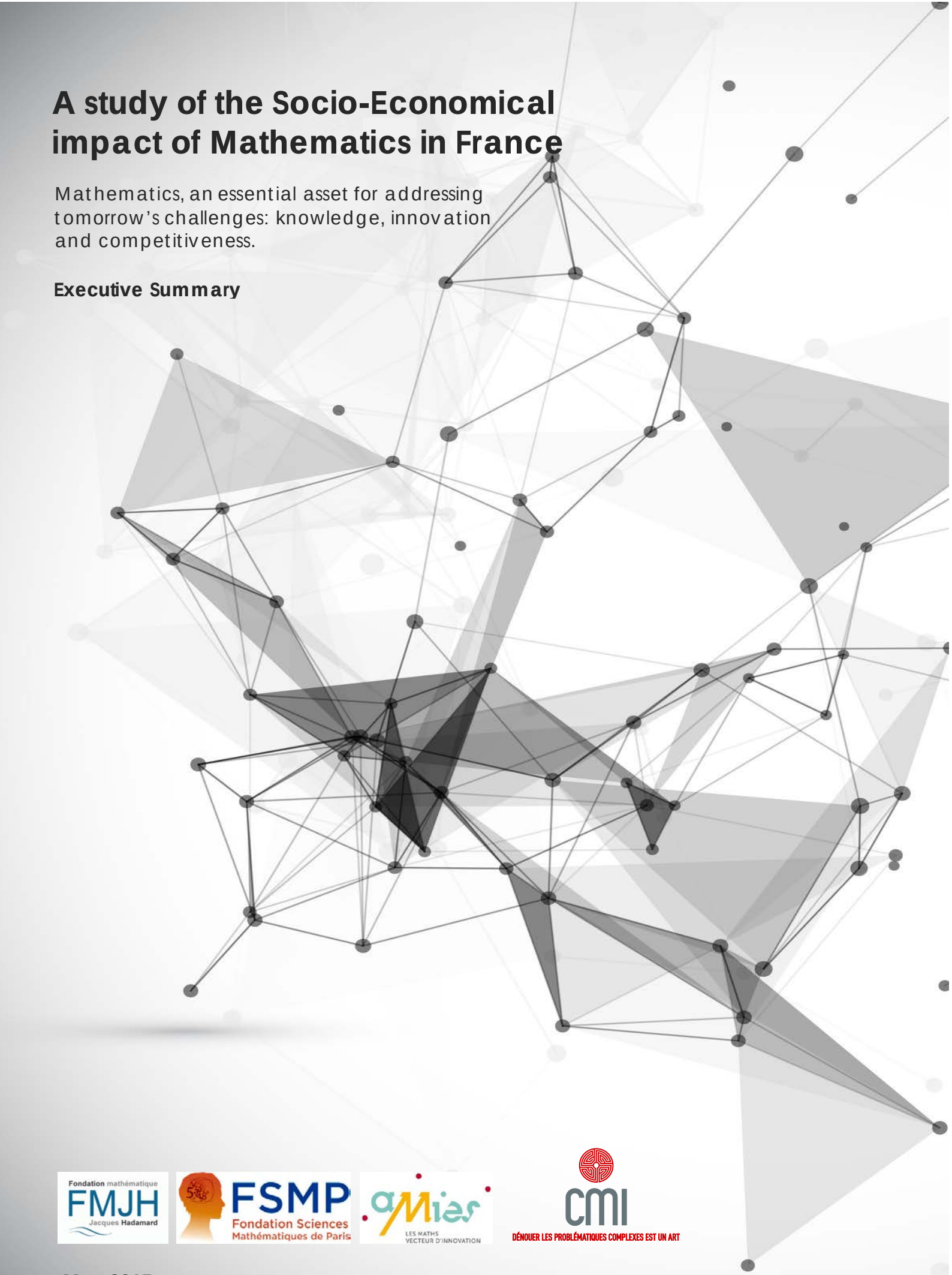
A study of the Socio-Economical impact of Mathematics in France

Mathematics, an essential asset for addressing tomorrow's challenges: knowledge, innovation and competitiveness.

Executive Summary



Fondation mathématique Jacques Hadamard FMJH

FSMP Fondation Sciences Mathématiques de Paris

aMies Les Maths vecteur d'innovation

CMI Dénouer les problématiques complexes est un art

Study conducted by CMI (Nicolas Kandel, Julie Koeltz, Flore Guyon, Romain Girard, Delphine Bartolini) requested by AMIES, in partnership with FSMP and FMJH and the support of Labex Archimède, Bézout, Carmin, CEMPI, CIMI, IRMIA, Lebesgue, LMH (FMJH), Milyon, PERSYVAL-Lab, SMP (FSMP).

SUMMARY

This study emphasizes the very strong and growing impact of mathematics for the competitiveness and growth of the French economy:

- *The jobs affected by mathematics have a strong added value (15% of GNP and 9% of employment) and are increasing in number (+0.9% per year from 2009 to 2012 vs. +0.5% for overall employment)*
- *It turns out that 44% of key technologies, identified as such by government reports, are strongly affected by progress in mathematics.*
- *The mobilization of 5 major competency fields of mathematics (signal and image analysis, data mining, modelling-simulation-optimization (MSO), high performance computing (HPC), computer system security and cryptography) will increase in numerous activity sectors, in particular energy, health, and telecommunications.*

The employability of mathematics students is excellent: companies (both large ones and SME's) are progressively becoming aware of this impact but are still somewhat ill-organized for managing in-house mathematical expertise.

The study finally underlines the necessity to reinforce the links between the higher education system and the companies, in particular for the universities:

- *Clarity of the higher education and research system is still too weak.*
- *Attractiveness of careers for PhD's in companies is still insufficient.*
- *Initiatives of support for mathematical expertise in SME's still needs reinforcing.*

By seeking to correct these points of weakness, the scientific excellence of French mathematics will truly constitute a competitive advantage for the economy.

KEY FIGURES

4 000 researchers and lecturer-researchers

500 PhD's per year

60 principal research labs of which 42 labs of **INSMI**

25% of students at levels between Bac+2 and Bac+8 are trained in or by mathematics

2.1 million trained students employed in 2015

8,5% of the workforce

37 key technologies out of 85 are impacted by mathematics

Of which 11 are very strongly impacted

Molecular Simulation	Technologies for life-imaging
Nuclear energy	Complex systems engineering
Smart grids	and systems of systems
Exploration and production of	Progressive/Intelligent
hydrocarbons.	Manufacturing
Genetic engineering	Holistic security
High performance computing	Communications and data

3.8 million posts impacted by mathematics, **2.4 million jobs, that is** **9%** of employment

285 Billion€ of added value
15% of GNP

Top 5 sectors most impacted by mathematics (weight of employment related to mathematics by sector)

IT Services: **75%**

Scientific R&D: **62%**

Production and distribution of electricity and gas: **57%**

Extraction of hydrocarbons: **56%**

Producation of electronic products: **54%**

56% of employment impacted by mathematics is concentrated in 3 regions: Ile-de-France, Rhône-Alpes and Provence-Alpes-Côte d'Azur

15 sectors among the top 20 of sectors the most impacted by mathematics exhibit growth rates superior to that of the French GNP.

CONCLUSIONS AND PERSPECTIVES FOR ADDRESSING TOMORROW'S CHALLENGES: KNOWLEDGE, INNOVATION AND COMPETITIVIENESS

In spite of a relatively modest workforce (4000 researchers and lecturer-researchers), **French research in Mathematics holds a world-leading position**. The French scientific system in mathematics is also particularly well-connected at an international level (close to half of the publications are co-authored in the framework of international collaborations, far ahead of the US or China).

This situation potentially constitutes a significant competitive advantage for the French economy, due to the considerable crosscutting nature of the discipline and the crucial issues that are addressed through its contribution to 5 key domains: signal and image analysis, data mining, modelling-simulation-optimization (MSO), high performance computing (HPC) and issues related to computer system security; progress in these domains will condition our competitiveness in sectors as strategic as energy, health, banking and insurance as well as telecommunications.

This study demonstrates the strong socio-economical impact of mathematics in France, compared to our neighbours: 9 % of jobs impacted (versus 10% for the United Kingdom, 11% for the Netherlands), jobs with strong added value (15% of French GNP versus 16% for the United Kingdom), jobs bringing more growth (+0,9 % for jobs strongly impacted by mathematics versus 0,5% on average in France).

The interviews that were conducted in companies reveal both a **growing need for mathematicians** and an increasing awareness of the issue of well integrating mathematicians.

This overall diagnostic is very favourable for mathematics. However, it encounters several weaknesses:

- *Structuring in the research-industry relationship.*
- *Clarity of the higher education and research system.*
- *Attractiveness of study courses in mathematics (stability of registrations) and career pathways in industry for PhD's even though the professional perspectives are excellent for those that have followed these courses.*
- *Follow-up of mathematical careers in companies.*

In this context, it seems that four major dimensions should be taken into account in order to address these challenges of tomorrow in the fields of knowledge, innovation and competitiveness based on mathematics.

1. The quality of research-industry relations, by reinforcing the capacities and levers for contractual research, joint research and transfer.

2. The capacity to adapt training paths and enhance the status of the acquired skills.

3. The continued mobilization of mathematical competencies by industry, their follow-up and the enhancement of the value of mathematical careers in the private sector.

4. The continued support of research and training in mathematics.