis *et al*, 2003, Journal of the European Economic Association, and the more recent ranking of Tilburg University, https://econtop.uvt.nl/

Geometry, Mathematical Physics, Probability and Statistics. Created 20 years ago, the staff of the laboratory has increased substantially in recent years and currently consists of 32 permanent faculty and CNRS members. Among them, two are CNRS Research Directors and two CNRS Research Fellows. Two of the Assistant Professor positions are of the type “Chaire-MCF”. Besides research, the laboratory is strongly involved in higher education with 19 students conducting a PhD, 2 post-doctoral positions, and 4 ATER.

AGM obtained the highest grade A+ at the last evaluation by the AERES in 2008. The number of publications of the members of the lab in the period 2005-2008 exceeds 200, including research monographs and book chapters, with more than 170 in refereed journals. The number of publications in the period 2009-2011 exceeds 150. Many of them appeared in prestigious journals (Ann. of Maths., Adv. in Maths., Inventiones, Duke Math. J., etc).

The scientific achievements of AGM professors have been honored by prices and other scientific distinctions: Bôcher Memorial Prize (F. Merle, 2005), CNRS Silver Medals (F. Merle, 2005), Prize of the French Academy of Sciences (E. Hebey in 1995 and F. Merle in 1998), Prize of the Annales Institut Henri Poincaré (F. Merle, 1997; N. Tzvetkov, 2004). Elisabeth Logak has been a one-year fellow of the Radcliffe Institute of Advanced Study (2010-2011).

At present, two AGM professors are junior IUF fellows, F. Germinet (2007) and N. Tzvetkov (2010), and P. Doukhan is senior IUF fellow (2011). Before them F. Merle (1998), E. Séré (1999), E. Vasserot (2003) enjoyed the same distinction. A major achievement occurred in June 2010: two distinct ERC Starting Grants have been attributed for 5 years by the European Research Council to M. Lewin (MNIQS) and N. Tzvetkov (DISPEQ).

The AGM team researchers actively participate in other types of research contracts, most notably with ANR. Currently five AGM members are leaders of ANR projects: T. Banica (GALOISINT, since 2007), F. Germinet (EMTMD, since 2008), E. Hebey (CAGE, since 2009), M. Lewin (NoNAP, since 2010), A. Shirikyan (STOSYMAP, since 2011). Other examples of such contracts are the research project MIT-France fund coordinated by E. Hebey with T. Colding (MIT) and the project Long-time behaviour of solutions for stochastic Navier-Stokes equations coordinated by A. Shirikyan (CNRS-Royal Mathematical Society convention).

Members of AGM are editors of mathematical journals of great value: Discrete and Continuous Dynamical Systems, International Journal of Differential Equations, International Mathematics Research Notices, International Mathematics Research Papers, Journal of Hyperbolic Equations, Nonlinearity, Potential Analysis, Stochastic Processes and Their Applications, etc.

Most of the members of the AGM research team have teaching duties at all university levels, in particular, in Master 2 and PhD programs. The master program involves two directions: pure mathematics and applied mathematics, including a finance concentration developed in partnership with ESTI, an engineering school of Cergy-Pontoise. This makes all together about 30 students each year. About one fifth of mathematics students continue their studies at the doctoral school “Economie, Mathématiques et Management – Cergy”. There are now 19 PhD students conducting research in various fields of mathematics.

The scientific activity of the AGM laboratory focuses mainly on the development of concepts and tools of analysis in a very broad sense, the partial differential equations (PDE) being the unifying theme. These research interests cover many aspects of the linear and non-linear analysis of dispersive and elliptic equations, including existence, stability, and control of solutions for stationary and evolution equations. Major advances have been realized in the blow-up theory for various PDEs of dispersive and elliptic type modeling physical or biological situations. Researchers in the AGM team have developed an outstanding expertise in fields such as control theory or calculus of variations: variational techniques have been developed and successfully applied in many problems of physical interest such as the existence of ground states or more general equilibrium and steady states for large systems. Aspects of probability and mathematical statistics, dynamical systems and ergodic theory were also developed in connection with PDE techniques for the description of flows of nonlinear dispersive equations or for the study of randomly forced PDEs. On the purely probabilistic side, several remarkable results have been obtained on the long and short-range dependence properties in probability and statistics and on their applications to finance, industry, ecology and biology.

Significant results, potentially relevant in Finance and Economics, have been obtained in the theory of random walks and Markov processes. Important progress has been realized in the study of random operators, a theory at the crossroad of various mathematical theories (spectral analysis, PDEs, probability, stochastic processes) with concepts originating in the physics of disordered condensed matter and which considers systems of a great complexity, similar to that of recent economic problems.

More generally, the methods developed these last twenty years are highly relevant for the economic and financial problems that lie at the heart of MME-DII's research and training program. The interest in these issues is clearly revealed by the fact that P. Doukhan is at the same time professor in the Economy Department and member of the AGM research team. Moreover, E. Taflin, a member of AGM working on mathematical finance (bond markets and optimal portfolio theories), is also professor at EISTI. Reinforcing such links is a priority for the AGM team, as denoted by the attempts to hire on a professor position an expert in optimal transport theory.

- *LAGA*

LAGA is an UMR of CNRS and UPN and is headed by Laurence HALPERN

The research program of LAGA is organized into seven research teams: (1) Arithmetic and algebraic geometry (coordinator J. Tilouine); (2) -Mathematics for Information and Image Processing (C. Carlet, F. Dibos); (3) Modeling and Scientific Computing (F. Weissler); (4) Mathematical Physics and Partial Differential Equations (J-M. Delort); (5) Probability and Statistics (Y. Hu); (6) Ergodic Theory and Dynamical Systems (J. Barral); (7) Algebraic Topology (G. Powell)

Among the seven research teams of LAGA, four will participate, fully or partially to the LabEx project ("Mathematical Physics and Partial Differential Equations"; "Probability and Statistics", "Modeling and Scientific Computing", "Ergodic theory and Dynamical Systems"). This involves 21 researchers (out of a total of 84 permanent faculty members).

The laboratory has been evaluated A+ by AERES. The LAGA has a significant scientific output, measured by the number of articles in refereed journals (over 300 in 4 years), and PhD and Habilitation diplomas, invitations to seminars and international conferences, scientists awards and distinctions. LAGA enjoys a reputation of research excellence in France and abroad as evidenced by the awards received by a number of its members (the CNRS bronze medal, prize of the Academy of Sciences, appointments to IUF), as well as invitations to international conferences such as the prestigious International Mathematical Union. Thus LAGA is an attracting lab for international scientific visitors and for post-doctoral students. On the other hand, it has intensively developed its international relations at the institutional level in particular through its participation in FP European projects.

LAGA members participate or coordinate ANR contracts, industrial contracts, international conventions (currently fifteen). They organize or co-organizing conferences (over 40 in the last three years) and seminars. The laboratory budget is shared equally between stable budgets and contracts.

LAGA has a steady inflow of CNRS researchers (two in 2010, one in 2011) and regular professor hirings (Two new professors and 7 new assistant professors in 2011). Moreover the University of Paris 13 has assigned to the LAGA a Chair of Excellence (Prof. Kapranov and Prof. Zworski are invited for 2010-2011). Recent recruitments were made with the double concern to maintain the high-level research potential in pure mathematics, and to diversify the research themes by opening to other disciplines of application, in particular in economics and finance, biology, cryptography, images, climatology, etc.

Several key fields of LAGA's research program closely connect to MME-DII's research program, in particular probability, statistics and PDEs. On all of these topics, LAGA has developed collaboration with AGM. Furthermore, LAGA has already developed a joint-research program with economists at CEPN, in the fields of financial modeling and MFGT. These represent key stepping-stone toward a broader integration in MME-DII.

The LAGA is heavily involved in higher education. For 2 years, LAGA has offered 5 thematic courses for the Graduate School of Galilee Paris 13 (graduate school combining science and medicine). LAGA is also involved in the department of engineering and various Masters on Paris13 (Economics and

Finance, Images and Networks). LAGA heads the Master in mathematics and computer science at Institut Galilée. It is also deeply involved in doctoral training and LAGA PhDs are recruited in excellent laboratories, or in large industrial research centers at the end of their studies. To enhance its attractiveness to Master 2 students, LAGA has developed funds M2 scholarships on its own funds for highly qualified students. Over the last few years, LAGA has developed cooperation at the master's level with Vietnam (Hanoi, Ho Chi Minh City). Finally the LAGA is involved in the creation of the University of Science and Technology (USTH) in Hanoi and will participate in the master ICST (courses will be held in Hanoi) beginning in 2012.

- *MODALX*

MODALX is a research center in mathematics founded in 1994. It is mainly focused on stochastic modeling. It gathers a total of 25 permanent faculty members (7 full professors and 18 assistant professors), 17 of which are involved in MME-DII.

This relatively young research group has been growing in the recent years, to become one of the major research centers in France dedicated to probability theory and mathematical statistics. It is also involved in higher education with the master ISIFAR and an average of 6 PhD students over the years.

The overall grade awarded to MODALX by the last AERES evaluation session in 2007 was A.

The scientific production of MODALX mostly consists in research, both applied and theoretical leading to publication in peer-reviewed international journal of the highest standards. The last four-year inventory of publications, undertaken for the period 2004-2007 counted a total of 94 refereed journal publications. Note that this publication record corresponds to a period when MODALX faculty was fewer and included around 20 members. An updated full listing of MODALX production can be found at http://hal.archives-ouvertes.fr/lab/modal\'x/.

With an average age of 41, MODALX is younger than most research centers in France. This is partly explained by the success of our young members in getting promoted. During the last three years, four of our assistant professors obtained a professor position. Moreover, many former faculty members retired during the last ten years, so that the part of the faculty staff has been replaced by young dynamic researchers. During the three last years, the center hired 8 assistant professors and 4 professors.

MODALX is characterized by a large international openness. During the 4 last years, about 30 professors from 17 different countries visited the center for a period of one month. Since 2007, about 10 international scientific events were organized and supported by the center. Their list can be found at the website of the lab: www.u-paris10.fr/modalx.

To illustrate the research achievement of MODALX, one could mention the following contributions. In *mathematical statistics*, P. Bertail revitalized the bootstrap method in estimation theory by adapting it in the framework of Markov chains. P. Soulier, in a highly cited paper published in Econometrica, introduced new tools for estimating the parameters of long memory in stochastic volatility models. Being based in a social and human sciences university, the research center has always been motivated by statistical applications. Several members (Bertail, Chèze, Genolini, Hardouin, Soulier) are involved in developing quantitative tools for exploring large data sets and explaining complex phenomena in presence of uncertainty which are commonly encountered in economics, finance and insurance. In *probability theory*, N. Enriquez solved a long-lasting problem in the area of random walks in random environment, by deriving an explicit formula for a constant which characterizes the asymptotic behavior of the walk. The introduced tools are now commonly used in related fields. C. Léonard, in a pioneering work, linked large deviation theory and transport inequalities. In a seminal work with M. Benaim, O. Raimond built up a theory of self-attracting diffusion processes. The interest of these three topics for the LabEx is explained in the scientific project.

All of these topics occupy a central position in the first axis of the MME-DII research project.

MODALX members are involved in six ANR projects (A3, AST&Risk, GeMeCoD, MAGNUM, MEMEMO2, Randymeca).

MODALX is engaged in the success of the master degree ISIFAR which is specialized in value-at-risk. Despite the present economic crisis, all the students are getting a job rapidly, mostly in finance or

insurance industry. A present ambitious project is to obtain the enabling act for graduate students to work as an actuary (an occupation the access to which is protected by a quota) with this master degree. This will make the diploma even more attractive for both students and employers.

- *ESSEC*

ESSEC stands out among French business schools with an institutional culture that strongly promotes research. ESSEC Research Center comprises 122 full time professors in all areas of Economics and Management. Although there has been no official evaluation, ESSEC is recognized for the quality of its research. As an example, a recent study by Courtault, Hayek, Rimbaud and Zhu concludes that ESSEC Business School occupies the third position in France (after INSEAD and HEC) for research in Management.[6]

Researchers directly involved in the LabEx belong to 5 academic departments; Economics, Finance, Decision Science, Marketing and Operations Management.

Several faculty members received distinctions in recognition of their academic excellence. For example, Celik was awarded the EU Marie Curie reintegration grant in 2010, Lamiraud received the prize for the best paper in Health Economics in 2007, Charléty the prize for the best paper in Finance in 2005, Bemmaor received an award from the French Marketing Association for his "Outstanding Contribution to Methodology" in 2000. ESSEC faculty members regularly publish in top journals.

In line with the LabEx, fields of interest of the 20 ESSEC researchers cover Mathematics and applications to Finance (Extreme Values, Pricing, Derivatives, Risk Analysis, Energy and Commodity Finance,…), Corporate Finance (M&A, Economics of Bankruptcy, Corporate Governance,…), Econometrics (Time Series Econometrics, Forecasting), microeconomics (Mechanism Design, Industrial Organization, Labor economics, Consumer Behavior), Macroeconomics (monetary policy, empirical macroeconomics). As testified by their bibliographic scores, several professors are references in their field (e.g. Martel for Economics of bankruptcy, Poncet for Monetary finance and Portfolio theory).

As a Business School, ESSEC has close ties with both public and private actors. LabEx researchers participate regularly in various contracts. To cite only a few, Lamiraud is the co-investigator of a research project (financed by the Swiss National Science Foundation) which aims at assessing competition in Swiss health insurance markets. Charléty, Chevillon, Souam and Potin currently work on a research project on "shareholder voting" with the financial support of the European Institute of finance (EIF). EIF also financed two projects of Poncet on "optimal benchmarking" and "the predictability of asset returns" in 2006 and 2007.

ESSEC professors also sit in various official committees as the Scientific Committee of the Bank of France's Research Foundation (Poncet), the Scientific Committee of the French Security Exchange Commission and the French Institute of Directors (Charléty). Vranceanu served as an Economic Affairs Officer for the UN Economic Commission for Europe (Geneva, Switerland).

ESSEC Business School offers various programs at the graduate and post-graduate levels, in particular at the doctoral and masters levels. Since the creation in 1974 of a doctoral program, more than 170 doctors have been trained at ESSEC. More recently, a joint PhD Program in Economics (2006) and a joint Doctoral School, EM2C (Economie, Management et Mathématiques de Cergy, ED 405) (2010) were created in collaboration with UCP. A PhD in Finance was launched in 2011.

ESSEC offers advanced master's programs which are short, intensive and career-oriented. Each of them focuses on a particular area of management or business sector. LabEx researchers are particularly involved in the Master's degree in Finance which is targeted to a career in the actuary field and that was ranked 3rd as Best Master in Finance Program in the World by the Financial Times in 2011.

The research center of ESSEC, CERESSEC, was created in 1963. CERESSEC is managed by a professor who is elected by his peers for a three-year term as the Dean for Research. It provides direct support and incentives for research. CERESSEC will contribute financially to the LabEx by funding

[6] J-M Courtault, N. Hayek, E. Rimbaud and T. Zhu, Research in Economics and Management in France: A bibliometric study using the h-index, *Journal of Socio-Economics*, 39, 2, pp. 329--337.

participation to conferences, providing for research assistants and data acquisition, funding visiting professors.

- *LPTM*

Founded in 1992 as a Research Group in Statistical Physics, LPTM became an UMR of CNRS and UCP in 1998. It specializes in theoretical physics. In the last decade, two members have won the CNRS Bronze Medal for Physics. In 2009, it has obtained a CNRS position on the topic "Mathematics for Physics" –. In 2010 a CNRS endowed Maître de Conférences - chair of Physics has been awarded. The unit was rated A by the National Research Agency AERES in 2008 and continues to thrive towards excellence by hiring a first class specialist in combinatorial analysis, author of a proof of the so-called Razumov-Stroganov conjecture.

Out of a total of 21 members, 20 are steadily producing published works according to the national French standard. Their publications in internationally refereed physics journals are distributed as follows: 44 in 2009 and 34 in 2010.

This unit is dedicated to the theoretical study of various physical phenomena with potential technological applications. A vast spectrum of systems centered on many-body physics with mutual interactions is handled: strongly correlated systems, complex systems, stochastic systems and their applications in physics, biological systems, frustrated spin systems, etc. A strong emphasis is put on Monte-Carlo simulations for reaching reliable conclusions in complex cases. Moreover sophisticated approaches have been developed in the area of statistics and statistical mechanics which are relevant for physical problems. Finally some transport problems are dealt with the modern approach of inverse methods combined advanced mathematical techniques.

The topics and research methods explored in LPTM enter in strong resonance with the scientific project of MME-DII. In particular models of particle interactions developed in physics could be explored to produce new models of individual interactions, in particular in a non-homogenous setting. The mean-field approach to particle-environment interaction is very tightly connected to the mean-field approach to strategic interactions. Numerical methods used in theoretical physics are of wide applicability to problems such as financial optimization or the modeling of aggregate system dynamics.

Researchers in LPTM are already in close contact with the mathematicians of AGM and to some extent, with the finance specialists at THEMA. They will develop broader interactions within MME-DII, with other mathematics teams, as well as with the economics and finance research centers. In particular, they will fully take part in the various research and training activities of the LabEx (monthly seminars, bi-annual conferences, specialized courses at the doctoral and post-doctoral training, thematic school, and thematic semester).

- *LEM*

LEM is a young research center in economics of UPA. It gathers a total of 12 permanent faculty members. The recruitment policy is very active: on average, one assistant or full professor is being hired every year, resulting in a doubling of faculty size since 2005.

LEM researchers received several scientific awards and distinctions. In particular, A. Billot was appointed IUF senior fellow in 2011 after having been appointed junior fellow He was also awarded the CNRS Bronze Medal (1989). L. Ménager was awarded the Best Young Researcher Prize in Economics from the Banque de France (2011). O. Bos was awarded two grants from the European Science Foundation (2009) as well as a Marie Curie fellowship from the European Commission (2008).

LEM was involved in more than 15 applied research contracts with the European Commission, the French Office of Foreign Affairs, the Commissariat Général au Plan, the Office of Foreign Affairs and British Council, the Ministry of Labor, the Caisse des Dépôts et Consignation and the Economics Watch of Defense. Next year, a fellow of LEM has be designated as invited speaker at the Mission Climat of the Caisse des Dépôts et Consignation, to advise on the future market for carbon emission trading.

LEM demonstrates a high degree of international openness: on average 10 renowned international scholars come as visiting professors every year.

Research at LEM covers two main fields: economic theory and public economics. The economic theory group covers many areas of economics: formation of preferences, decision theory, game theory, social choice, mechanism design and behavioral economics. Work in this domain often lies at the frontier between economics, psychology and mathematics, through both theoretical and experimental contributions. The public economics' group develops applied models and empirical analysis for the analysis of labor market policy, educational policy and the internal organization of firms.

On both topics, the research interests of LEM researchers are highly convergent with the objectives of the MME-DII project.

LEM is also involved in the training of students. Seven students are currently involved in a PhD at LEM. LEM is also involved in an interdisciplinary Master's degree in Sciences and Economics.

- *CEPN*

The CEPN (Centre d'Economie de Paris Nord) is an UMR of CNRS and UPN. It gathers 52 permanent lecturers, 4 CNRS researchers, and 90 PhD students.

The research project of CEPN covers a broad range of economic issues. Research conducted at CEPN traditionally emphasizes an institutional and historical approach. Researchers of CEPN involved in the MME-DII project focus on industrial organization, macroeconomics and public economics. Lastly, a more recent research group, which brings together economists and mathematicians, has focused on the application of a new mathematical tool (the Mean Field Game Theory) to economic problems, notably in finance, growth theory and industrial economics.

In its areas of expertise, the laboratory has obtained an important number of research grants: ANR PANIC, ANR PROPICE, Cost ISO 902 (European Cooperation in Science and Technology**),** AUGUR **(**an international research project of the Seventh Framework Program of the EU). In 2009, the CNRS has assigned to the CEPN a Chair of Excellence for an assistant professor (J. Vauday, member of this project).

Since 2009, the development of the Mean Field Game theory is a strategic axis of the laboratory that has received a strong support from CNRS and UPN. This support is demonstrated by the recruitment of two mathematicians by the CEPN. In 2009 the laboratory recruited one assistant professor in mathematics (specialized in mathematical finance), benefited from a grant to fund a multidisciplinary doctoral thesis and received a substantial grant for application of MFG to economics and finance. In the near future, CEPN intends to recruit a full professor in mathematics specializing in mean field game theory. This important research axis of CEPN is strongly associated to the MME-DII project.

Another active research field with strong connections with the MME-DII project is the development of mathematical and statistical tools for risk management (risk measures, default risks, sovereign risks, exchange rates). This research field is also rooted in various complementary research projects in corporate finance, industrial economics and macroeconomics (in particular computable general equilibrium).

CEPN researchers involved in MME-DII also take part in training programs as well as valorization activities. At the master's level they are involved in two training programs "Ingénierie Financière et Modélisation"(professional curriculum) and "Economie internationale, Finance et Régulation » (research curriculum). CEPN has also developed collaborations with firms of the financial sectors (Risk Data, BNP ParisBas, Société Générale, Amundi, Generali and Thomson Reuters…) on new research projects concerning the measures and management of risks.

- *EPEE*

EPEE (*Centre d'Etude des Politiques Economiques de l'Université d'Evry*) is a research center in economics founded in 1995. It is attached to the UEVE. The laboratory has been evaluated B by AERES. EPEE gathers 20 faculty members affiliated with the University of Evry, 11 of which are involved in MME-DII.

EPEE is founding member of the CNRS research federation *Travail, Emploi et Politiques Publiques* (FR CNRS n° 3126) and is member of the research network T2M (Theory and Methods in Macroeconomics) chaired by M. Guillard (professor of economics at the University of Evry). EPEE support the research network M3D (*Mathématiques et Decision pour le Développement Durable* – Mathematics and Decision for Sustainable Development).

A key research area of EPEE is macroeconomic modeling. It is also a strategic development axis for EPEE. Last year, two professor specialized in macroeconomic dynamics has been hired (L. Ragot, S. Bosi). The research program in macroeconomics of EPEE focuses on the development of innovative dynamics models to analyze a broad range of macroeconomic issues such as labor market dynamics, monetary and fiscal policy, aggregate fluctuations and their origin (endogenous or exogenous fluctuations, role of financial bubbles), management of pension funding taking account of macroeconomic and demographic constraints, environmental economics, etc.

Most members of EPEE are involved in training programs at the master's level and four members of the research team organize a seminar dedicated to the doctoral training of the PhD students in economics. The master's program includes two areas: a master in finance and a master in environmental economics (B2D2: *Bioéconomie, Biodiversité et Développement Durable*). Furthermore, EPEE is strongly involved in the doctoral program of the University of Evry in social sciences (Ecole Doctorale *Sciences de la Société*). There are around 6 or 7 PhD students in economics and most of the doctoral dissertations defended are in the field of macroeconomic dynamics. Every year, two PhD students on average joint the research team.