Deloitte.

Consiglio Nazionale delle Ricerche

Unione Matematica Italiana

Deloitte Economics

The economic impact of mathematical research in Italy

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Istituto per le Applicazioni del Calcolo

SMII SPORTELLO MATEMATICO PER L'INNOVAZIONE E LE IMPRESE

UMI Osservatorio sulla Ricerca

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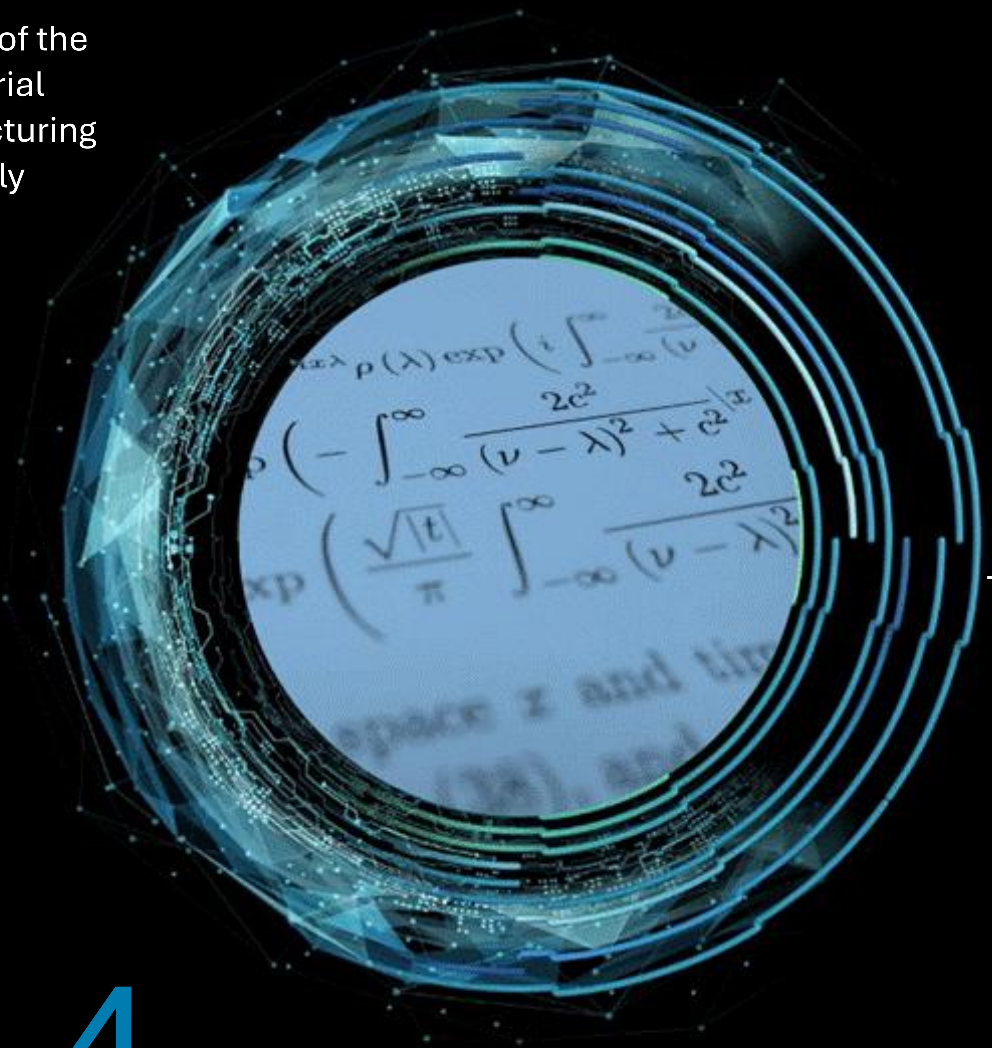
680.1 EUR/bn

Contribution to Gross Value Added

equal to about 34% of the national total
of which 308.5 EUR/bn direct impact

Equivalent to the economic contribution of the entire industrial and manufacturing sectors in Italy



8.4 FTE/mln employees

Supported employment

equal to about 35% of the national total
of which 2.7 FTE/mln direct impact

296.2

EUR/bn
Contribution to tax revenues

Glossary

Mathematical Research: activities carried out by academic institutions, research centres, companies, individuals and governments aimed at extending and deepening mathematical knowledge base. The main actors involved are mathematicians and, more generally, professionals who make use of mathematics, both as researchers and as users of its methodologies and tools.

AILA: *Associazione Italiana di Logica e sue Applicazioni* (Italian Association for Logic and its Applications).

AIRO: *Associazione Italiana Ricerca Operativa* (Italian Association for Operations Research).

AMASES: *Associazione per la Matematica Applicata alle Scienze Economiche e Sociali* (Association for Mathematics Applied to Economic and Social Sciences).

ANVUR: *Agenzia Nazionale di Valutazione del Sistema Universitario e della Ricerca* (Italian National Agency for the Evaluation of the University and Research System).

Artificial Intelligence (AI): technology that allows computers and machines to simulate human learning, understanding, problem-solving, decision-making, creativity and autonomy. AI-powered applications and devices can see and identify objects, understand and respond to human language, learn from new information and experiences, provide detailed recommendations to users and experts, and act independently, replacing the need for human intelligence or intervention[1].

CNR: *Consiglio Nazionale delle Ricerche* (Italian National Research Council).

Compounded Average Growth Rate (CAGR): represents the average percentage growth of a quantity over a period of time[2].

Direct impact: initial production or economic activity generated by an exogenous increase in final demand in a specific sector. It is the immediate and direct response of the sector affected by the increase in demand, without considering the effects that propagate to other sectors or to the economy (B2C transactions).

FTE: Full Time Equivalent, the number of full-time equivalent employees of annual duration, used as the main measure of employment.

Gross Domestic Product (GDP): final result of productive activities of resident production units. It corresponds to the total production of goods and services of the economy, minus intermediate consumption and increased by VAT and indirect taxes on imports. It is also equal to the sum of value added at basic prices of the various branches of economic activity, plus taxes on products (including VAT and import taxes), net of subsidies on products[3].

Gross Value Added (GVA): aggregate measuring the growth of the economic system in terms of new goods and services made available to the community for final uses. It is the result of the difference between the value of the production of goods and services achieved by the individual branches of production and the value of the intermediate goods and services consumed by them (raw materials and auxiliaries used and services provided by other production units). It corresponds to the sum of factor remuneration and depreciation. It can be calculated at basic prices, producer prices, and factor cost[4].

IAC: *Istituto per le Applicazioni del Calcolo – Consiglio Nazionale delle Ricerche* (Institute for Computing Applications of the Italian National Research Council).

INDAM: *Istituto Nazionale di Alta Matematica "Francesco Severi"* (National Institute for Advanced Mathematics "Francesco Severi").

Indirect impact: additional production generated in other sectors of the economy as a result of increased intermediate demand from the sector directly concerned. when a sector increases its production, it purchases inputs from other sectors, which in turn increase their production to meet this demand: companies that receive direct spending make additional purchases from their own suppliers, creating a chain reaction in the supply chain. These effects are called indirect impacts (B2B transactions) and reflect the interconnected nature of modern economies, in which companies depend on networks of suppliers and service providers[5].

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[1] IBM, *Artificial Intelligence*: https://www.ibm.com/think/topics/artificial-intelligence
[2] Italian Stock Exchange. CAGR: what it is and how to calculate it. https://www.borsaitaliana.it/notizie/sotto-la-lente/cagr-259.htm
[3] *ISTAT* (2019). Italy in 150 years (Chapter 12).
[4] *ISTAT* (2025). Glossary: https://www.istat.it/wp-content/uploads/2025/05/Glossario-rapporto2025.pdf
[5] For example, when a construction company receives payment for the construction of a building, it purchases materials from suppliers, hires subcontractors, and purchases equipment. These suppliers, in turn, make their purchases from other businesses, creating a chain reaction throughout the supply network. The steel supplier who supplies materials to the construction project must purchase raw materials, pay for transportation services, and purchase industrial equipment. The transport company, therefore, purchases fuel, vehicle maintenance services and insurance. Each transaction generates additional economic activity on top of the original construction expense. Projects in the service sector create indirect effects through technology purchases, professional services, facility maintenance, and business-to-business transactions. A financial services company that expands operations generates indirect effects through office construction, IT equipment purchases, legal services, and facilities management.

Induced impact: economic effect deriving from the increase in the expenditure of labour income generated by direct and indirect impacts (increase in the disposable income of workers active in the area under analysis and in the supplier sectors). When workers employed in the sectors directly and indirectly involved spend their wages on goods and services, this further stimulates production in other sectors of the economy. This effect is captured in models that include household spending behaviour (additional B2C transactions). In other words, workers employed directly or indirectly by a project spend their earnings on housing, food, health care, education, recreation, and consumer goods. This household spending supports additional business activity and employment across the economy, particularly in the retail, personal services, health care, and housing sectors[6].

Input-Output (I-O) model: a linear model with fixed prices that describes the technical relationships between the productive sectors of an economy, represented by fixed technical coefficients. It shows how the output of one sector depends on inputs from other sectors to generate a unit of output. The model allows you to calculate how exogenous changes in the final demand of a sector affect the total output of the economy, including direct, indirect and induced effects. The solution of the model is based on the construction of the inverse Leontief matrix, which incorporates all sectoral interdependencies.

ISTAT: *Istituto Nazionale di Statistica* (Italian National Institute of Statistics).

Labour Force Survey (LFS): It is the timeliest source of statistical information on the Italian labour market. With approximately 250,000 households interviewed annually, the information collected forms the basis from which official estimates of employed and unemployed persons are derived, as well as information on the main aggregates that make up labour supply.

Machine Learning: subset of artificial intelligence, focused on algorithms that can "learn" patterns from training data and, subsequently, make accurate inferences about new data. This pattern recognition capability allows machine learning models to make decisions or make predictions without explicit, rigidly coded instructions[7].

Mathematical Sciences: The set of areas of study and research dedicated to mathematics, which include both theoretical and applied aspects. This field encompasses various branches such as algebra, analysis, geometry, statistics, and applied mathematics. The expression “Mathematical Sciences” emphasizes the systematic and methodological character of the discipline: it can indeed be used interchangeably with the expression “mathematical disciplines”, as both indicate the set of specializations and branches of study that constitute the mathematical field, without substantial differences in meaning.

Programme for International Student Assessment (PISA) Math Score: index that measures the ability of 15-year-olds to use mathematics to solve real problems. It assesses how well students can formulate, apply, and interpret mathematics in various contexts. A mathematically literate student can use mathematics, to describe, predict and explain phenomena, and make decisions supported by evidence or logic as an engaged and informed citizen. This indicator is measured as an average score[8].

Research and Development (R&D): creative and systematic work undertaken to increase the stock of knowledge, including knowledge about humanity, culture and society, and to devise new applications of available knowledge. The term R&D covers three main types of activities: basic research, applied research and experimental development. For an activity to be considered as R&D activity, it must meet five key criteria: the activity must be novel (aimed at innovative discoveries), creative (based on original and non-obvious concepts and assumptions), uncertain (with an uncertain final outcome), systematic (planned and with a defined budget), and transferable and/or reproducible (capable of producing results that could eventually be replicated).[9]

SIMAI: *Società Italiana di Matematica Applicata e Industriale* (Italian Society of Applied and Industrial Mathematics).

STEM: acronym for Science, Technology, Engineering, and Mathematics. It refers to a broad field of academic and professional disciplines that are critical to innovation, economic competitiveness, and social development[10].

UMI: *Unione Matematica Italiana* (Italian Mathematical Union).

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[6] Cassar, I. P. (2015). Estimates of output, income value added and employment multipliers for the Maltese economy (No. WP/03/2015); d'Hernoncourt, J., Cordier, M., & Hadley, D. (2011). *Input-Output Multipliers–Specification sheet and supporting material, Spicosa project report* (Doctoral dissertation, Université Libre de Bruxelles (ULB), Belgium; University of East Anglia); Stratford Analytics https://www.stratfordanalytics.com/understanding-direct-indirect-and-induced-economic-effects-a-complete-guide/ For example, a construction worker building a new facility spends wages on groceries, utility bills, mortgage payments, and entertainment. These expenses support grocery store employees, service workers, bank staff, and restaurant workers, who in turn spend their earnings, continuing the cycle.
[7] IBM, *Machine Learning*: https://www.ibm.com/think/topics/machine-learning
[8] OECD: https://www.oecd.org/en/data/indicators/mathematics-performance-pisa.html
[9] Unesco: https://databrowser.uis.unesco.org/resources/glossary/2460
[10] National Science Foundation (NSF): https://stem.ucdavis.edu/what-stem

Preface

Mathematics has always guided human development and in today's digital society its role has become pervasive and irreplaceable. Today, its applications are not limited to physics and engineering, but span biology, medicine, economy, and social and environmental sciences, employing increasingly sophisticated models.

Mathematical Sciences are experiencing continuous expansion and constitute the core of nearly all innovative technologies. They are the basis of web algorithms, genome sequencing, data transmission and modern artificial intelligence. Without mathematics, we would not have most of the technologies we take for granted: from encryption algorithms for secure transactions to image compression algorithms in our smartphones, from medical imaging techniques to the satellite navigation systems we use every day.

Embedded in our everyday reality and undergoing continuous evolution, Mathematical Research stands today as the cornerstone for scientific innovation, economic growth, and the sustained competitiveness of the entire modern productive ecosystem.

In this context, the *Consiglio Nazionale delle Ricerche* and the *Unione Matematica Italiana* commissioned Deloitte to prepare a report, in order to independently quantify the economic impact of Mathematical Research on the Italian economy (hereinafter “Study”).

The Study takes its cue from and compares with similar studies, carried out in previous years by Deloitte, for the United Kingdom and the Netherlands. Similar investigations have also been carried out in France and Spain. The Study provides quantitative data on the contribution that Mathematical Research offers to the Italian economy in terms of supported employment and Gross Value Added.

Mathematical Research in Italy stands out for its internationally recognized level of excellence, as documented in the Study through comparison with the main European countries. Scientific output is among the highest in Europe, comparable to that of France, the United Kingdom and Germany, despite significantly lower investment in R&D as a percentage of GDP.

This scientific solidity translates into a significant impact on the production system. Mathematics contributes decisively to the development of advanced technologies and the training of highly qualified personnel, capable of operating in complex and innovative industrial contexts. It therefore represents a strategic element for the country's competitiveness, for its ability to innovate and for attracting investments.

In the light of this evidence, this Study aims to provide policy makers and industrial actors with an objective information basis to guide future strategic choices. In particular, we hope that the results presented herein may contribute to the definition of the next National Research Plan and foster a strengthening of interactions between research and the productive system.

In this perspective, recognizing mathematics as a key enabling technology represents an essential step to support national productivity growth and face the challenges of digital transformation and artificial intelligence with appropriate tools.

CNR and *UMI* extend their gratitude to the mathematical associations *AMASES*, *AIRO*, and *SIMAI* for their valuable collaboration in responding to the questions related to Mathematical Research posed by Deloitte during the preparation of this Study.

Marco Andreatta, President of the *Unione Matematica Italiana*
Roberto Natalini, Director of the *Istituto per le Applicazioni del Calcolo* at the *CNR*

Executive Summary

With the aim of gaining deeper insight into the contribution of Mathematical Research to the Italian economy, the Scientific Commission of the *UMI* and the *IAC* of the *CNR* engaged Deloitte to undertake an economic analysis Study, designed to quantify the impact and economic benefits of Mathematical Research in Italy.

The analysis concentrates on Mathematical Research, defined primarily as advanced research undertaken by academic institutions, research centres, enterprises, private actors, and governmental bodies, with the aim of enhancing the accumulated knowledge base. However, the applications of Mathematical Research have also been taken into consideration, aimed at solving everyday problems in the economic, medical, industrial, etc. fields, as well as supporting the work of professionals who make more or less extensive use of them. The Study quantifies the contribution of Mathematical Research at **680.1 billion euros** of **Gross Value Added** and **8.4 million jobs supported**, highlighting significant direct, indirect and induced effects.

Context and impact channels

Mathematical Research holds extraordinary importance for the functioning of current systems, as it contributes to sustaining essential technologies: think, for example, of those involved in finance, life sciences and AI. Mathematics is configured as a **tool capable of converting complex phenomena into interpretable models**, which, in turn, guide decisions in different spheres, social and industrial, public and private. The number of talents specialized in Mathematics and Mathematical Sciences is expanding, giving rise to a growing space for the realization of future impacts. Enrolments, graduates and doctorates in Mathematical Sciences and related disciplines have increased over the last decade, indicating a growth in highly qualified human capital. However, there is an even more marked growth in the other STEM fields: with reference to the latter, both the number of enrolled and graduate students grew more than enrolled (CAGR of 2.9% vs 3.1%) and graduates (CAGR 1.6% vs 2.8%) in mathematics. Noteworthy is also the **scientific output** in the field of mathematics, despite the limitations that still persist in Research and Development investments. Italy, as will be demonstrated further in this Study, ranks among the top positions in terms of scientific output quality alongside nations such as the Netherlands, Germany, France, and Spain, notwithstanding that the proportion of Research and Development spending in higher education and public education expenditure as a percentage of GDP remain significantly lower than those of such countries.

In addition to this, Mathematical Research has a consolidated reputation with a significant presence of **positive polarity in the media**: communication could therefore be leveraged to emphasize the value and impact attributable to mathematics in the creation of new professional opportunities and in the development of emerging technologies.

Four key areas can clarify, by way of example but not exhaustively, how Mathematical Research generates measurable economic and social value across the sectors that constitute the economy. (i) **Social protection**: epidemiological models inform public health responses; quantitative algorithms counter fraudulent activities; probabilistic models, frequently coupled with numerical simulations, enhance climate and infrastructural resilience. (ii) **Management of industrial processes**: analytical and computational tools make it possible to improve the quality of work and research supports the development of new, more sustainable materials. (iii) **Technological innovation and AI**: the adoption of AI is growing in Italian companies, supporting productivity and competitiveness. Generative AI offers significant positive implications in the further development of Mathematical Research applications; nevertheless, competency management capabilities and the establishment of governance frameworks are essential to ensure the responsible deployment of this technology. (iv) **Scenario forecasting**, **uncertainty management, and optimization**: robust/stochastic optimization, Monte Carlo simulations, and operations research improve planning.

Economic and employment impact

The analyses performed suggest that Mathematical Research has contributed, in terms of **Gross Value Added**, EUR **680.1 billion** to the Italian economy in 2025, representing approximately 34% of the national aggregate. Of this total, **308.5 billion** represent the **direct impact**, 221.3 billion the indirect impact and 150.3 billion the induced impact. For every euro of direct impact, an additional 1.2 euros are generated through indirect and induced channels. In particular, to give an illustrative idea of the magnitude of the impacts generated, **the estimated contribution of Mathematical Research to Gross Value Added is equivalent to the economic contribution of the entire industrial and manufacturing sectors in Italy**.

In terms of employment impact, Mathematical Research supported **8.4 million jobs**, equal to about 35% of the national aggregate, confirming its cross-sectoral relevance for the labour market. The estimate includes **2.7 million direct employees**, about 3.2 million indirect employees in the supply chains, and about 2.5 million induced activities supported by household spending. In practical terms, the entire occupation in Italy could be connected to mathematics, considering that almost every work activity applies at least basic mathematics, but the aim of the analysis was to restrict the quantification to Mathematical Research.

In addition, against the economic contribution described above, it is estimated that the **contribution to tax revenue** of Mathematical Research was approximately **296.2 billion** euros as of 2025.

These impacts have been quantified by resorting to the so-called "Input-Output" approach, a recognized and consolidated method for socio-economic impact analyses.

In its application, a perimeter of professions influenced, to a greater or lesser extent, by Mathematical Research, in their normal operation, has been preliminarily defined. Once the occupations were identified, the intensity of Mathematical Research for each sector was estimated, taking into account the distribution of professions within the different sectors. The Input–Output model has therefore made it possible to estimate the impacts generated by Mathematical Research.

It can also be observed that, worldwide, the development of mathematical knowledge is associated with better economic performance. In particular, there are high and significant correlations between the PISA Math Score of a panel of countries and GDP per capita, as well as GDP per hour worked. Excluding some outliers, the correlation is 77% in the first case and 73% in the second. The analysis of Italian media coverage (2015-2025) reveals a consolidated and favourable perception of Mathematical Research, with a significant growth in visibility in recent years. Sentiment is predominantly neutral, with a significant positive component. Overall, the analysis shows that public opinion values both the practical usefulness of mathematics and the educational importance, highlighting the need for structured initiatives aimed at promoting the discipline as an enabling factor for the scientific, technological, social and cultural development of the country.

Key takeaways

To summarize, Mathematical Research can be considered as a strategic asset, which generates, in total, **680.1 billion euros** of **Gross Value Added** and supports **8.4 million jobs**: for this reason, it can be considered a priority to promote policies capable of supporting this engine of growth, such as increasing investments in Research and Development, the development of greater collaboration between industry and academia, the application of monitoring tools, the promotion of the responsible use of AI, etc.

Increasing the dissemination of mathematical knowledge and advanced quantitative skills, as well as promoting and supporting Mathematical Research represent fundamental opportunities, in order to increase productivity, increasing resilience and improving the competitiveness of the various sectors and the economy as a whole, and allowing Italy to increase the well-being and standard of living of the population. Italy could amplify the economic returns of Mathematical Research, fuel the growth of talent, as well as promote the use of technology and investments with strategic priorities.

In terms of labour productivity, technological acceleration and the use of AI can **support an increase in productivity** and compensate for the expected labour force reduction due to demographic ageing, a phenomenon that is particularly relevant in Italy. However, without **interventions aimed at supporting human capital**, in particular through the **dissemination of the necessary mathematical knowledge and quantitative skills**, there is a risk of a significant erosion of human work activities and the quality of these activities. This makes it even more necessary to promote professional and academic training courses with a strong quantitative component, aimed at providing the necessary tools for managing the phase of change we are going through; on the contrary, a not fully responsible use of the latest technologies and AI could give rise to negative effects on the country’s economic growth.

1. Introduction

The commissioning parties of the Study

Consiglio Nazionale delle Ricerche

CNR, founded by mathematician Vito Volterra in 1923, has a human capital of excellence of over 8,500 units including researchers, technologists, technicians and administrative staff, with more than 500 researchers ranked among the Stanford University-Elsevier Top 2% Scientists 2025 globally. By virtue of its extensive territorial presence across the nation, the *CNR* functions as a strategic hub bridging the academic world, the industrial ecosystem, and governmental institutions, thereby guaranteeing a decisive contribution to both national and international competitiveness and scientific progress.

The *CNR* participates in over 50 international scientific bodies, including the International Science Council, plays a leading role in Horizon Europe and also holds a solid position among Italian institutions for the number of grants obtained from the European Research Council.

Concurrently with fundamental research endeavors, the Institution advances the valorization of scientific results, thereby fostering technology transfer towards the industrial and productive ecosystem. This is evidenced by the presence of the *CNR* in all the main investment lines of Mission 4, Component 2 (M4C2) of the National Recovery and Resilience Plan (NRRP), called "From research to business" and coordinated by the Ministry of University and Research, which has provided 8.5 billion euros to transform scientific excellence into industrial value. The *CNR* actively participates in all 5 national centres dedicated to frontier technologies and is the leader of 14 of the 32 Research Infrastructures funded by the NRRP, and partners in the others. It also takes part in about 50% of the Technological Innovation Infrastructures supported by the program and is involved in all 14 research partnerships funded by the NRRP.

As far as technology transfer is concerned, the *CNR* manages a portfolio of intellectual property rights (IPR) consisting of over 400 active property rights, many of which are the subject of licensing or technological collaboration agreements, which generate, in addition to direct income, also numerous R&D contracts commissioned to the institutes. The *CNR* further promotes the establishment of new ventures based on advanced technologies or the know-how of its researchers, with 65 active spin-offs operating in cutting-edge technology sectors (Biotech, Deep Tech, Advanced Materials), of which 31 have been created over the past five years.

***Istituto per le Applicazioni del Calcolo "Mauro Picone"* (CNR-IAC)**

Founded in 1927 by the mathematician Mauro Picone, the *IAC* was the first institute of the *Consiglio Nazionale delle Ricerche* and the world's first institution wholly dedicated to applied mathematics. Born with the pioneering vision of combining theoretical mathematical analysis with the concrete needs of engineering and industry, the institute led the evolution of advanced computing in Italy, culminating in 1955 with the acquisition of *FINAC*, one of the first electronic computers on a European scale. Today the *IAC* operates through the headquarters in Rome and the secondary offices in Bari, Florence and Naples. Its workforce consists of approximately 90 units, encompassing researchers, technologists, technicians, and administrative staff, alongside a significant cohort of early-career researchers (doctoral candidates, postdoctoral fellows, and grant recipients), thus fostering a dynamic and multidisciplinary research environment.

The institute's main research lines include:

- **Optimization and numerical linear algebra**: discrete modelling, continuous and discrete optimization methods, numerical linear algebra, decision science.
- **Probability, statistics and machine learning**: statistical inference, probabilistic methods, machine learning, complex data analysis and multidimensional signal and image processing.

- **Differential and stochastic mathematical modelling, study of complex systems**: from epidemic dynamics to vehicular traffic, from differential models for degradation to those for biological systems.
- **Scientific computing and high performance**: methods and algorithms for high-performance computing, numerical simulation of physical systems (particle and continuous, in classical, quantum and relativistic fields) and computational modelling of complex systems.
- **Mathematics for Health and Biomedical Sciences**: development of models, methods and algorithms for the analysis and integration of high-dimensional biological and clinical data, with applications ranging from basic biology to diagnostics and therapeutic protocols.

The Institute promotes an intense dissemination activity aimed at placing mathematics at the centre of contemporary society. Through the Comics&Science publishing project, a science comic book series, and the MaddMaths! website, the *IAC* promotes scientific literacy among the general public. The commitment to dissemination is also expressed in the constant participation in events such as the Science Festivals of Genoa and Rome, the Turin Book Fair and the European Researchers' Night.

Within the Institute, and thanks to dedicated funding from the Ministry of University and Research, the *Sportello Matematico per l'Innovazione e le Imprese* operates, having been established in 2012 with the aim of leveraging mathematics to support innovation and society. The project originates from the recognition of the strategic role of Mathematical Sciences as a competitiveness driver for enterprises and, simultaneously, from the challenges faced by the Italian productive system in accessing research outcomes, partly attributable to limited interaction between the academic and business communities. With its network of 37 research partners in the area, the *Sportello Matematico* therefore proposes itself as a project bridge between the Italian mathematical community and the business system. The strategic objectives are to create a network of excellence for Industrial Mathematics in Italy; promote Mathematical Technologies towards Small and Medium-sized Enterprises; facilitate collaborations between research and business; encourage the inclusion of young STEM graduates in the national industrial ecosystem.

Dr. Roberto Natalini

Director of the *Istituto per le Applicazioni del Calcolo "M. Picone"*, *CNR*

Unione Matematica Italiana

The *UMI* is the organization representing the Italian mathematical community. Established in 1922 at the instigation of the International Council for Mathematical Research, which promoted the establishment of National Scientific Societies, it is a non-profit association based in Bologna with approximately 2,500 members.

Its primary purpose is to follow and promote the development of Mathematical Sciences and their applications, disseminating the results. For this reason, it focuses its activity in various strategic areas.

Research Promotion and Dissemination

UMI promotes Mathematical Research and disseminates its results with the publication of three journals, the *Bollettino* (published by Springer), a *Newsletter* (distributed to all members) and a *Journal* entitled "Mathematics, Culture and Society".

It has established *Observatories dedicated to Research and Doctoral Education*, aimed at promoting and valorizing research conducted by universities and national research institutions.

To foster collaboration on scientific topics of great relevance for our society and to disseminate the results to a wide audience, in recent years it has created thematic research groups, including the groups on *Cryptography and Codes, Socio-Epidemiological Modelling, Probability and its Applications, Mathematics of Images and Vision, Mathematics of Dynamical Systems, Mathematics for Artificial Intelligence, Mathematics for Climate, Approximation Theory and Applications*.

Scientific Networking

The *UMI* organizes Congresses and Scientific Meetings across various Italian university locations to present and discuss the broad spectrum of Mathematical Research output. The *UMI Scientific Congress* is an event of great importance for Italian and international mathematics and is held every four years (the next one at the University of Salerno in 2027). The *Conference for PhD Students* is an event aimed at young researchers to encourage the dissemination of their results and promote the creation of collaborations (the next one at the University of Florence in 2026).

It establishes contacts for scientific collaboration and exchange of information with Mathematical Societies in various countries around the world, also through the organization of *joint Congresses* and the signing of *Memorandums of Understanding*.

In particular, *UMI* is a member of the *European Mathematical Society (EMS)* and promotes its activities, participating, for example, with the University of Bologna in the organization of the *EMS Congress in Bologna in 2028*.

In order to foster relationships among mathematicians and other practitioners of allied scientific disciplines, including physicists, computer scientists, engineers, economists, and biologists, and to monitor research autonomy and funding in Italy, the *UMI* has adhered, since 2024 alongside 140 other Societies, to the Network of Italian Scientific Societies. More specifically, *UMI* frequently collaborates with the *Società Italiana di Matematica Applicata e Industriale (SIMAI)*, the *Associazione per la Matematica Applicata alle Scienze Economiche e Sociali (AMASES)*, the *Associazione Italiana Ricerca Operativa (AIRO)* and the *Associazione Italiana di Logica e sue Applicazioni (AILA)*. Some members of these associations have actively participated as consultants in the realization of this Study.

Teaching Support

Through the *CIIM* (*Commissione Italiana per l'Insegnamento della Matematica*), *UMI* works to promote, reinforce, and modernize mathematics instruction across schools at all educational levels. In partnership with the Ministry of Education, it develops innovative education programs, such as the Mathematical High School, and contributes to the implementation of new national educational standards, including the design of integrated curricula with Computer Science.

The *UMI* has furthermore established an *Osservatorio Corsi di Studio* to monitor mathematics teaching activities at national university institutions.

Talent Enhancement

The *UMI*, supported by the Ministry of Education and Merit and in partnership with public and private regional educational institutions, organizes the *Mathematical Olympiads*, thus providing hundreds of students throughout the country with the opportunity to experience mathematics as a creative and engaging discipline, while simultaneously recognizing its strategic importance for scientific and technological advancement.

Every year, the *UMI* announces a series of *awards* for scholars in different fields of mathematics and its applications. The prizes are co-financed by private individuals and various research institutions. Participation in the awards is numerous and promotes the enhancement of the work of young researchers.

Inclusion, equality and cooperation

Through the *Diversity, Inclusion and Equality Committee, UMI* promotes the enhancement of individual differences (gender, age, culture, abilities) to create fair work environments in the mathematical field, studying and proposing new inclusion initiatives. The recent *UMI International Cooperation Group with the Global South* supports international cooperation projects in numerous countries in Africa, South America and the Middle East.

Prof. Marco Andreatta

President of the *Unione Matematica Italiana*

Context, objectives, and scope of the Study

In the field of Mathematical Research, Italy boasts a long and prestigious tradition that grants it considerable international standing. Between 1800 and 1900, Italian schools of mathematical analysis, geometry, and probability were instrumental in the nation's formation and its initial substantial economic development, thereby establishing it among the world's leading powers. It is worth mentioning, for example, the role that Mathematical Research has played, as well as in providing a basis and development for University Research, in the foundation of the Polytechnic Engineering Schools[11], the Scuola Normale Superiore, the many Research Institutes, public such as the *CNR*, *INDAM*, *ISTAT*, or private such as Olivetti, the Fiat Research Centre, etc.

The landscape of national Mathematical Research is characterized by substantial vitality, with an extensive presence across university venues and public and private research institutions, encompassing numerous internationally recognized centres of excellence.

In contemporary society, marked by constant and pervasive data generation and dissemination, mathematics assumes strategic significance: it represents the instrument that enables the transformation of numerical data into knowledge, namely into concepts that permit the derivation of conclusions from empirical phenomena. Through the fundamental pillars of data analysis, mathematical modelling, numerical simulations, and statistics, you can identify hidden relationships, anticipate trends, and support informed decisions. Statistics make it possible to estimate trends, quantify uncertainty and validate hypotheses; mathematical modelling makes it possible to construct simplified representations of reality (deterministic, stochastic or dynamic models), which make complex phenomena understandable and manipulable; data analysis (data *analytics, machine learning, visualization*) facilitates the extraction of significant information from even very large databases, allowing the recognition of patterns and regularities that are not immediately visible.

The present Study could only be conducted through the application of mathematical models.

Despite all this, there is often a lack of full awareness of the importance and impact of Mathematical Research for the production system and the economy of the country. In the current context, of growing importance of the role of scientific and technological research as a driver of economic and social development, it is essential to understand and quantify the specific contribution of scientific disciplines within the national economic system. In particular**,** Mathematical Research represents a **strategic area for innovation, competitiveness and value creation**, thanks to its **ability to provide models, tools and methodologies applicable to multiple production sectors**.

The present Study thus constitutes an integral component of this scenario, with the objective of delineating a comprehensive and rigorous analysis of the contribution that Mathematical Research provides to the Italian economy..

In the meaning that has been adopted for this analysis, research in the mathematical domain refers essentially to **advanced Mathematical Research**, **undertaken by academic institutions, research centres, enterprises, private actors, and governmental bodies, which serves to enhance the accumulated corpus of mathematical knowledge**. Among the main disciplinary areas that it is considered appropriate to recall are analysis, algebra, geometry, number theory, mathematical physics, numerical analysis, probability theory, data analysis, operations research, and, in general, mathematics applied in different economic, financial, social, biological, medical contexts, etc.

The **primary purpose** of the **Study** is to **provide** a **quantification** of the **economic impact** attributable to **Mathematical Research** thus defined, both in terms of **employment supported** in the different professions in which Mathematical Research plays an important role, and in terms of **Gross Value Added generated by these professions** for the Italian economy.

In particular, the Study considers the different ways in which Mathematical Research influences economic performance in Italy and **quantifies** its **economic and social contribution** in **2025**. The approach adopted was therefore aimed at the preliminary identification of the professions that can be classified as users of the applications of Mathematical Research. Subsequently, the intensity of this use was quantified and, finally, the distribution of the professions identified in the

[11] The Polytechnic University of Milan was founded in 1863: https://www.polimi.it/il-politecnico/il-politecnico-nella-storia; The Polytechnic University of Turin was founded in 1859: https://www.polito.it/ateneo/chi-siamo; The Scuola Normale Superiore in 1810: https://www.sns.it/it/la-storia; The *CNR* was founded in 1923: https://centenario.cnr.it/cento-anni-di-storia/; *ISTAT* was founded in 1926: https://www.istat.it/attivita-e-servizi-per-tipo-di-utenti/giornalisti/storia/; Olivetti was founded in 1908: https://www.treccani.it/enciclopedia/l-avventura-olivetti_(The-Italian-Contribution-to-the-History-of-Thought:-Technique)/; The Fiat Research Centre was founded in 1978.

various sectors of the Italian economy was analysed. This information related to direct employment was used in an impact estimation model, in order to estimate the GVA generated for the economy. The estimates provided by this study therefore represent an important step in the process of evaluating the impact of Mathematical Research in Italy.

In this context, although there is a growing interest in the disciplines in Mathematical Sciences and STEM, as evidenced by the significant expansion over the last few years of graduates in this field, the demand for quantitative professions in the European Union is growing faster than the supply of qualified workers[12]. This Study thus aims to serve as an instrument that facilitates the analysis and advancement of the importance of Mathematical Research as a catalyst for the growth and reinforcement of the national productive system.

The applications of Mathematical Research and the possible benefits for the country's economy

As Keith J. Devlin observes in his book *The Language of Mathematics: Making the Invisible Visible*, mathematics is the main tool through which it is possible to identify and understand the structures and relationships underlying observable reality. Devlin points out that mathematics is not limited to simple numerical calculation but offers the conceptual tools to detect and describe situations present in everyday life[13]. A complementary perspective is proposed by Ian Stewart in *In Pursuit of the Unknown: 17 Equations That Changed the World*, which shows how mathematics is not only descriptive, but also creative: each fundamental equation represents a new way of observing the world, organizing experience and formulating predictions. According to Stewart, mathematics is not limited to representing phenomena but provides the conceptual lenses to interpret and understand them more deeply[14]. It is precisely this ability, to extract meaning from data and to transform complexity into comprehension, which forms the core of contemporary mathematical expertise.

The role of mathematics in culture, scientific development and applications is well outlined in the words of many Italian mathematicians, who have had a strong influence on scientific thought over the last 50 years. Gian Carlo Rota (Steel Prize) considered, for example*, "mathematics the great achievement of the human intellect, [...] a central discipline in culture, capable of connecting abstract thinking and practical applications, especially in computer science".* Furthermore, in a seemingly paradoxical manner, he contended with well-grounded arguments that "*the ideal of all science is to become mathematics. The ideal of physical laws is to become mathematical theorems!"*. Enrico Bombieri (winner of the Fields Medal in 1974) and Ennio De Giorgi (winner of the Wolf Prize for mathematics in 1990) considered mathematics not an isolated knowledge, but a means to foster dialogue and understanding between different people and cultures, overcoming the ethics of tolerance for that of sharing. For this reason, De Giorgi often used the phrase *"the sapiential value of mathematics"*. Bombieri, for his part, highlights that *"the immense power of mathematical abstraction and its remarkable capacity for synthesis: highly disparate objects that appear to share no common features can become remarkably similar when examined from a mathematical perspective"*.

The importance of mathematics is also evident in the educational and civic sphere, since this competence is today recognized as a form of literacy, which is to say, as fundamental literacy for living in society. The OECD, in the *PISA 2021 Mathematics Framework*, defines *mathematical literacy* as "*the ability to formulate, use and interpret mathematics in a variety of contexts to describe, explain and predict phenomena*". This definition extends the value of mathematics beyond the academic sphere, posing it as a set of skills that enable individuals to critically analyse numerical information, evaluate patterns, and make informed decisions in economic, scientific, and social spheres. In this way, mathematics education makes it possible to create a connection between the formal language of numbers and the everyday reality of choices. In other words, mathematics allows us to move from data to meaning, from phenomenon to model, from observation to understanding, offering a rational key to understanding the context in which we live.

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[12] Cedefop. (2023). Skills in Transition: The Way to 2035.
[13] Devlin, K. (2000). The language of mathematics: Making the invisible visible. Macmillan.
[14] Stewart, I. (2012). In pursuit of the unknown: 17 equations that changed the world. Basic Books.

Mathematics also plays a fundamental role and has a significant impact on the Italian economy and society. Mathematics represents, for example, a means of **protecting and improving society's living standards**, a method for **managing uncertainty**, **predicting scenarios** and **optimising processes**, in particular **industrial** and **organisational processes**, and finally the **driving force** behind recent **technological** innovation and **development of artificial intelligence**.

What follows are qualitative considerations concerning the manner in which mathematical research and application contribute concretely to economic growth, to the sustainability of systems, and to the technological evolution of the nation, thereby highlighting their strategic significance in both understanding and transforming contemporary reality.

Using mathematics to protect and improve society's living standards

Mathematics plays a fundamental role in safeguarding Italian society, understood as improving the levels of quality standards, allowing the analysis and management of complex phenomena that affect health, the economy and the environment. Its applications range from the fight against health emergencies to the prevention of digital fraud, up to the protection of the territory and infrastructures.

Consider, for example, that during the Covid-19 pandemic, Italian researchers developed the SIDARTHE mathematical model, capable of simulating the spread of the virus, distinguishing between asymptomatic, symptomatic and diagnosed subjects. This approach made it possible to assess the impact of containment measures in advance and improve the management of the health emergency[15].

Mathematics is equally crucial to financial security: in the period 2022-2024 alone, Italy experienced the theft of nearly 560 million euros through cybercrime and online fraud[16]. Banks responded accordingly by investing more than 2 billion euros in mathematical analysis systems and predictive algorithms between 2020 and 2024 to detect suspicious transactions and prevent fraudulent behaviour[17].

A particularly relevant area is then that of environmental risk management, infrastructure protection and ecological protection, where mathematical models and numerical simulations are used to estimate the probability of disasters and preserve the territory[18].

Mathematics thus represents a strategic element of protection for society, as it enables the modelling of complex phenomena and supports decisions based on objective data. Through predictive models and quantitative analysis, it contributes to anticipating epidemics, preventing fraud, mitigating environmental risks, and strengthening infrastructure resilience, thereby making the national system safer and more sustainable.

[15] Giordano, G., Blanchini, F., Bruno, R., Colaneri, P., Di Filippo, A., Di Matteo, A., & Colaneri, M. (2020). Modelling the COVID-19 epidemic and implementation of population-wide interventions in Italy. Nature medicine, 26(6), 855-860.
[16] Autonomous Federation of Italian Banks. 2025: https://www.fabi.it/2025/03/22/oltre-mezzo-miliardo-rubato-dai-ladri-digitali-in-tre-anni-frodi-informatiche-e-online-aumentate-del-30-nel-2024/.
[17] Italian Banking Association, 2025: https://www.abi.it/abi-si-consolida-lutilizzo-dei-canali-digitali-per-le-operazioni-bancarie/.
[18] Guerriero, L., Ruzza, G., Calcaterra, D., Di Martire, D., Guadagno, F. M., & Revellino, P. (2020). Modelling prospective flood hazard in a changing climate, Benevento Province, Southern Italy. Water, 12(9), 2405.

The role of mathematics in industrial process management

Mathematics has progressively strengthened its role as an enabling factor in scientific and industrial innovation, as it is able to provide flexible and highly reliable techniques. In manufacturing, for example, mathematics is an integral part of the environment, in the optimization and monitoring of structures, artifacts and industrial processes, in design simulations, in prototype design, in project optimization, in production and inventory planning and in the management of supply chains. Some of the most widely used applications are listed below.

Multidisciplinary Design Optimization (MDO) provides analytical and computational procedures and tools to coordinate the efforts of design teams from different disciplines. Simulation-based design of complex systems in aerospace and automotive systems, for example, relies on computational and numerical analyses supported by automated simulations. Production planning programs are designed to ensure efficient utilization of productive factors in order to meet demand. To this end, the flexibility of production resources must be taken into account, as well as the stochastic nature of supply and demand within the supply chain. The improvement of decision-making models and algorithms is essential in sectors based on a complex mix of production and supply chains and in which it is necessary to take into account the design and launch times of new products, as well as the evolution of plants. When addressing supply chains, it is imperative to mention logistics and the mathematical models that underpin the handling of cargo within warehouses and across intermodal hubs.

Consider, moreover, the significance of utilizing molecular dynamics in the substitution of petroleum-derived products with sustainable materials, as it enables molecular-level simulation of the properties of novel chemical substances, proving essential for research on surfactants and polymers directed toward the development of compounds with targeted properties[19].

In this context, *Sportello Matematico per l'Innovazione e le Imprese* was introduced, operating since 2012 at the *Istituto per le Applicazioni del Calcolo* of the *CNR*. *Sportello Matematico per l'Innovazione e le Imprese* has set itself the goal of ensuring that mathematics has an increasingly profound influence on the country's production activities, since the collaboration between mathematics and industry tends to be, in Italy, not very systematic, due to a series of factors, such as:

- the industrial ecosystem is characterized by small companies, which, for financial and organizational reasons, tend to invest less in research.
- the limited propensity for Research and Development investment which, as anticipated, in terms of percentage of GDP, is lower in Italy compared to countries such as Germany, France, and Spain.

Sportello Matematico per l'Innovazione e le Imprese has in fact aimed to create connections between research groups in applied mathematics and companies[20].

The role of mathematics in recent technological innovation and AI

Artificial intelligence (AI) is exerting an increasingly decisive influence on the transformation of economic and production systems, affecting investment choices, the organisation of industrial supply chains and the functioning of public services, including health, education and justice. On a global scale, AI is also a driver of change in geopolitical and energy dynamics, also due to the high consumption of the data centres necessary for its operation.

Among the challenges that Mathematical Research is facing today are the creation, use and management of algorithms and procedures called to support the theoretical basis of the activities that are introduced under the name of AI. The importance of Mathematical Research, to make the products developed reliable and useful, to measure and manage their degree of entropy (a term used by the mathematician Terence Tao) and to manage their impact, is one of the main factors of economic development, as some large nations, including China, have intuited.

In the Italian setting, the economic impact of AI is on an upward trajectory. According to *Censis-Confcooperative*, AI could contribute to an increase in national GDP of 1.8% by 2035, equal to about 38 billion euros[21]. An *ISTAT* survey shows that in 2025, 16.4% of companies with at least 10 employees use at least one Artificial Intelligence technology, marking a significant increase compared to 8.2% in 2024 and 5.0% in 2023. Larger companies recorded a more marked growth in

[19] Society for Industrial and Applied Mathematics (2012). Mathematics in Industry https://www.siam.org/publications/reports/mathematics-in-industry/
[20] Natalini, R., & Sgalambro, A. (2015). Mathematics that makes a network: the Mathematical Hub for Italian Industry. *Mathematical Letter Pristem*, *93*(1), 4-9.
[21] Censis Cooperative, 2025: https://www.confcooperative.it/LInformazione/Primo-Piano/intelligenza-artificiale-e-persone-chi-servir224-chi

absolute terms from 32.5% in 2024 to 53.1%, widening the gap with SMEs, whose use has nevertheless doubled, from 7.7% to 15.7%[22]. These data highlight how AI is becoming a lever of structural competitiveness for the national production system.

In Europe, it is intended to establish a European Research Center for Artificial Intelligence in which Mathematical Research will have a fundamental role in the pursuit of reliability, efficiency, and transparency.

Within the Italian context that frames this Study, understanding the impact of Mathematical Research on technological innovation and artificial intelligence is essential not only from a scientific perspective, but also for its economic and employment implications. The integration of mathematical skills and quantitative models helps to stimulate productivity, foster business growth and create new, highly qualified professional opportunities. This evidence can also guide public policies, business strategies and training programs aimed at maximizing the benefits of mathematical-based technological innovation.

The increasing adoption of AI-related technologies by companies reflects a growing awareness of the strategic role of AI as a driver of innovation and competitiveness. Recent estimates indicate that the adoption of generative AI could lead to an increase in the country's productivity of up to a maximum of 18.2% within the next fifteen years, thus underlining the significant economic impact of this technology, if we take into account that from 1995 to 2023 Italian productivity recorded a -1%[23].

Despite this positive outlook, the uptake of AI in companies' day-to-day activities still remains limited, mainly due to the shortage of appropriate skills. This difficulty highlights the urgency of targeted investments in education and technical capacity development, which are necessary to ensure an effective employment transition and enhance the integration of human and technological skills.

Artificial Intelligence offers concrete opportunities to automate repetitive and standardisable tasks, support decision-making processes and simplify the organisation of work and production processes. However, it also entails significant challenges, including the risk of obsolescence of numerous traditional professional profiles. For this reason, it is fundamental to ensure conscious and structured management of occupational transition, in order to maximize social and economic benefits.

In this context, technological innovation is an essential lever to address the demographic and labour market criticalities that characterise Italy, helping to bridge the gap between demand and supply of skills and to support the productive growth of the national economic system.

In 2024, 31.6% of young people between 25 and 34 years old obtained a tertiary qualification, with constant growth in recent years. In parallel, the share of graduates in STEM disciplines rose to 18 per 1,000 residents aged 20-29, signalling a strengthening of mathematical and scientific skills in the education system. Basic digital skills are possessed by 45.9% of the population aged 16-74, a figure lower than the European average, which stands at around 55.6% for the same age group. In addition to these, there are strong territorial, age and gender disparities, which require targeted inclusion and education policies to ensure equal access to digital and mathematical technologies.

These data suggest that strengthening mathematical and scientific skills is crucial to fuel technological innovation and to prepare a workforce capable of effectively using Artificial Intelligence, thus contributing to the country's economic growth and competitiveness[24].

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[22] *ISTAT*, 2025, The use of AI doubles in one year and involves more than half of large companies: https://www.istat.it/wp-content/uploads/2025/12/Statreport_ICT2025.pdf

[23] The European House Ambrosetti & Microsoft Italy, 2024, AI 4 Italy: from theory to practice: https://www.astrid-online.it/static/upload/2135/21351---.pdf

[24] *ISTAT*, BES Indicators – Education and Training, 2024: https://www.istat.it/wp-content/uploads/2025/11/02-Istruzione-e-formazione-1.pdf

Using mathematics to predict, address uncertainty and optimize processes

Mathematics is the language that allows us to read the complexity of reality and to give shape to the phenomena that characterize it. By means of models, functions, and quantitative analysis, mathematics transforms data into knowledge, thereby rendering visible the structures and trends that characterize the functioning of economic, social, and natural systems. In an information-dominated era, the ability to process data according to a scientific approach signifies the transition from mere observation of phenomena to their rational comprehension.

In Italy, applied mathematics constitutes a fundamental pillar for prediction, uncertainty management, and the optimization of productive, logistic, and economic processes. Forecasting is based on the use of quantitative models – deterministic, stochastic and statistical – which, through the analysis of historical data, the use of numerical methodologies and simulations, allow to estimate future scenarios and improve strategic planning. In industrial contexts, mathematical programming and operations research make it possible to model the optimal distribution of resources, the sequence of operations and the management of production capacity, helping to reduce costs and times and increase the overall efficiency of production lines[25].

Uncertainty management, on the other hand, relies on tools such as robust, stochastic optimization and Monte Carlo simulations, which allow you to assess the impact of data and parameter variability on decision-making processes. These methodologies, developed and applied also in the Italian academic and industrial fields, make it possible to develop resilient solutions and plan effective strategies in conditions of risk or incomplete information.

Finally, mathematical optimization is a central aspect in decision science, oriented towards the search for the most efficient solution with respect to cost, time or return criteria. In Italy, research institutions such as the *IAC* and several university departments deal with discrete optimization, graph theory and flow networks, with applications in transport, logistics and energy[26].

The structure of the Study

The document is structured as follows. After a description of the conceptual framework in which the impact of Mathematical Research has been studied, the methodological approach used is briefly described. The central part reports the results of the quantification of the intensity of use of Mathematical Research in the various professions and the estimate of the impact of Mathematical Research, both in terms of Gross Value Added and employment, in Italy. The next section provides some considerations regarding the interpretation of the results obtained and Mathematical Sciences as a pillar for the most advanced economies. The last two sections contain some reflections regarding the promotion and support of Mathematical Research, as an opportunity for economic growth, and the main findings of a Sentiment Analysis conducted in order to capture the social perception of mathematics. In the Appendix, further details are provided on the methodological approach adopted and on the data sources.

[25] *Sportello Matematico per l'Innovazione e le Imprese*, https://sportellomatematico.it/ambiti/manifatturiero/
[26] *Consiglio Nazionale delle Ricerche*, https://www.iac.cnr.it/ottimizzazione-matematica-discreta-e-scienza-delle-decisioni

2. The conceptual framework

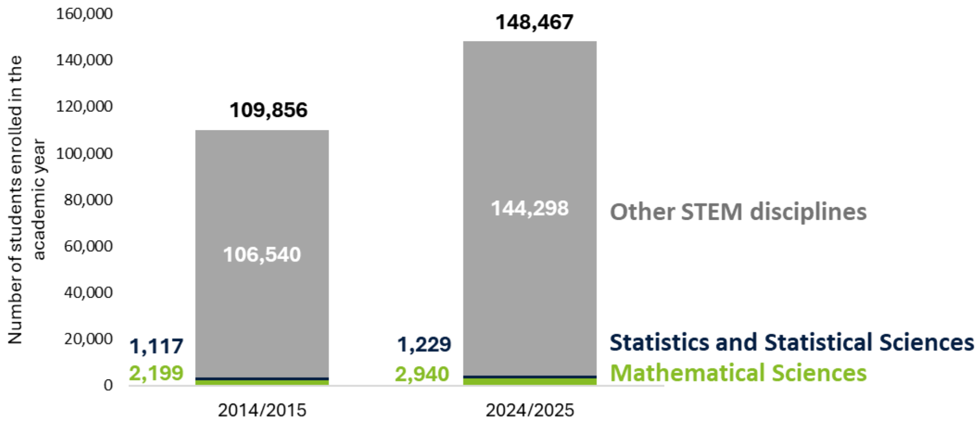
When assessing the impact of Mathematical Research in Italy, it is essential to first and foremost examine the context of mathematics education and Mathematical Research, together with the role it has played in the Country's economic development.

Education and Mathematical Research in Italy

Education

As evidence of the growing importance assumed by the Mathematical Research and, more generally, from scientific disciplines in Italy, it is useful to consider the significant increase in the last decade in the number of enrolled and graduate students and in the number of PhDs in related disciplinary fields. More specifically, the number of students enrolled in Mathematical Sciences (Figure 1) increased from 2,199 in the academic year 2014/2015 to 2,940 in the academic year 2024/2025, with an average annual growth rate (CAGR) of 2.9%, almost two percentage points higher than those enrolled in statistics and statistical sciences, equal to 1%, and just below the growth of those enrolled in other STEM disciplines, equal to 3.1%.

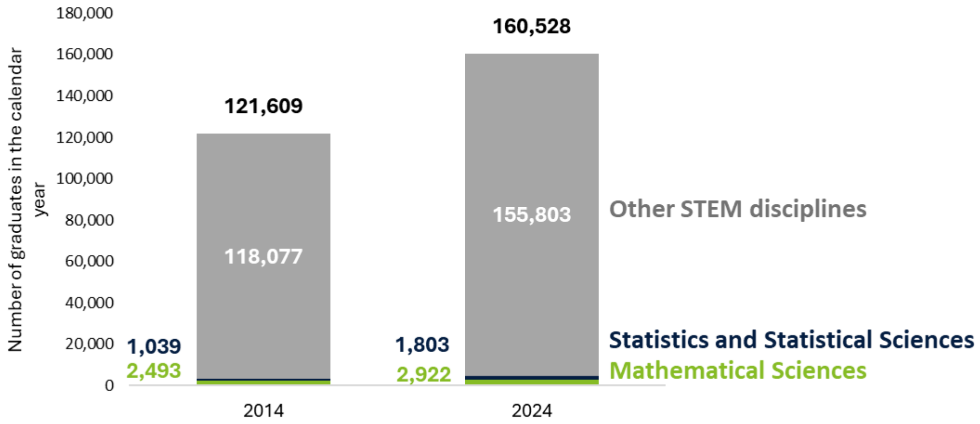
Figure 1. Students enrolled in scientific disciplines – Comparison A.Y. 2014/15-2024/25



Source: Deloitte analysis on Ministry of University and Research data, https://dati-ustat.mur.gov.it/dataset/immatricolati/resource/9bb0cf6d-1d4e-47f3-8ae9-0c665617b158

The number of graduates in mathematics and mathematical sciences (Figure 2) has increased in the last 10 years, by about 400 units, from 2,493 in 2014 to 2,922 in 2024, with a CAGR of 1.6%. However, this is the lowest growth among the considered disciplines, since the CAGR of graduates in statistics and statistical sciences was equal to 5.7% and that of graduates in other STEM disciplines was 2.8%. This phenomenon could be interpreted as resulting from the migration of enrolled students, throughout their academic pathway, from mathematics degree programs to other scientific disciplines.

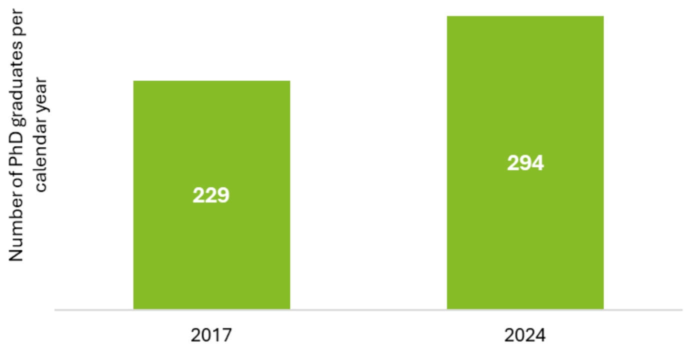
Figure 2. Graduates in scientific disciplines – Comparison 2014-2024



Source: Deloitte analysis on Ministry of University and Research data, https://dati-ustat.mur.gov.it/dataset/laureati/resource/75773630-77e4-47eb-be2b-370f9ec1296f

It is also worth taking into account the evolution of the number of graduates in doctoral courses related to mathematics (Figure 3), Mathematical Sciences and Mathematical Models, since those who obtain a doctorate in these disciplines represent the possible main actors of current and future Mathematical Research. The number of those who have obtained a doctoral degree has increased from 229 in 2017 to 294 in 2024, with an average annual growth of 3.6%: therefore, the pool of highly qualified human resources who could contribute to the further development of Mathematical Research is also increasing.

Figure 3. Graduates PhD in Mathematics, Mathematical Sciences and Mathematical Models – Comparison 2017-2024



Source: Deloitte analysis on Ministry of University and Research data, https://dati-ustat.mur.gov.it/dataset/formazione-post-laurea/resource/9ea1b410-d912-4017-a2dc-45ab0ec14911

Institutes that have conducted targeted analyses (e.g. Almalaurea) have shown that a good percentage of young researchers choose to continue their careers abroad, encouraged by higher salaries and easier living and working conditions. However, in Italy, young people with a background in mathematics find work within a year of graduation more easily than the national average (employment rate of 88.5% vs 80.1%) and with higher salaries (net monthly salary of 1,591 vs 1,487 euros)[27].

[27] Almalaurea, Employment Status of Graduates (2024): https://www2.almalaurea.it/cgi-php/universita/statistiche/tendine.php?anno=2024&LANG=it&config=occupazione

Research and scientific production

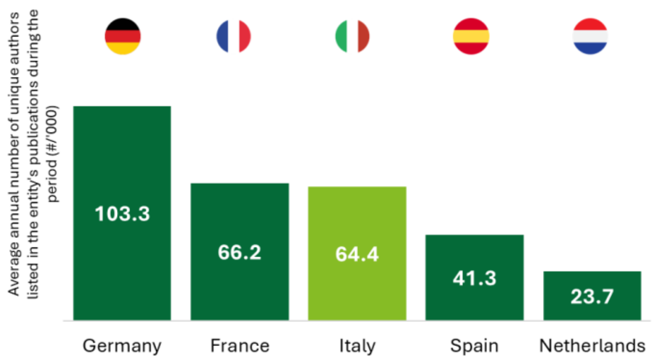
Italy generally holds a fundamental role in the research field.

Considering, on a preliminary basis, all publications, Italy, between 2020 and 2025, ranks fifth in Europe among the countries that have obtained the top 10% of citations[28] while, with regard to, specifically, publications in the scientific field, between 2018 and 2022, it emerged that disciplinary areas in which Italian publications have had the most citations have been, in order, medicine, engineering and computer sciences, as well as physical and mathematical sciences[29].

Considering more specifically the scientific productivity in the field of Mathematical Research, in Italy this proves to be among the highest and of quality in Europe, as evidenced both by various bibliometric indicators and by the percentage of Italian presence among speakers at major congresses and in international research networks. To provide a comparative analysis of research and scientific production in the field of mathematics, average data for the period 2020-2025 were examined for Italy and some comparable countries, such as Spain, France, Germany, and the Netherlands, across a series of metrics pertaining to scientific production in mathematical disciplines. From these emerges that Italy has achieved **excellent performance in scientific production in mathematical disciplines** substantially across all fronts.

The Figure 4 presents the **number of unique active authors** in the field of Mathematical Research, which provides a measure of the size of the community of active researchers in a given country. Italy occupies the third position, with over 64,000 active authors, attesting to a substantial scientific community, though numerically smaller than its German and French counterparts, which comprise, respectively, 103,000 and 66,000 active authors on average throughout the period.

Figure 4. Number of unique authors active in mathematical disciplines (2020-2025, thousands)



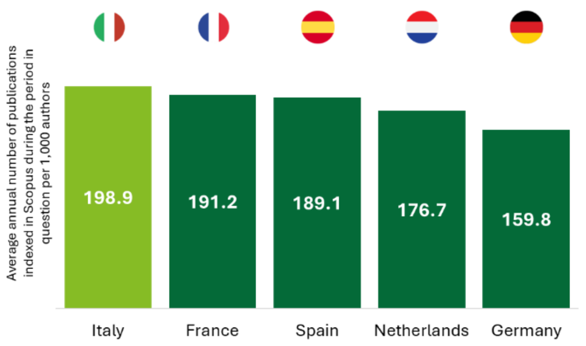
Source: Deloitte analysis on Scopus/SciVal data

Scientific production and productivity in Italy were also analysed, considering the **number of publications and citations** in mathematical disciplines produced by each country in the five-year period under review (Figure 5). Considering the size of the active scientific community, in Italy there are just under 200 publications per thousand authors (198.9 per thousand), a value that is higher than all the other countries considered. This figure suggests a higher level of efficiency in individual scientific production on average than in the main European countries analysed. A very similar performance is also obtained by analysing the number of citations received by Italian researchers. Italy ranks second among the countries analysed, with just under 89 thousand average annual citations and 1,400 citations per 1,000 active authors.

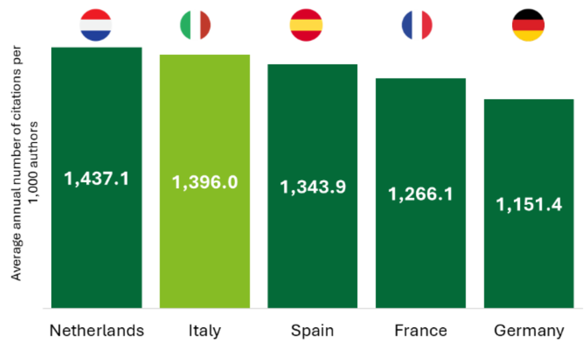
[28] Welsh H., 2025, Italy Country Report: ERA-LEARN country report, p. 13, https://www.era-learn.eu/documents/country-report-italy-may2025.pdf
[29] Ciriminna, R., Della Pina, C., & Pagliaro, M. (2025). Italy's excellence in research. *Heliyon*, *11*(1).

Figure 5. Publications and citations in mathematical disciplines

Average annual number of publications per 1,000 active unique authors (2020-2025, thousands)



Average annual number of citations per 1,000 active unique authors (2020-2025)

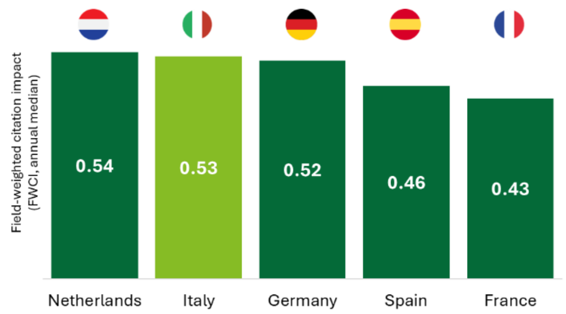


Source: Deloitte analysis on Scopus/SciVal data

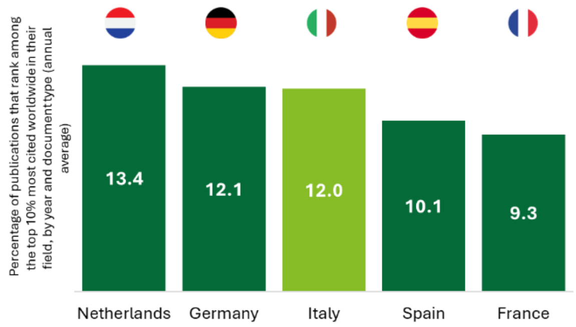
Also, with regard to the **quality of publications in mathematical disciplines** (Figure 6), Italian researchers show an excellent performance. If we consider the Field-Weighted Citation Impact Index, i.e. the index calculated as the ratio between the number of citations actually received by a single publication and the average number of citations received by publications of the same type and reference year, it can be seen that Italy, after the Netherlands, is the nation with the highest median among those considered (0.53 vs 0.54).

Figure 6. Quality of Publications in mathematics

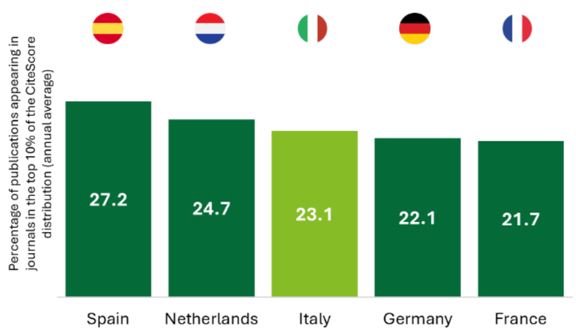
Field-Weighted Citation Impact (median, 2020-2025)



Outputs in Top Citation Percentiles (top 10%, field-weighted, 2020-2025)



Percentage of journal publications in the top 10% of the CiteScore distribution (top 10% by CiteScore Percentile, 2020-2025)



Source: Deloitte analysis on Scopus/SciVal data

Other indices also confirm the quality of national scientific production. For example, if we compare the percentage of publications in the top 10% of the most cited citations worldwide, Italy ranks third after the Netherlands and Germany. Even if we look at the percentage of publications in journals placed in the top 10% of the Citescore (a bibliometric indicator that measures the relative positioning of a scientific journal compared to other journals belonging to the same disciplinary category), Italy ranks third after Spain and the Netherlands.

The role of mathematics in the economic development of the country

Research in Mathematical Sciences represents a fundamental element of the Italian scientific and technological ecosystem, with significant implications for the country's economic competitiveness. In the Italian context, the Mathematical Research infrastructure is characterized by research institutions of international importance (such as, for example, *Consiglio Nazionale delle Ricerche*, *Istituto Italiano di Tecnologia*, *Istituto Nazionale di Alta Matematica*, Departments of Mathematics and the research centres of the main Italian universities) and by a consolidated legacy of scientific contributions as confirmed by comparisons with other countries in terms of scientific production.

This positioning reflects the ability of the Italian system to generate research with a high scientific impact, with potential significant repercussions on the country's economic growth and competitiveness. In the Italian context, research in Mathematical Sciences operates as a transversal enabling factor: from infrastructure (information technologies, computer security, energy) to productivity drivers (product and process innovation, qualified human capital, entrepreneurial capacity and investments). For example, developments in mathematical modelling and data analytics support process innovation in tech-intensive industries, while advances in cryptography and cybersecurity strengthen the country's digital infrastructure.

The generation and application of research in Mathematical Sciences has the potential to have a positive impact on multiple dimensions of the Italian economy.

Below is a conceptual framework aimed at helping in the understanding of how Mathematical Research integrates into the processes of long-term economic growth and the related possible impact mechanisms.

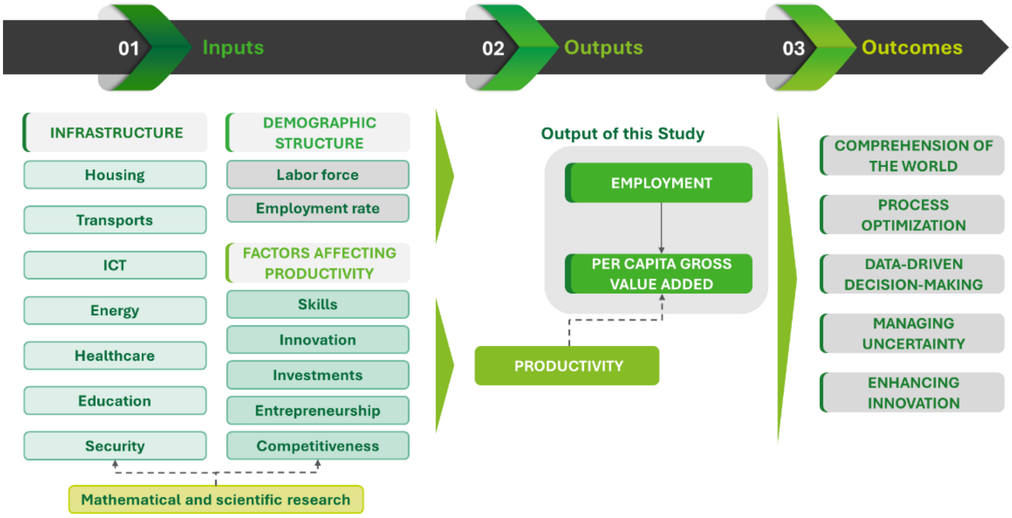
In general, in the long run, Italy's economic output - represented by the number of supported employees and the Gross Value Added produced - depends on the functioning of a hierarchical structure articulated on three sequential levels:

- Level 1 - Economic inputs (infrastructure, productivity, and demographic factors) in turn driven by the following enabling factors:
  - Infrastructure: housing, transport, ICT, energy, health, education, security.
  - Productivity: skills, innovation, capital investment, entrepreneurial activity, competition.
  - Demographic factors: active population, employment rate.
- Level 2 - Economic outputs (employment and Gross Value Added per capita).
- Level 3 - Outcomes in the ecosystem (e.g., understanding the world, optimizing processes, decision support, managing uncertainty, supporting innovation).

The picture provided in the Figure 7 illustrates the main determinants of long-term economic growth. Considering the supply side, economic output is a function of two fundamental elements: the number of people employed and the Gross Value Added. However, the Gross Value Added produced by individual workers is a function of productivity, which depends on factors such as skills, product and process innovation, level of investment in capital and R&D, entrepreneurial dynamism and degree of competition in the markets.

The infrastructure of the Italian economy, understood as the sectors in which workers are engaged, in turn influences the outputs considered, as these sectors are characterized by different levels of skills, investments, etc. and therefore by different levels of productivity. Shortages in these areas can constitute supply constraints, limiting both the expansion of the working population (e.g. due to insufficient housing availability or inadequate services) and productivity growth (e.g. due to shortcomings in digital connectivity or inefficiencies in transport). On the contrary, strengthening these enabling factors, inherent in the country's infrastructure, can support employment and productivity, generating economic growth and greater prosperity.

Figure 7. Long-term economic impact of Mathematical Research in Italy



Source: Deloitte

Mathematical Research thus integrates into the value and employment generation model outlined above, by promoting conditions necessary for the systematic improvement of inputs and, consequently, outputs and outcomes. Specifically, as shown by the Figure 8, it is possible to identify four sequential stages in which Mathematical Research is able to generate an impact.

- In the first stage, the generation of scientific research produces outputs such as the development of new scientific knowledge, the development of innovative methodologies and the refinement of established techniques.
- In the second stage, the enhancement of research outputs translates the results of the previous point into practical and commercial applications: the enhancement of human capital and specialized skills, the development of patents and commercial solutions, innovation in production processes and product development, the optimization of strategic decision-making processes, and the development of algorithms for operational efficiency.
- The implementation of the interventions referred to in the previous point gives rise to the strengthening of the economic ecosystem, which takes the form of the strengthening of technological and ICT infrastructures, the strengthening of education and training systems, the improvement of health services and public health, the optimization of energy and resource management, the increase in professional and technical skills, and the stimulation of innovation and applied research.
- In the fourth stage, we can witness the creation of economic and social value, which manifests itself in measurable and sustainable results: growth in qualified employment, increase in systemic productivity, increase in Gross Value Added, improvement of overall economic and social well-being and promotion of environmental sustainability and sustainable development.

In the Italian setting, this mechanism of impact is already operative in multiple strategic sectors. In 2023, Italy invested a total of 29.4 EUR/bn in R&D (1.37% of GDP), an increase of 7.7% compared to the previous year. The sectors with the highest investments in R&D were the production of motor vehicles, machinery and other means of transport, which together account for 38.4% of total expenditure, followed by electronics, scientific research, information technology and pharmaceuticals, each with a share of more than 5%[30]. These sectors represent the main channels through which Mathematical Research generates economic value in the Italian economic system.

[30] Prometeia, 2025, Research and Development: it moves, yet Italy lags behind: https://www.prometeia.com/en/about-us/insights/article/ricerca-e-sviluppo-eppur-si-muove-ma-litalia-resta-indietro-30435643

Mathematical Research also enables cross-disciplinary innovation: advanced mathematical methodologies are exploited by disciplines such as engineering, physics, biology and social sciences, to develop new products and services, promote specialized skills, increase operational efficiency and generate economic growth. Italy, with its well-established tradition of excellence in Mathematical and Scientific Research, is well positioned to capitalize on these competitive advantages and to amplify the economic impact of Mathematical Research in the coming years.

Figure 8. Economic impact chain of Mathematical Research

1

Production of scientific research

- Development of new scientific knowledge
- Development of innovative methodologies
- Refinement of established techniques

2

Leveraging research outputs

- Strengthening human capital and specialized expertise
- Developing patents and commercial solutions
- Innovation in production processes and product development
- Optimizing strategic decision-making processes
- Developing algorithms for operational efficiency

3

Strengthening the economic ecosystem

- Upgrading of technological and ICT infrastructure
- Strengthening education and training systems
- Improving healthcare services and public health
- Optimization of energy and resource management
- Enhancement of professional and technical skills
- Promoting innovation and applied research

4

Creating economic and social value

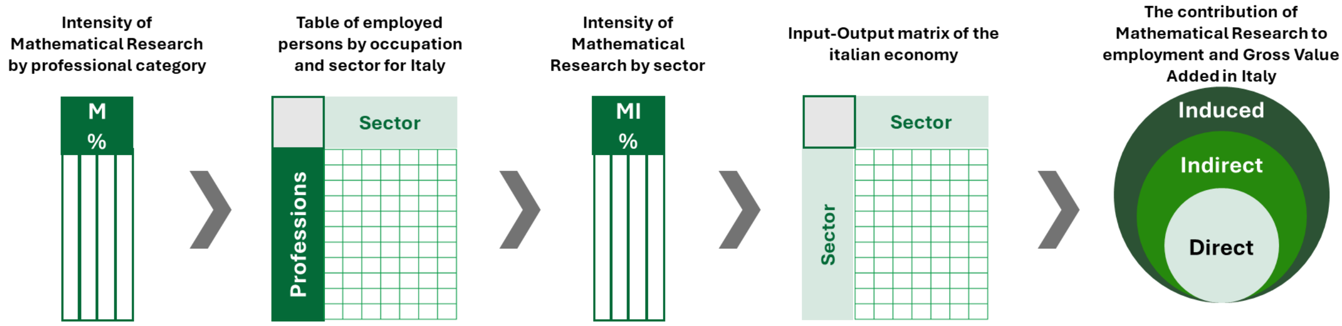
- Growth in skilled employment
- Increase in overall productivity
- Increase in Gross Value Added
- Improvement in overall economic and social wealth
- Promoting environmental sustainability and sustainable development

Source: Deloitte

3. Methodological approach

The methodological approach employed to quantify the impact of Mathematical Research on the Italian economy can be represented through the consecutive phases outlined below (Figure 9) and subsequently described.

Figure 9. Overview of the methodology



Source: Deloitte

The intensity of the use of Mathematical Research in economic activities

The perimeter of the professions and the intensity of the use of Mathematical Research

First, the scope of professions that make use of Mathematical Research was defined and a quantification was provided of the extent to which they use it (intensity of Mathematical Research use per occupation). In particular, the professions in which Mathematical Research, as defined above, exerts a significant influence have been identified, i.e. those attributable to the field of application and use of Mathematical Research and its results. The intensity of use of Mathematical Research on the various economic sectors in which the professions within the scope operate was then estimated. In particular, the intensity of Mathematical Research utilization across different professions was determined through a scoring process assigned to professions with the support and validation from recognized experts of the Italian scientific and mathematical community[31]. This attribution was further corroborated by a quantitative analysis, based on the distribution of workers by qualification, especially to degree classes, within the various professional profiles, thus ensuring an objective and replicable approach.

[31] The definition of the perimeter of the professional categories and the intensity of Mathematical Research was carried out in close collaboration with experts belonging to the *CNR*, the *UMI* and the Italian mathematical scientific community.

The intensity of Mathematical Research in industrial sectors

Subsequently, the intensity of the use of Mathematical Research in each industry sector was calculated.

To this end, using LFS data and data on employment by sector, both provided by *ISTAT*, a matrix "occupations by sectors" was developed that would establish the relationship between the distribution of diverse professions across all economic sectors, thereby enabling the quantification of Mathematical Research intensity across various sectors. Based on the "occupations by sectors" matrix, for each profession, the incidence in terms of employment on the various economic sectors was then calculated. To refine this estimate, based simply on the number of employees, the incidence was obtained by weighting the number of employees by the median income of the reference professional category, used as a proxy for the productivity of the different professions in each sector. Finally, this made it possible to obtain an estimate of the intensity of the use of Mathematical Research on the activity carried out in each economic sector. For further details, please refer to the Appendix (A.1.1 and A.1.2).

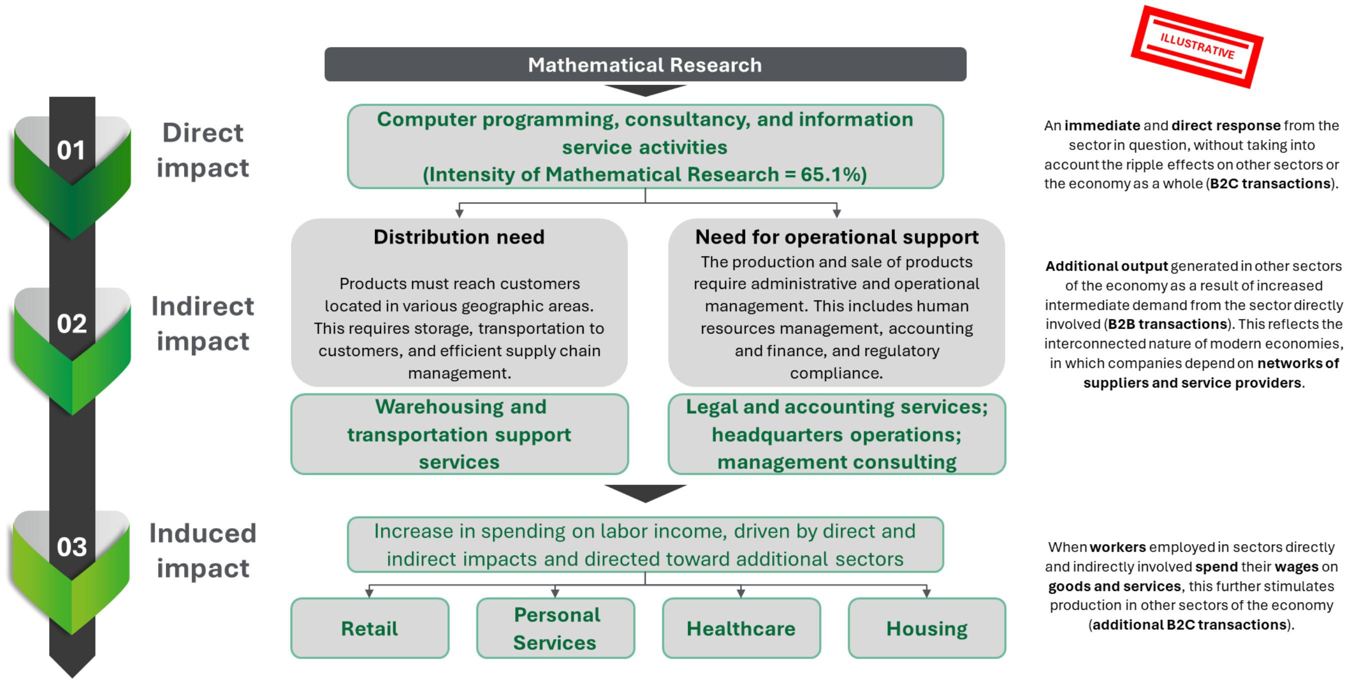
Estimating the economic impact of Mathematical Research

In order to assess the economic impact of Mathematical Research in Italy, we then proceeded to estimate the economic contribution (Gross Value Added generated) and employment (supported employment) of Mathematical Research in terms of impact, direct, indirect and induced, through the application **of Leontief's Input-Output model**[32], based on the symmetrical Input-Output tables, relating to the Italian economy, provided by *ISTAT*. TheI-O model is a linear economic model with fixed prices, which describes the technical relationships between the productive sectors of an economy, represented by fixed technical coefficients. It shows how the output of one sector depends on inputs from other sectors, acquired to generate a unit of output. The model allows you to calculate how exogenous changes in the final demand of a sector affect the total output of the economy, including direct, indirect and induced effects. The solution of the model is based on the construction of the inverse Leontief matrix, which incorporates all sectoral interdependencies. For further details, please refer to Appendix (A.1.3).

In the Figure 10 a representation is provided, by way of example, of the propagation of the impacts of Mathematical Research starting from one of the sectors with the highest intensity, i.e. programming, computer science consulting and related activities, which has an intensity of use of Mathematical Research equal to about 65%. A sector of this type, due to the impact it receives directly from Mathematical Research, can activate, indirectly, other sectors, which constitute its suppliers, as well as service providers. The illustration indicates, by way of example (and not exhaustively), the sector of warehousing and transport support activities and the sector of legal and accounting activities: the first could be activated due to the need to store and distribute the products deriving from the concrete application of Mathematical Research, while the second could be activated due to the need for administrative support, legal and accounting services, in the performance of operational activities. Both these sectors have a lower intensity of use of Mathematical Research than the computer programming and consulting sector and equal to, respectively, 16% and 29%, but, despite this, they are recipients of the expenditure of the directly impacted sector and, therefore, are also configured as channels of (indirect) impact of Mathematical Research.

[32] Leontief, W. (Ed.,). 1986. Input-output economics. Oxford University Press.

Figure 10. Illustrative example of the different impact channels (sector: Computer programming, consultancy, and information service activities)



Source: Deloitte

The increase in the incomes of those who work in the sectors directly and indirectly involved, deriving from the direct application of Mathematical Research, in the programming sector, and from the expenditure incurred to have services necessary for the performance of their activities, in the sectors of transport and legal and accounting activities, determines the activation of income expenditure in other sectors in which workers can meet their daily needs, such as retail, healthcare, etc. The induced impact is therefore provided by these sectors, activated through spending on additional B2C transactions. Similarly, the sectors activated by induced effects tend to have a lower intensity of use of Mathematical Research than the directly impacted sector that has been taken into consideration.

In the methodological approach used, the impacts were estimated using **three main metrics**, represented by the contribution to the economy, employment and tax revenue:

- **Economic contribution**: measured as a contribution to the sum of the increases in the Gross Value Added of all the companies that benefit from Mathematical Research. The sum of the Gross Value Added (which measures the value generated by the factors of production of a firm) on all firms can in fact be considered as the most appropriate measure of the economic contribution to the Gross Domestic Product (GDP). Specifically, GDP at market prices on the supply side is obtained by adding the GVA to the base prices of all production sectors and adding taxes on products net of production subsidies.
- **Supported employment**: measured in terms of the number of full-time equivalent (FTE) employees.
- **Contribution to tax revenue**: includes VAT, employer and employee social security contributions, personal income taxes and corporate income taxes.

Limitations of the Study

Although based on **standard techniques consolidated in the economic literature**, this approach has some limitations:

- The intensities of use of Mathematical Research by occupation have been estimated on the basis of assumptions concerning limited data and may not accurately reflect reality, being overestimated or underestimated.
- In the calculation of the direct effects on employment, workers without a university degree or equivalent were excluded, potentially leading to an underestimation of the impact.
- Economic benefits from the widespread use of products and technologies based on advanced mathematical algorithms, such as the internet and mobile phones, have not been estimated, implying an overall underestimation of the contribution of mathematics to society.

4. The economic impact of Mathematical Research in Italy

As described above, Italian employees who use Mathematical Research contribute to the Italian economy essentially in three ways:

- Firstly, these jobs enable the people employed within them to earn an income. This is called **direct effect**.
- Secondly, the sectors, in which these people work, procure goods and services from other sectors, which, in turn, procure goods and services from other sectors, and so on. The impact of these purchases is referred to as an **indirect effect**.
- Finally, there is the impact of the increase in household spending, deriving from the direct and indirect effects in the sectors affected by Mathematical Research. This is called the **induced effect**.

This section aims to quantify the overall impact of Mathematical Research, both in terms of Gross Value Added generated and supported employment[33] which, as anticipated, was quantified through the application of the Input-Output method.

The following paragraph presents the overall impacts and the distinction between indirect and induced impact for the main sectors. Further details on the methodology applied have been provided in the Appendix.

The intensity of Mathematical Research in the sectors of the Italian economy

The applications of Mathematical Research described above imply the use of Mathematical Research by a variety of professional practitioners.

Starting from the academic sphere, but increasingly also in the extra-academic domain, the figure of the applied mathematician, i.e. connected to the technological and productive fabric, is expanding and strengthening. The pervasiveness and strength of Mathematical Research in many productive activities makes it increasingly necessary. Every activity that uses science and technology makes use of Mathematical Research; among these, the following can be noted, by way of example:

- financial activities and, more generally, economic and social planning;
- engineering and the study of the environment; the problem of climate change is understandable and can only be addressed with rigorous mathematical models, both local and global;
- modelling in life sciences; from the sequencing and reading of the genome, to the monitoring of the spread of epidemics, to the evaluation of the effects of pharmacological treatments, to the models of human internal organs;
- computer security, cryptography and telecommunications science;
- image recognition, their interpretation, and their generation, both within the scientific domain and in the more broadly social sphere;
- the design of means of transport, on land, in water and in the air; in general, the creation of sophisticated industrial machines.

[33] Employment is measured in terms of the number of full-time equivalent (FTE) employees of annual duration.

As previously noted, Mathematical Research does not evade the demands of the technological and productive sector and, in Italy as well, opens research avenues connected to and informed by such demands, thereby creating highly innovative and versatile mathematics professionals. These figures support economic and social growth by providing the following actions:

- deep understanding of the underlying mechanisms;
- improvement of decision-making capacity;
- stimulation of innovation and the creation of spin-offs;
- opening up new and broader scenarios;
- increased efficiency.

For the purposes of this Study, the LFS data provided by *ISTAT* were used to concretely define the number of workers who make use of Mathematical Research. Starting from over 800 professional categories[34], the intensity of use of Mathematical Research has been estimated as described above in the methodological section.

Of the approximately 24 million individuals comprising the labor force in Italy in 2025, approximately 8.4 million utilize Mathematical Research to varying degrees, representing approximately 35% of the total workforce.

Just to give examples of what emerged from the data, think of software analysts and designers, technical-health professions, insurance agents, technicians in the engineering field, etc., which are mathematically intensive professions. On the other hand, there are professions characterized by a lower intensity of use of Mathematical Research, such as, for example, restorers and specialists in the conservation of cultural heritage, pharmacists, distribution and marketing technicians.

Figure 11. Top 25 sectors by intensity of use of Mathematical Research (2025)

Source: Deloitte analysis on Eurostat and *ISTAT* data.

The workers were grouped by sector, taking a total of 64 sectors as a reference. By considering the intensity of use of Mathematical Research on individual professions, it was possible to estimate the "overall" intensity of use in the different sectors. Figure 11 provides a representation of the 25 sectors that proved to be those with the highest intensity of Mathematical Research utilization. The main sectors in terms of intensity are architecture and engineering studies (72%), programming, IT consulting and related activities (65%) and scientific research and development (53%).

[34] Professions provided for by the CP 2011 and CP 2021 classification.

The direct impact of Mathematical Research

The direct impact of Mathematical Research on employment

In terms of supported employment, as described above, the impact of Mathematical Research has been estimated considering the sectors of the Italian economy characterized by the use, albeit partial, of applications of Mathematical Research, and considering that the intensity of use assumes different values depending on the sectors considered. Figure 12 presents an overview of the leading 25 sectors in terms of direct employment supported. In terms of share of the total number of directly supported employees, more than 70% is included in the sectors of technical and professional activities, industry and Research and Development: these are, after all, the sectors with a higher concentration of technical skills and which require the greatest use of applications of Mathematical Research. Details of the supported employees in all economic sectors are provided in the Appendix.

Figure 12. Top 25 sectors by contribution in supported direct employment (2025)

Source: Deloitte analysis on Eurostat and *ISTAT* data.

Specifically, the top five sectors by **employment supported by Mathematical Research** in direct terms are programming, IT consulting and information services (about 327,600 employees), activities of architectural and engineering firms (about 297,200 employees), legal and accounting activities (about 180,700 employees), education (about 176,500) and construction (about 120,000). In total, the **direct impact** of Mathematical Research in terms of employment (considering all sectors, even those with lower contributions) is **equal to about 2.7 million FTE employees**, representing about 11% of the total number of employees in Italy in 2025.

These sectors are probably not a surprise and confirm the importance of Mathematical Research in programming and, more generally, in computer science, as well as in engineering, design and construction activities.

The direct impact of Mathematical Research on GDP

As for employment, the impact in Gross Value Added was also estimated through the I-O Model.

From the analysis carried out, it emerges **that the direct contribution in Gross Value Added is equal to about 308.5 billion euros, which represents 15% of the total national aggregate**. Figure 13 shows the leading 25 sectors by direct impact in Gross Value Added. In the case of the Gross Value Added contribution, the technical and professional activities, industry and R&D sectors provide about 80% of the total impact. Specifically, the top five sectors for contribution in Gross Value Added are programming, IT consulting and information services, real estate activities, legal and accounting activities, activities of architectural and engineering firms and provision of financial services.

Figure 13. Top 25 sectors by direct contribution in Gross Value Added (2025)

Source: Deloitte analysis on Eurostat and *ISTAT* data.

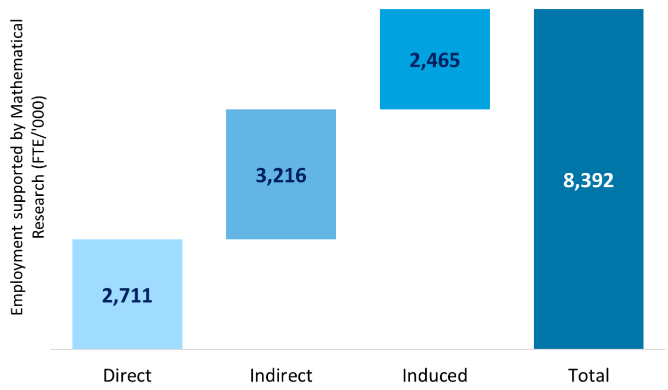
The total impact of Mathematical Research

In addition to the direct impacts previously discussed, the **indirect and induced impacts of Mathematical Research have also been estimated**, which, **added to the direct impacts**, determine the **overall** impacts. Also in this case, the details of the contribution in terms of employment and Gross Value Added are provided below.

The total impact of Mathematical Research on employment

The overall contribution to employment supported by Mathematical Research is estimated at **8.4 million workers**: in addition to the 2.7 million direct employees mentioned above, there are also about 3.2 million indirect employees and about 2.5 million induced employees (Figure 14). For every direct employee, it is therefore estimated that about 2.1 additional jobs are supported in indirect and induced terms.

Figure 14. Contribution to employment of Mathematical Research (2025)



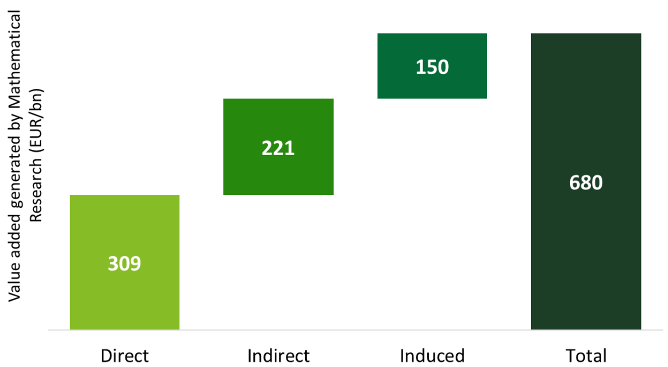
Source: Deloitte analysis on Eurostat and *ISTAT* data.

The total impact of Mathematical Research on GDP

The contribution to the Gross Value Added supported by Mathematical Research is estimated at **680.1 billion euros**, of which 308.5 billion euros in direct impact, 221.3 billion euros in indirect impact and 150.3 billion euros in induced impact (Figure 15).

It is therefore estimated that for every euro of direct impact, an additional 1.2 euros are generated in indirect and induced terms.

Figure 15. Contribution to Gross Value Added of Mathematical Research (2025)



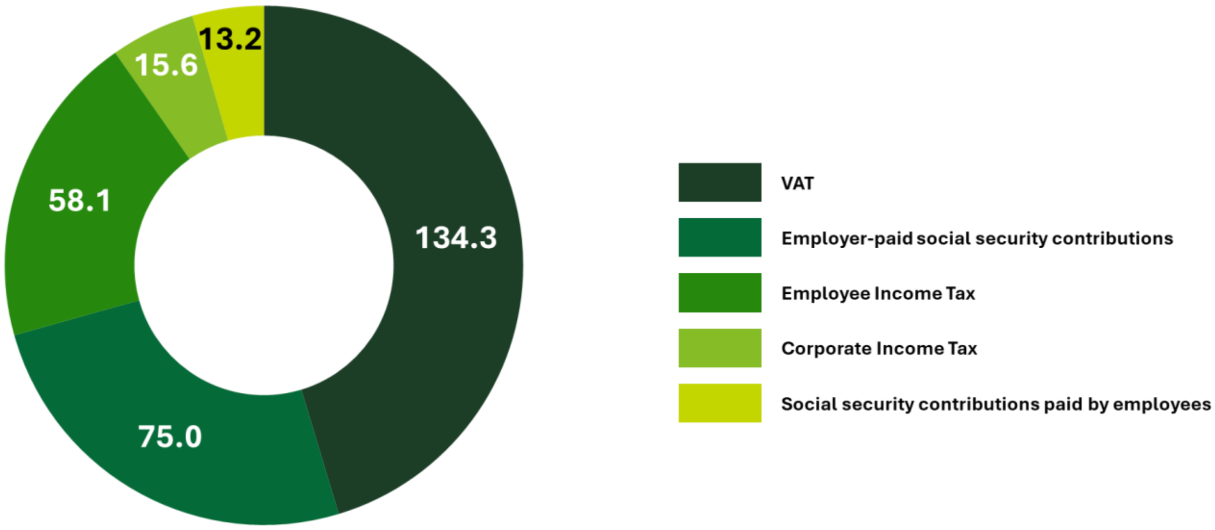
Source: Deloitte analysis on Eurostat and *ISTAT* data.

The total impact of Mathematical Research in terms of contribution to tax revenue

Against the economic contribution described above, it has been estimated that the contribution to tax revenue of Mathematical Research was approximately **296.2 EUR/bn** in 2025.

In Figure 16 the distribution of tax revenue attributable to Mathematical Research, in the various items that compose it, is reported, reflecting the economic impact on the main taxes and contributions at national level. Specifically, it is estimated that the Mathematical Research produces a revenue of about 134.3 billion euros in terms of VAT (Value Added Tax). In addition, employers' social security contributions amount to around 75 billion euros, which is a key component of financing the social security system. Income taxes on workers employed in sectors related to the Mathematical Research contribute around 58.1 EUR/bn. On the corporate tax front, Corporate Income Tax provides an estimated contribution of 15.6 EUR/bn. Finally, the social contributions payable by workers amount to about 13.2 EUR/bn, completing the picture of tax and social security revenues generated by the Mathematical Research activity.

Figure 16. Composition of the contribution of Mathematical Research to tax revenue (EUR/bn, 2025)



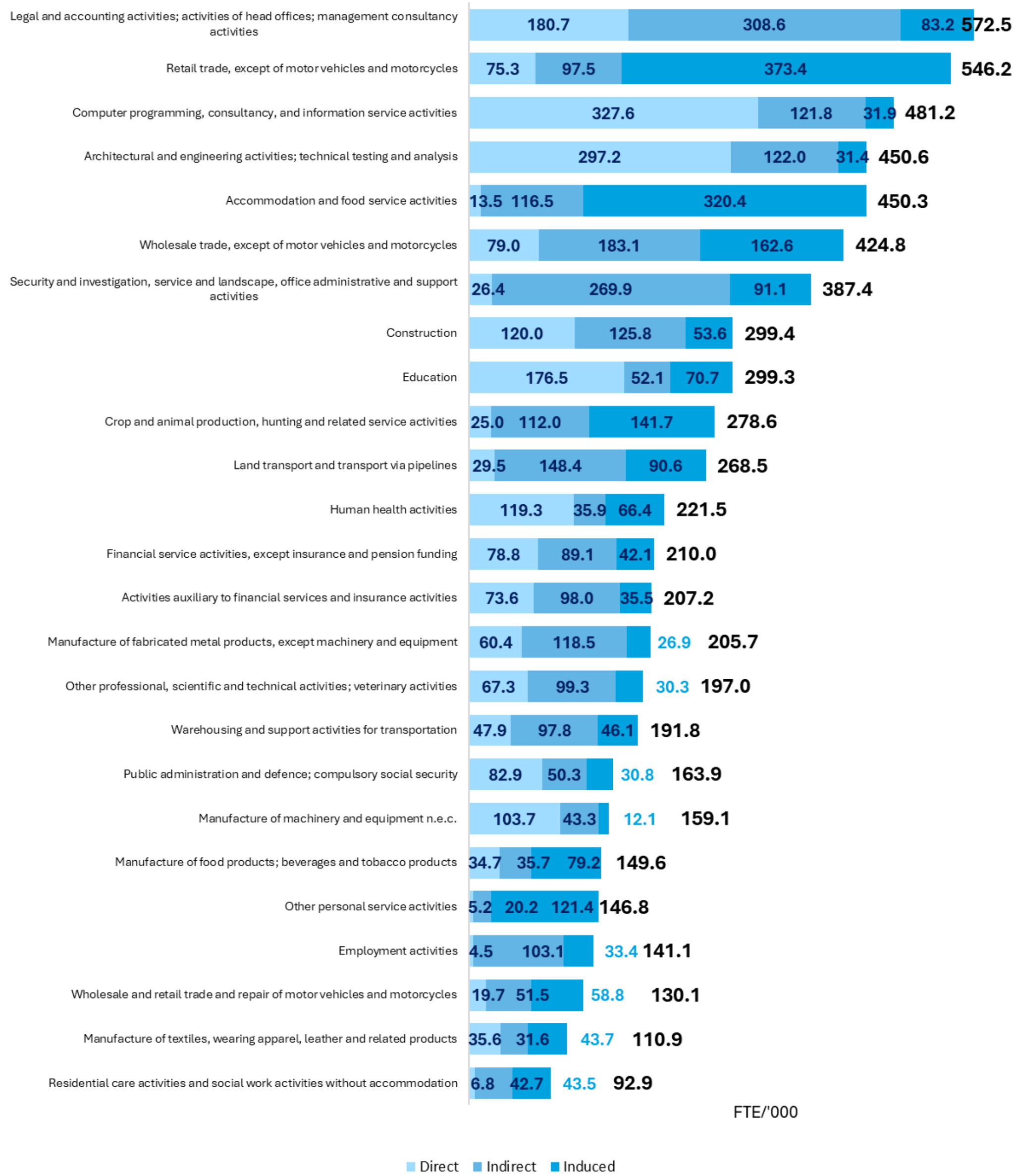
Source: Deloitte analysis on Eurostat and *ISTAT* data.

Sector analysis

The overall impacts described above can be further analysed in terms of contribution by sector and by impact channel. This further degree of detail makes it possible to investigate in which sectors the direct impacts are more concentrated rather than the indirect and induced ones.

Figure 17 shows below a representation of the top 25 sectors by total impact in terms of supported employment. The five sectors on which Mathematical Research has the greatest total impact are legal and accounting, retail trade, programming, IT consulting and information services, activities of architectural and engineering firms and accommodation and food services.

Figure 17. Top 25 sectors by contribution in total supported employment (2025)



Source: Deloitte analysis on Eurostat and *ISTAT* data.

A comparison between direct and total impact shows that, in some sectors such as retail trade and accommodation and food services, the induced impact attributable to Mathematical Research is particularly significant compared to the direct impact. In other sectors, such as wholesale, construction and land transport, the indirect impact exceeds the direct impact. This happens because, in these areas, the effect of Mathematical Research manifests itself more along the supply chain, through B2B transactions, or through the additional B2C transactions generated by the increase in the incomes of workers employed in sectors with a more significant direct impact. Therefore, even in sectors where the direct use of Mathematical Research is less intense and the direct impact is more limited, the contribution can still be significant, especially at an indirect and induced level.

Also, in terms of Gross Value Added, the top 25 sectors by total impact have been reported (Figure 18). The five sectors on which Mathematical Research has the greatest total impact are real estate, legal and accounting activities, head office activities, management consultancy, wholesale trade, excluding motor vehicles and motorcycles, provision of financial services (excluding insurance and pension funds) and programming, IT consultancy and related activities and information services activities.

Figure 18. Top 25 sectors by contribution to Gross Value Added (2025)

Source: Deloitte analysis on Eurostat and *ISTAT* data.

Similarly with respect to the employment impact, the comparison between direct and total impact on Gross Value Added shows that, in some sectors, such as retail trade and accommodation and food services, the induced impact attributable to Mathematical Research is greater than the direct impact, while, in others, such as the supply of electricity and gas and storage and transport support activities, in addition to accommodation and food services, the indirect impact is greater than the direct one. Therefore, even in these cases, Mathematical Research is attributable to a greater impact on the supply chain or on further transactions determined by the increase in the incomes of those operating in the sectors directly impacted.

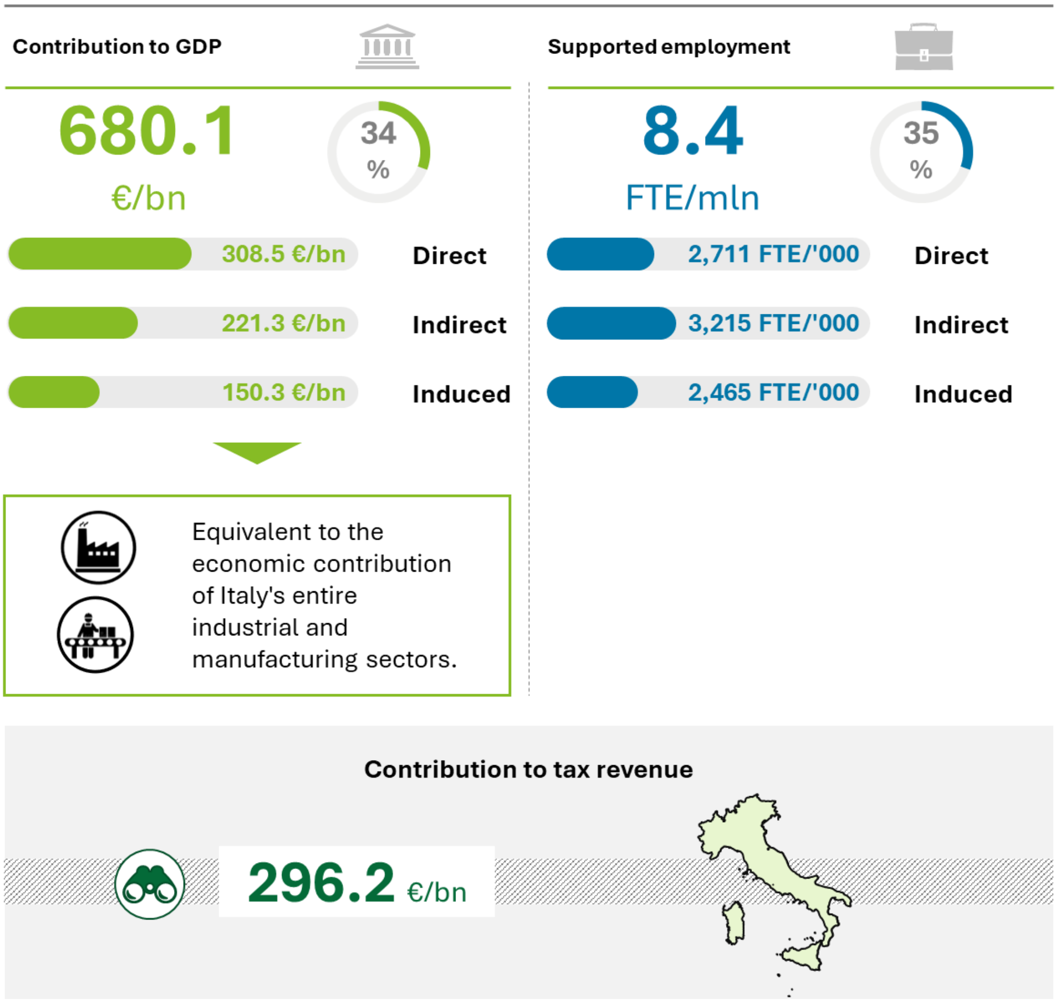
The overall impact of Mathematical Research

It is therefore estimated that the **Mathematical Research in Italy in 2025** has overall (Figure 19):

- contributed more than **680 billion euros** to **Gross Value Added**, equal to about **34%** of the national aggregate;
- supported about **8.4 million jobs**, equal to about **35%** of the national aggregate;
- contributed to **tax revenue** with around **296.2 billion euros**.

To provide an illustration of the magnitude of the impacts generated, the estimated contribution of Mathematical Research to Gross Value Added is equivalent to the economic contribution of the entire industrial and manufacturing sectors in Italy.

Figure 19. Total contribution of Mathematical Research to the national economy (2025)



Source: Deloitte analysis based on Eurostat and *ISTAT* data.

5. Mathematical Sciences as a pillar for the most advanced economies

The economic importance of mathematics

The results of the Study reveal an important finding: Mathematical Research supports 34% of Italian GDP and 35% of national employment. These numbers reflect a structural and consistent economic reality. It can be said that mathematics is the fundamental language through which modern society transforms data into knowledge and complexity into operational solutions that generate economic and social value.

Mathematical Research generates an economic impact of about 680 billion euros.

In terms of employment, the 2.7 million direct employees supported by Mathematical Research correspond to 8.4 million employees supported in total terms. For every worker who directly uses Mathematical Research, another 2.1 are supported in the economy. This employment multiplier highlights how mathematics is an **enabling factor** for the **entire economic structure**; it not only creates direct employment but generates competencies and tools that spread throughout the economy, creating opportunities for qualified employment in sectors apparently distant from the full application of pure mathematics.

These results demonstrate how Mathematical Research represents a strategic asset for Italian competitiveness. In a global economy increasingly based on data, artificial intelligence and process optimization, the ability to develop and apply advanced Mathematical Research becomes a critical factor for development. The **cross-cutting impact** of mathematics on **heterogeneous sectors** suggests that **investments in Mathematical Research** can generate **widespread positive externalities**, further amplifying the return on public investment with a multiplier effect.

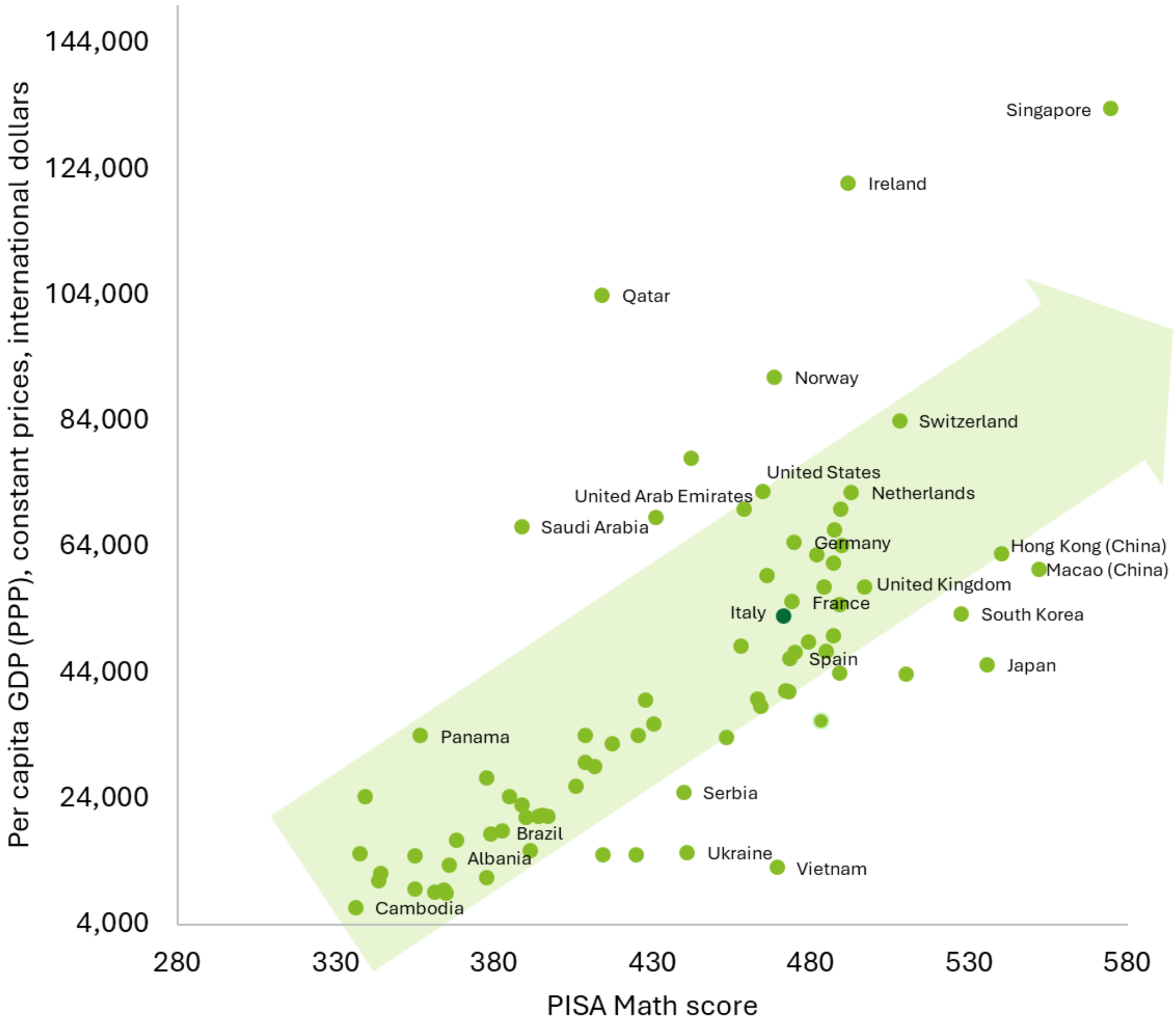
The fundamental role of mathematics for innovation and competitiveness

Mathematics represents a fundamental basis for the economic success and competitiveness of an advanced country. Mathematical skills (measured for example through the PISA Math Score), represent a fundamental indicator not only of the educational level, but also of the innovative and productive potential of a nation.

Analysing the relationship between mathematical skills and GDP per capita, as shown in Figure 20, countries with higher PISA scores tend to have a higher GDP per capita, as also evidenced by the arrow, which represents the linear relationship between the two variables and has a positive slope. This trend is particularly evident among Western nations, such as the United Kingdom, France, Spain, Italy, the Netherlands and Germany, as well as in the United States. However, there are some exceptions, such as Ireland, Norway and Qatar, which, despite having lower levels of mathematical proficiency, have a very high GDP per capita. Singapore stands out as the country with the highest values of both GDP per capita and PISA score.

Hypothesizing not to consider countries such as Singapore, Ireland, Vietnam, and Qatar, a correlation index of 77% is obtained between per capita GDP and PISA Math Score.

Figure 20. Relationship between mathematical ability and GDP per capita (2022)

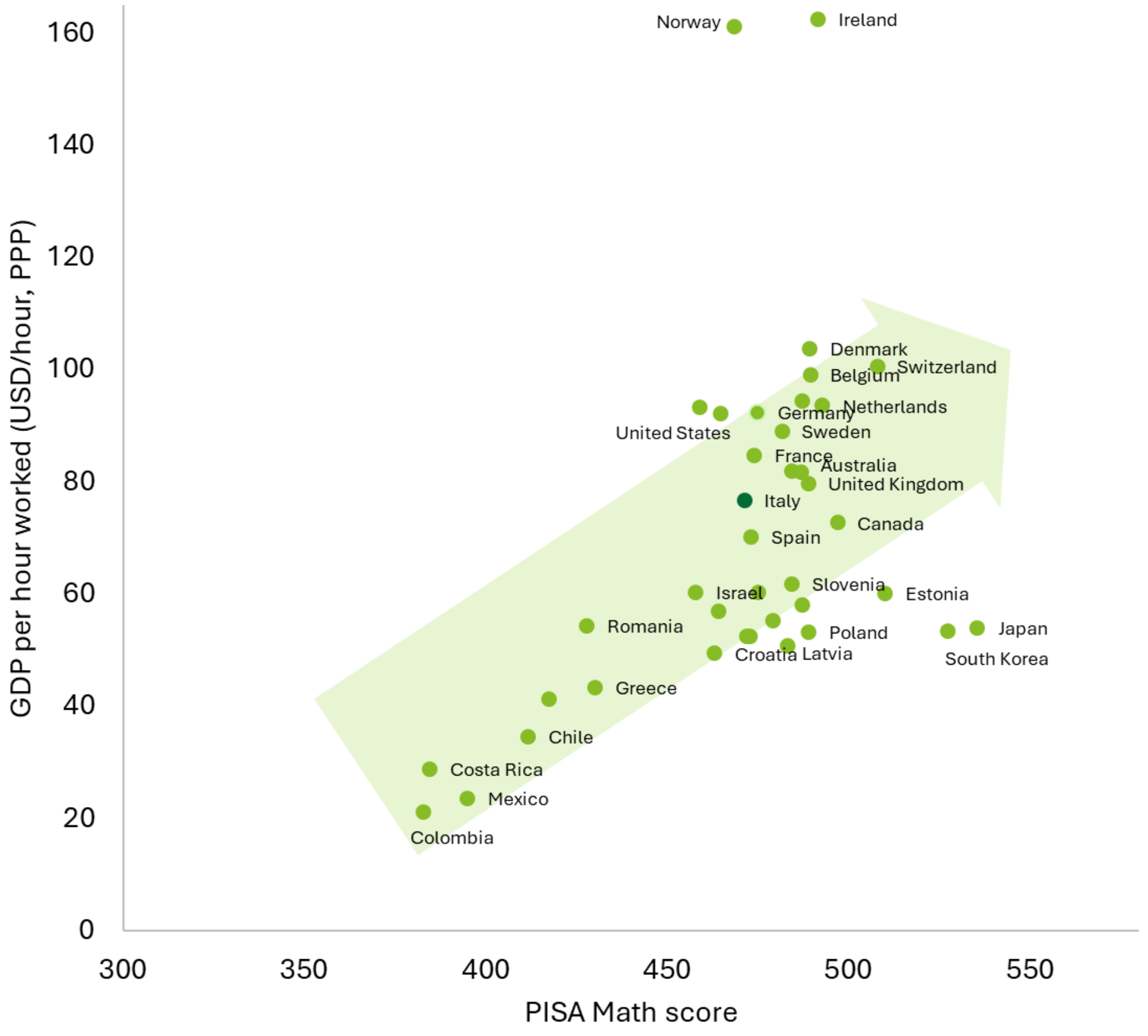


Sources: Deloitte analysis on OECD data, Mathematics performance https://www.oecd.org/en/data/indicators/mathematics-performance-pisa.html and Monetary Fund, GDP per capita, purchase power parity (PPP), constant prices, international dollars https://data.imf.org/en/Data-Explorer?datasetUrn=IMF.RES:WEO(9.0.0)

Also analysing the relationship between mathematical skills and labour productivity, measured as GDP per hour worked, in the various countries of the world (Figure 21), a positive relationship emerges: the higher the mathematical skills, the higher the productivity of labour. This evidence underlines how labour productivity can be linked to the level of mathematical skills of the workforce and, more generally, of the community. Among the exceptions, Norway and Ireland show high levels of productivity despite lower mathematical skills. In addition, Italy, despite having lower mathematical skills, has higher productivity than countries such as Spain, Japan and Canada.

Again, the correlation index between GDP per hour worked and PISA Math Score, excluding outliers (Norway, Ireland, Japan and South Korea) is 73%.

Figure 21. Relationship between mathematical ability and GDP per hour worked (productivity measure, 2022)



Sources: Deloitte analysis on OECD data, Mathematics performance https://www.oecd.org/en/data/indicators/mathematics-performance-pisa.html, GDP per hour worked, USD, PPP, current prices https://www.oecd.org/en/data/indicators/gdp-per-hour-worked.html

The quantities just analysed suggest that the strengthening of mathematical skills, through, for example, the **increase in investments in Research and Development**, can promote the **support** of **economic growth** and **long-term competitiveness**.

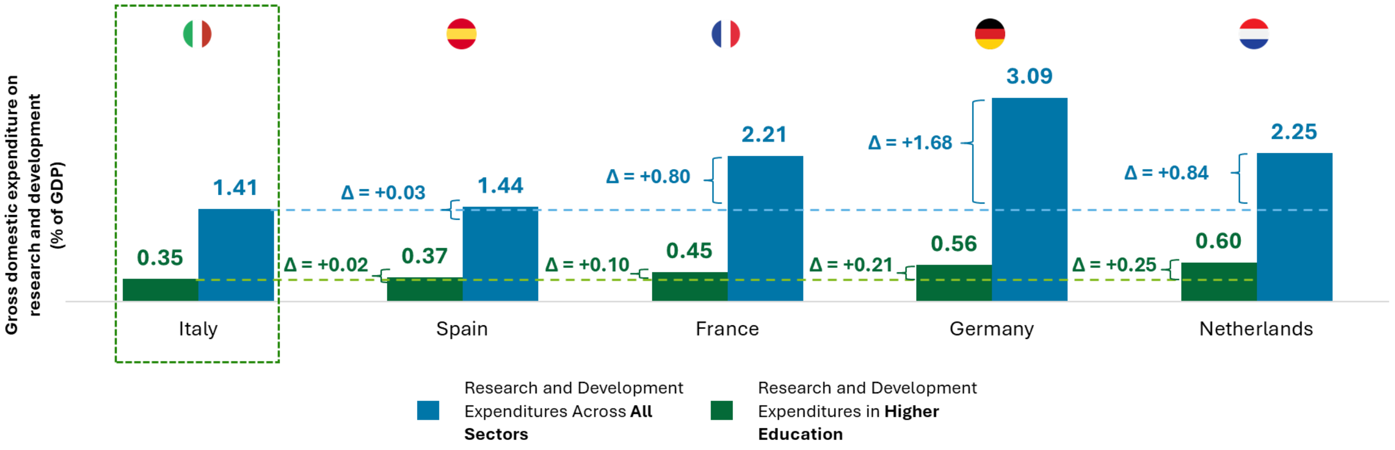
6. The promotion and support of Mathematical Research as an opportunity for economic growth

Investments in research and training

As discussed above, mathematics can be a key factor in supporting modern economic innovation. From artificial intelligence to digital finance, from logistics to smart manufacturing and industry, mathematical skills have become a critical factor in competitiveness. Italy, however, has a significant gap compared to the main European countries in terms of investment in research and education.

In fact, despite the fact that, as shown above, Italy occupies an excellent position in terms of scientific production in mathematical disciplines, in terms of **R&D spending on total GDP** (Figure 22), has the lowest percentage among the main European countries considered, both in terms of total expenditure and in that specifically dedicated to higher education.

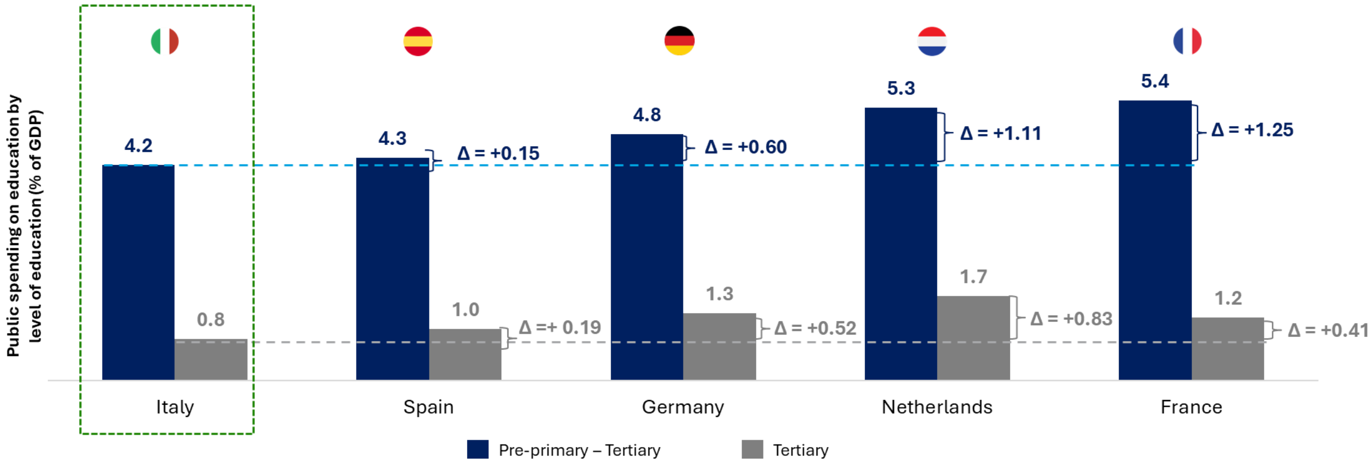
Figure 22. Percentage of gross domestic expenditure on R&D in GDP (2020-2024 average, % of GDP)



Source: Deloitte analysis of Eurostat data. https://ec.europa.eu/eurostat/databrowser/view/rd_e_gerdtot__custom_21784434/default/table

A similar situation is also found for the expenditure on education (Figure 23). In fact, both in relation to the level of tertiary education and to all levels of education from pre-primary to tertiary, Italy is the country among those analysed that has the lowest percentage of expenditure on education in relation to GDP.

Figure 23. Share of public expenditure on education by level of education in GDP (2017-2022 average, % of GDP)



Source: Deloitte analysis of Eurostat data, https://ec.europa.eu/eurostat/databrowser/view/educ_uoe_fine06__custom_20780354/default/table

This gap in terms of investments does not have merely academic consequences but translates into a lower innovative capacity of Italian companies and a difficulty in attracting international talent in research-intensive sectors (Hi-Tech, etc.).

In addition, the lack of mathematical skills may also limit Italy's ability to attract investments in high value-added sectors, such as data centres, international research centres and technology startups.

The results of this study demonstrate how promoting and supporting mathematical research can represent a significant investment opportunity to support the country's economic growth, which would undoubtedly have beneficial implications.

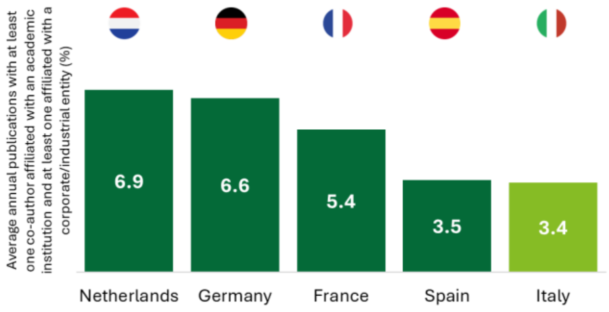
Technology transfer

Technology transfer in the mathematical field represents the process of converting pure and applied Mathematical Research into innovative solutions with concrete economic value. In an era characterized by digital transformation and artificial intelligence, mathematics is increasingly a fundamental driver of industrial innovation, and not just a discipline of purely academic interest.

As shown above, Italy has an excellent tradition in Mathematical Research, with significant contributions at the international level. However, there is a **critical gap** between **academic excellence** and its **transformation into commercial and industrial applications**.

In terms of **collaboration** between **universities** and **enterprises** in mathematical disciplines, Italy still presents a gap compared to the main European countries. When considering, for instance, the percentage of mathematical publications featuring at least one co-author affiliated with an academic institution and at least one with a corporate or industrial entity (Figure 24), Italy occupies the last position, with 3.4%. This percentage, although similar to that of Spain, is significantly lower than in the other European countries considered and equal to about half of Germany and the Netherlands.

Figure 24. University-business collaboration in mathematical disciplines (2020-2025, percentage)

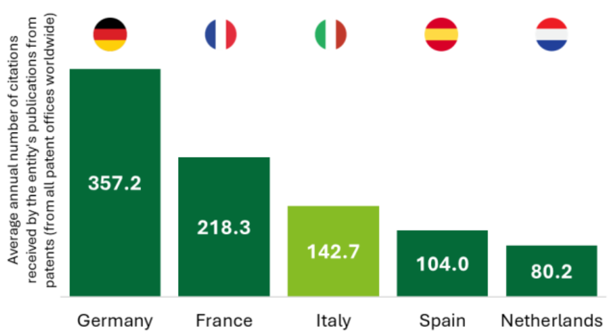


Source: Deloitte analysis on Scopus/SciVal data

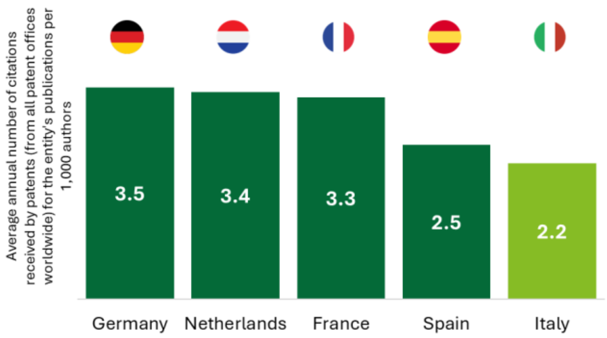
Also in relation to the **technological and application impact of research**, as shown by the Figure 25, Italy shows a significant gap in the number of patent citations received per 1,000 authors (which provides a measure of how well scientific results are taken up in the patent innovation process), with just over 2 patent citations per 1,000 authors, compared to over 3 citations in Germany, the Netherlands and France. These data highlight a gap, from the point of view of the application of the research, compared to the main European countries, underlining the need to strengthen the effectiveness of the transfer of the results of the Mathematical Research in innovative processes.

Figure 25. Citations received from patents

Average annual number of patent citations received (2020-2025)



Average annual number of patent citations received per 1,000 active unique authors (2020-2025)



Source: Deloitte analysis on Scopus/SciVal data

Technology **transfer in the mathematical field**, also highlighted by the number of citations received from patents that reflect the results of research, therefore represents a **strategic opportunity** for Italy to **generate sustainable economic growth**, **create qualified** jobs and position itself as a European leader in digital innovation. Possible support tools, such as the creation of national mathematical technology transfer hubs, greater tax incentives for university-business collaborations, greater education and reskilling programs in applied mathematics, venture capital funds dedicated to mathematical spin-offs, as well as interventions aimed at attracting and retaining mathematical talent, could represent a concrete opportunity for the country.

7. The perception of Mathematical Research in Italy

The perception of Mathematical Research is an important lens through which it is possible to understand the positioning of mathematical sciences within Italy's scientific and cultural landscape. In a context shaped by growing global challenges and the need for technological innovation, the reputation and visibility of Mathematical Research directly affect public investment decisions, the direction of science policy, and civil society's interest in mathematical disciplines. Yet, systematic understanding of how Mathematical Research is represented and perceived in the Italian media remains limited. The perception of Mathematical Research is a strategic indicator of the positioning of Mathematical Sciences within the Italian scientific and cultural landscape. In a landscape characterized by growing global challenges and the structural need for technological innovation, the reputation and visibility of Mathematical Research exert a decisive influence on three interconnected dimensions: the allocation of public investments, the formulation of research-related policies and the level of awareness of civil society.

With the aim of studying this aspect, the perception of mathematics and Mathematical Research in Italy was analysed through the systematic examination of a corpus of news[35] relating to the period 2015-2025. The proposed analysis combines Sentiment Analysis and Topic Modelling techniques to identify the overall tone of media coverage and the prevailing thematic content[36].

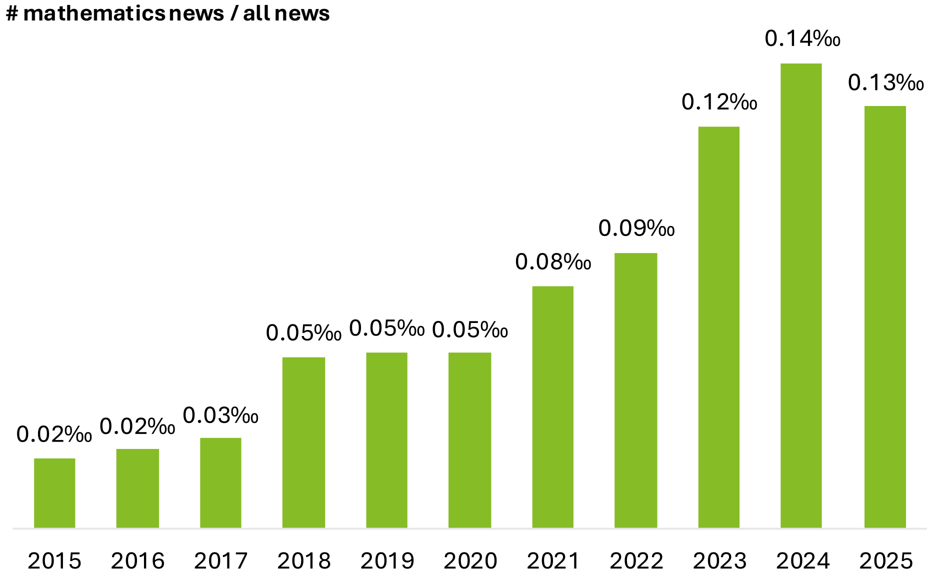
[35] The news under analysis were extracted from the Dow Jones Factiva database, using three search queries defined from keywords such as "Mathematics", "Mathematical Research" and "Mathematical Applications". The queries used are: "Mathematics and social, educational and scientific contexts", "Mathematics with real-world applications, designs, and impacts" and "Mathematics with a focus on research and applications". More details on this are provided in the Appendix.

[36] More details on the methodology used and the results obtained are provided in the Appendix.

From the analysis carried out, considering the relationship between the number of news published on mathematics and the overall news in the period 2015-2025 (Figure 26

Figure 26), there is a **growth** in the **media coverage of mathematics in the last decade**.

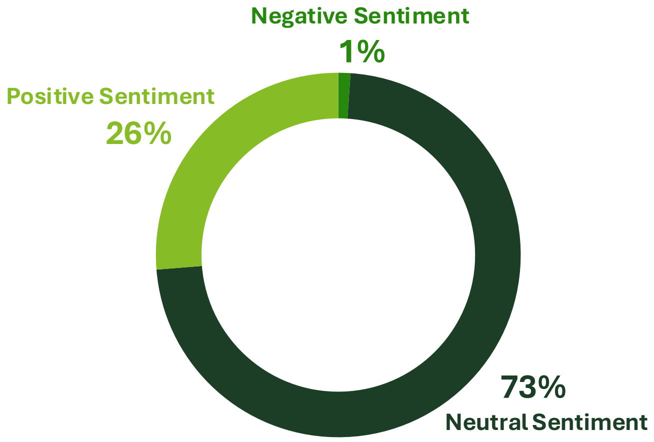
Figure 26. Relationship between mathematics news and all news (2015-2025)



Source: Deloitte analysis on Dow Jones Factiva data.

Sentiment analysis shows a distribution characterized by a **predominance of neutral tone** (73%), followed by a **significant positive component** (26%), while negative sentiment remains marginal (1%) (Figure 27). This configuration, particularly the almost total absence of negative sentiment, constitutes a preliminary indicator of a consolidated and favourable image of Mathematical Research in the Italian public debate, suggesting a stable perception of the discipline.

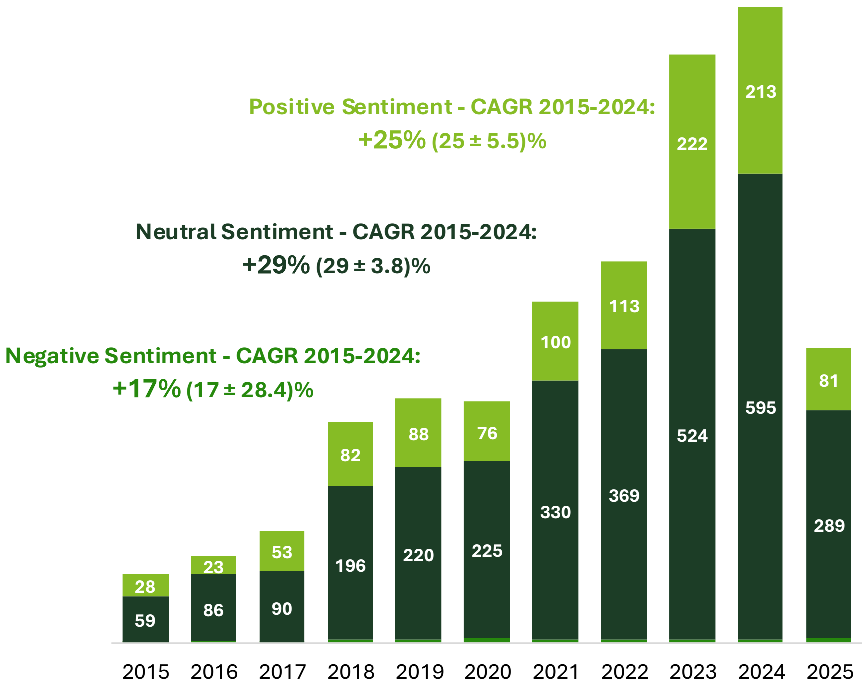
Figure 27. Sentiment Analysis: percentage of positive, neutral and negative sentiment (2015-2025)



Source: Deloitte analysis on Dow Jones Factiva data.

The temporal analysis (Figure 28) suggests that **the positive and neutral polarity accelerate markedly** (CAGR 2015-2024 of +25% and +29% respectively), while the negative polarity shows a more modest growth (CAGR 2015-2024 +17%). With respect to the growth of the negative polarity, this is estimated to be in a wider range than the ranges of the growth of the positive and neutral polarity, between -11.4% and 45.4%. In addition, in the two-year period 2023-2024 there is a further increase in positive polarity compared to previous periods, showing an even more marked growth trend in recent years[37].

Figure 28. Sentiment Analysis: Sentiment growth by year

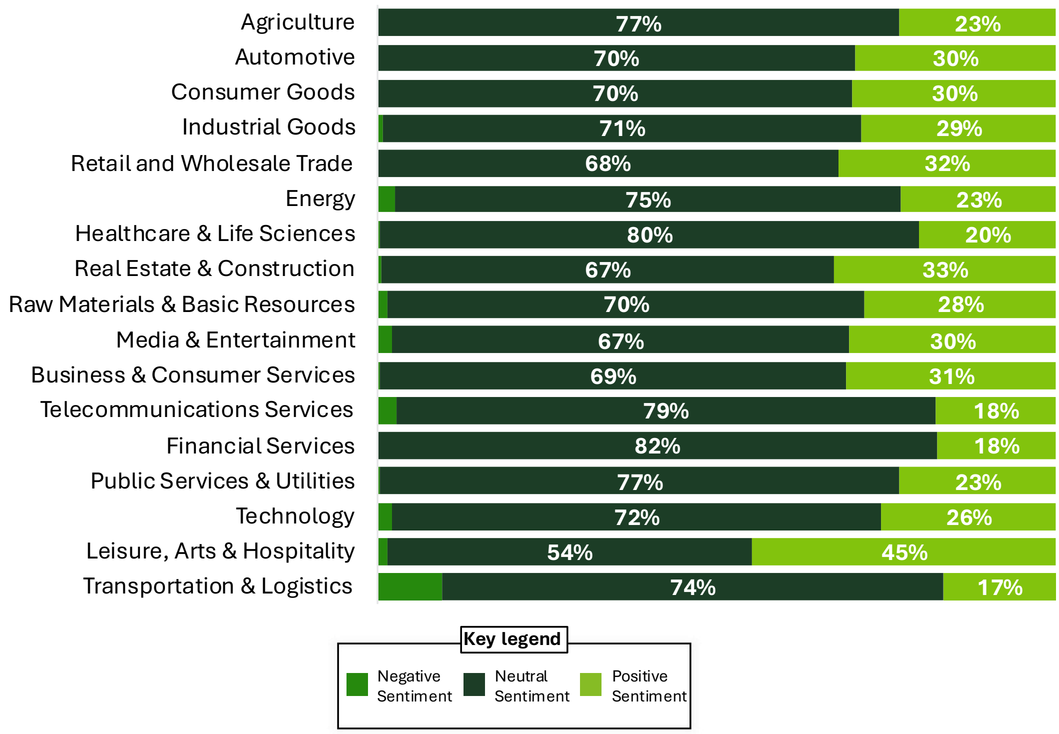


Source: Deloitte analysis on Dow Jones Factiva data. CAGRs reported with 95% confidence intervals.

The sector analysis (Figure 29) shows a variability in the levels of positive sentiment between the different sectors considered. The highest values are observed in the **Leisure, Arts & Hospitality sector** (45%), followed by a group of sectors with relatively similar percentages, including **Real Estate & Construction** (33%) and **Retail and Wholesale Trade** (32%).

[37] The data for 2025 were not included in the calculation of the CAGRs as they were partial at the time of the analysis. The formula used to calculate CAGRs is reported in the Appendix.

Figure 29. Sentiment Analysis: Distribution of Sentiment by Sector (2015-2025)



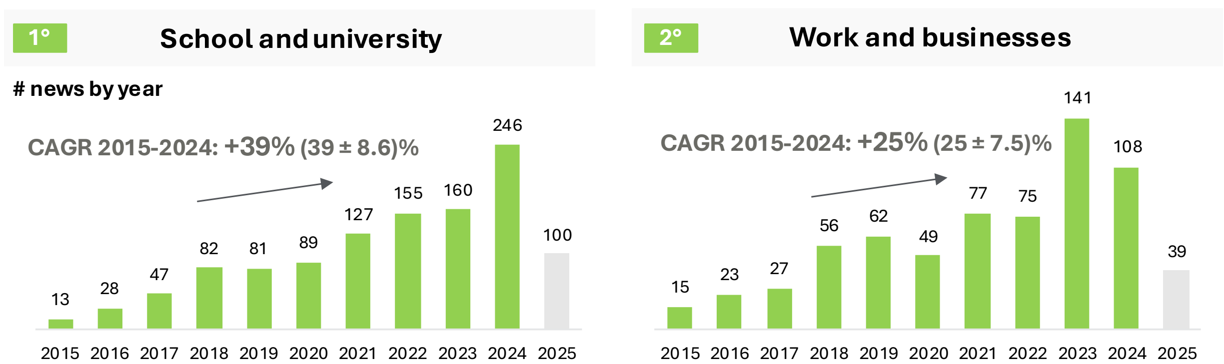
Source: Deloitte analysis on Dow Jones Factiva data.

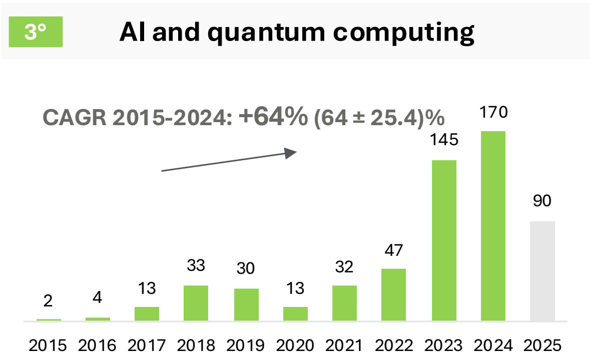
The thematic analysis conducted (Topic Modelling), on the basis of the number of news per year of the main topics in which Mathematical Research is recalled, (Figure 30 and Figure 31) has made it possible to identify the macro-topics in which Mathematical Research appears to be most present (dominant macro topics):

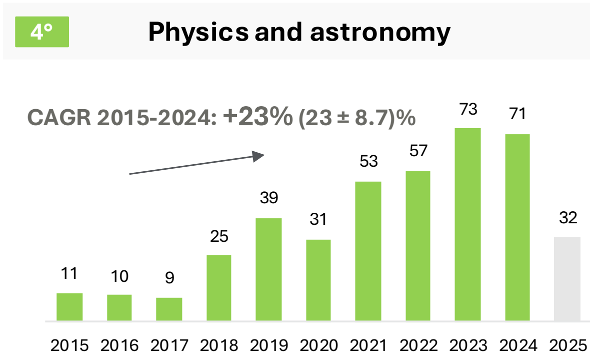
“**School and university**” (reflecting the central role of mathematics in education),
“Work and businesses” (highlighting professional applicability), and
“AI and quantum computing” (emphasizing the link between mathematics and contemporary technological innovation).

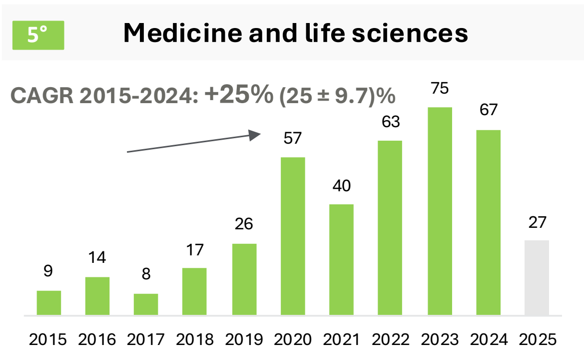
In evolutionary terms, the **topic** related to **artificial intelligence** has experienced the **most significant growth** in recent years. This dynamic reflects the emergence of mathematics as a **discipline considered fundamental** for the **development** of **new technologies**, with a growing media awareness of the crucial role of mathematical models and algorithms in supporting the progress of artificial intelligence and quantum computing.

Figure 30. Topic Modelling: number of news per year of the main topics (2015-2025)



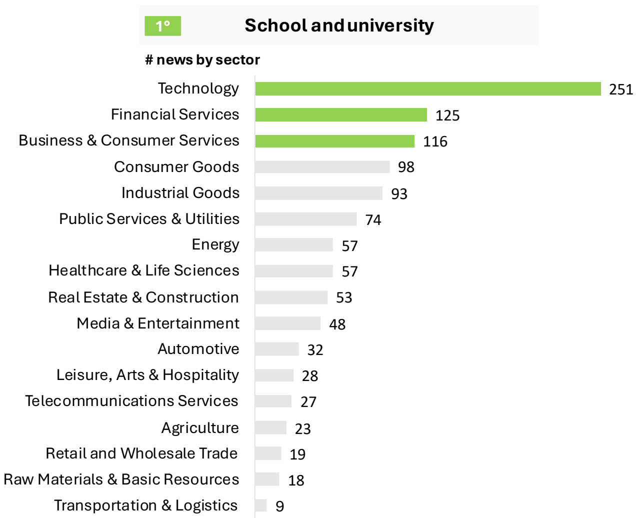


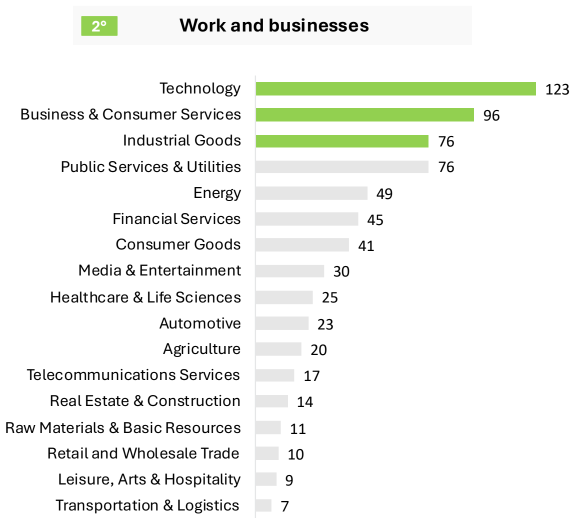


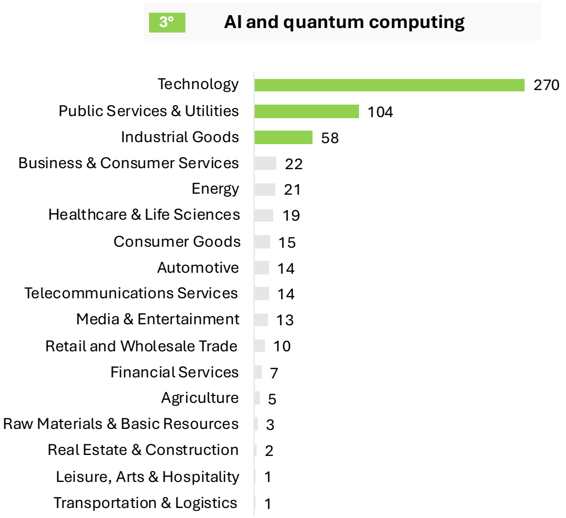


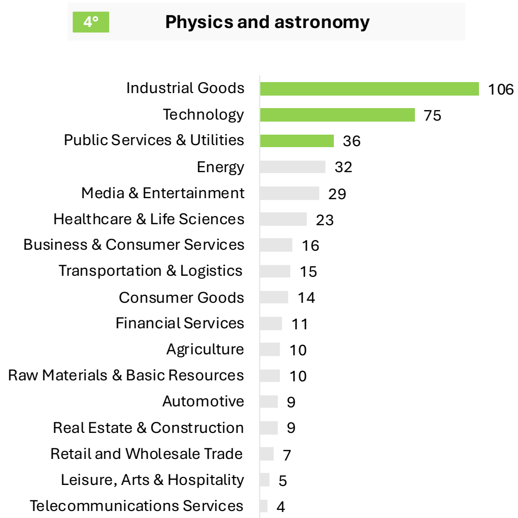
Source: Deloitte analysis on Dow Jones Factiva data. CAGRs reported with 95% confidence intervals.

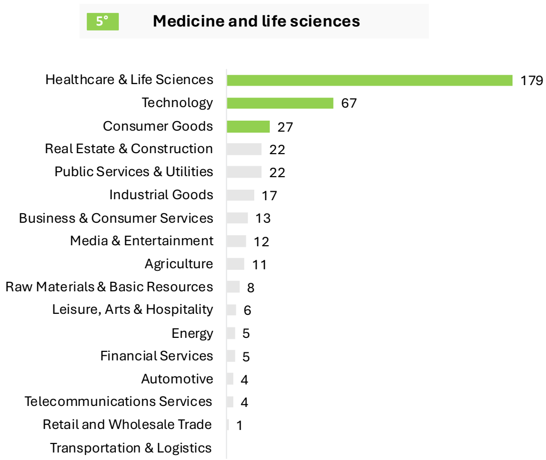
Figure 31. Topic Modelling: number of news by sector of the main topics (2015-2025)











Source: Deloitte analysis on Dow Jones Factiva data.

Overall, the findings confirm that mathematics is perceived not only as an academic discipline but also as a science applied to real-world problems. This reinforces the strong link between Mathematical Research and the broader socio-economic context highlighted by the impact analyses. Our results also suggest the value of a communication strategy that emphasizes both the practical usefulness of mathematics and its educational importance, recognizing these as complementary dimensions.

The results of the analyses conducted not only provide valuable insights for the implementation of effective communication strategies, but also support, more broadly, the launch of structured initiatives aimed at strengthening the strategic role of mathematics as an enabling factor for the country's scientific, technological, social, and cultural development.

8. Concluding remarks

The Study highlighted how Mathematical Research represents a fundamental resource for the economic and social future of the country.

The analyses conducted suggest that Mathematical Research contributed to the Italian economy in 2025, in terms of Gross Value Added, for 680.1 billion euros, with significant multiplier effects along the supply chain and on household consumption. Of this total, 308.5 billion represent direct impact, 221.3 billion indirect and 150.3 billion induced. To appreciate its scale, it should be noted that the estimated contribution of Mathematical Research to Gross Value Added is equivalent to the economic contribution of the entire industrial and manufacturing sectors in Italy.

It has also been estimated that Mathematical Research has supported 8.4 million jobs, confirming its transversal relevance for the labour market. The estimate includes 2.7 million direct employees, about 3.2 million indirect employees in supply chains and about 2.5 million induced activities supported by household spending. As anticipated, the entire occupation in Italy could be connected, at least at a basic level, to mathematics, but the goal was to restrict the quantification to Mathematical Research.

Given the economic contribution outlined previously, it is estimated that Mathematical Research's contribution to tax revenue reached approximately 296.2 billion euros in 2025.

The analysis also shows that scientific production in Italy in mathematical disciplines is also solid. In fact, Italy ranks among the top European countries for publications, citations and quality of research. However, R&D spending as a percentage of GDP in Italy is still lower than in other European countries. It could therefore be appropriate to promote initiatives to increase it, in order to improve Italy’s performance, where there is still room for growth, and further consolidate national excellence in Mathematical Research, a strategic factor for the country’s economic growth, also in light of contemporary technological developments that make the demand for profiles with a scientific-mathematical background increasingly significant.

In this context, it is important to address challenges of considerable economic and social importance, such as the wage differences between Italy and the rest of Europe and the enhancement of highly qualified professions. The rapid technological development of recent years, marked by the entry of artificial intelligence into mass society, represents a reason for reasonable optimism regarding the positive impact that innovation can have on Italian productivity and it is precisely on the intervention of professionals characterized by a quantitative profile, that it will be appropriate to focus on to convert innovations into productive momentum.

A stable and lasting continuous funding of centres specialized in Mathematical Research would allow, for example, the planning of long-term projects and the attraction of excellent researchers, reducing the dispersion of talents to international contexts that provide better economic opportunities. At the same time, it seems appropriate to develop structured incentives for collaboration between the public and private sectors, facilitating technology transfer from academic research to industrial, economic, medical applications, etc. The impact channels analysed between academia and business show how theoretical discoveries are converted into innovations that find application in different sectors.

However, Italy has a lower level of investment in education than other countries. To support and possibly increase the contribution to the Italian economy, there should also be more investment in education up to the tertiary level. It could be useful, for example, to expand scholarships and economic incentives to encourage the inclusion of the best university students in the labour market and support the need for skills, through upskilling and reskilling programs, for workers in traditional sectors. It is crucial to facilitate the international mobility of researchers and students, creating competitive conditions compared to other European countries to retain talent and encourage the return of those who have gone abroad.

Among the main directions for addressing the challenges for the future in the fields of knowledge, innovation and competitiveness based on mathematics, it is worth briefly highlighting the following:

- Continuous support for research and education in mathematics from both public and private sectors.
- Strengthened relationships between research and industry, consolidating the capacities and instruments for joint research and knowledge transfer, encompassing new and innovative collaboration frameworks between the productive sector and the research community.
- Continuous adaptation of training courses to new production needs, improving the value of the skills acquired.
- Increased use of mathematical skills by industry, their follow-up and improvement of the value of mathematical careers.

In conclusion, Mathematical Research from the Study appears to play an important role in the economic future of the country. Economic data, strategic implications, public perception and international evidence converge in the conclusion that investing in Mathematical Research allows for important returns in terms of economic and employment value.

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Appendix

1. Economic impact analysis: estimation methodology

1.1 Defining the analysis perimeter

Defining the perimeter of the professions in which Mathematical Research exerts a significant influence is a crucial step to ensure the validity and effectiveness of the analysis conducted. In this perspective, the research starts from the identification of the professions relevant to the Study, i.e. those attributable to the application field of Mathematical Research. To identify the professions involved in the production and/or application of Mathematical Research, the updated CP2021 classification was used[38], which allows the professions present in the labour market to be associated with specific economic sectors (Ateco 2007[39]).

The process of identifying the CP2021 codes to be included in the scope was structured as follows:

1. Preliminary selection of professions through the analysis of the "classes" (three-digit codes) present in the CP2021 classification.
2. In the case of classes not entirely related to Mathematical Research, a further disaggregation was carried out, identifying the most appropriate items among the "units" (five-digit codes) falling within the same class.

The definition of the perimeter of the professional categories was carried out in close collaboration with the experts belonging to the Italian scientific community of mathematicians (*CNR* and *UMI*, to which experts belonging to *SIMAI* and *AMASES* were added), who provided a reference framework, associating each category with a score representative of the degree of intensity in the use of Mathematical Research. This assessment was subsequently independently reviewed by the Economics Team, which based its analysis on LFS data[40]. The LFS database was used to examine the distribution of workers in relation to the degree classes obtained, distinguishing in particular between:

- Graduates in STEM disciplines (hereinafter "main": scientific, engineering, etc.), who apply Mathematical Research in a continuous and significant way.
- Graduates in non-STEM disciplines (hereinafter "secondary": economic, social and communication sciences, agricultural-forestry and veterinary, medical-health and pharmaceutical), who use Mathematical Research indirectly.

Depending on whether you belong to one or the other category, a different weight has been assigned to professions.

On the basis of these data, a score associated with each profession was calculated, expressed through a score between 0 and 3, determined according to the relative frequency of graduates in the different disciplines, observed within the

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[38] Starting from 2023, *ISTAT* adopts the CP2021 classification of professions, the result of a revision of the previous version (CP2011) and further alignment with the International Standard Classification of Occupations – Isco08. The CP2021 classification is the tool that allows the professions present in the labour market to be traced back to specific professional groupings, useful for communicating, disseminating and integrating statistical and administrative data on professions, also ensuring comparability at an international level. Profession refers to the set of activities that an individual must carry out in the exercise of his or her work, activities that involve their own knowledge, skills, identity and status. *ISTAT*: https://www.istat.it/classificazione/classificazione-delle-professioni/

[39] Ateco is the classification of economic activities adopted by *ISTAT* for statistical purposes, i.e. for the production and dissemination of official statistical data. At national level, the classification is also used for other administrative purposes (e.g. tax). Ateco represents the national version of the European classification of economic activities Nace from which it inherits the structure in the first four hierarchical levels (sections, divisions, groups and classes) and the contents in the lower levels (categories and subcategories). The relationship between the two classifications, defined both methodologically and normatively, ensures that the statistical data produced on the basis of the Ateco classification are comparable with those produced by other European countries on the basis of the Nace classification. *ISTAT* (2025). Ateco 2025 Classification of Economic Activities. 1. Technical-methodological guidelines. https://www.istat.it/wp-content/uploads/2025/10/Ateco-2025.-1.-Linee-guida-tecnico-metodologiche-Ebook.pdf

[40] LFS makes it possible to process the quantities of greatest interest with reference to the professions being assessed: number of individuals, gross salary and impact on the Ateco sectors.

profession itself. Finally, the scores developed by Deloitte were compared with those provided by the Clients, in order to mutually validate the results obtained.

Finally, in line with the classification adopted by LFS, each profession in the perimeter, identified with the relevant CP2021 code, has been associated with the corresponding CP2011 code[41].

Table A1. Perimeter of occupations that make use of Mathematical Research

Profession Code CP2011	Definition Profession	Total number of employees	Mathematical intensity	Number of employees impacted by Mathematical Research
12110	Entrepreneurs and administrators of large companies operating in agriculture, livestock, forestry, hunting and fishing	5,000	33%	1,670
12120	Entrepreneurs and directors of large companies operating in mineral extraction, manufacturing, production and distribution of electricity, gas and water and waste management	11,300	67%	7,530
12130	Contractors and directors of large construction companies	8,400	39%	3,270
12161	Entrepreneurs and directors of large companies in the transport and warehousing sector	3,000	72%	2,170
12162	Entrepreneurs and directors of large companies in publishing, film, radio and television production services	100	72%	70
12163	Entrepreneurs and directors of large companies in IT and telecommunications services	1,500	72%	1,080
12170	Entrepreneurs and directors of large banks, insurance companies, real estate agencies, financial brokerage	4,000	94%	3,780
12180	Entrepreneurs and administrators of large companies in business and personal services	5,000	61%	3,060
12191	Entrepreneurs and administrators of large private educational, university and research institutions	1,000	56%	560
12192	Entrepreneurs and administrators of large hospitals, private clinics or large social care companies	1,100	44%	490
12210	Directors and general managers of companies operating in agriculture, livestock, forestry, hunting and fishing	1,300	33%	430
12220	Directors and general managers of companies operating in manufacturing, mineral extraction, production and distribution of electricity, gas, water and waste management activities	30,000	67%	20,000
12230	Directors and general managers of construction companies	4,000	44%	1,780

[41] This association was necessary because the database used, i.e. the Labour Force Survey 2022, uses the classification.
2011 Professions Officer (CP2011).

12261	Directors and general managers of companies in the transport and warehousing sector	6,000	56%	3,360
12263	Directors and general managers of companies in IT and telecommunications services	7,400	100%	7,400
12270	Directors and general managers of banks, insurance companies, real estate agencies and financial intermediation	20,000	67%	13,330
12280	Directors and general managers of business and personal services companies	5,300	67%	3,530
12310	Directors and managers of the finance and administration department	13,100	94%	12,370
12330	Sales and Marketing Directors and Executives	20,000	61%	12,220
12350	Procurement and Distribution Department Managers and Managers	8,500	72%	6,140
12360	Directors and managers of the IT services department	2,500	100%	2,500
12370	Directors and managers of the research and development department	4,000	78%	3,110
13110	Entrepreneurs and managers of small businesses operating in agriculture, livestock, forestry, hunting and fishing	60,000	33%	20,000
13120	Entrepreneurs and managers of small companies operating in mineral extraction, manufacturing, production and distribution of electricity, gas and water and waste management activities	80,000	44%	35,560
13130	Entrepreneurs and managers of small companies in construction	74,000	44%	32,890
13161	Entrepreneurs and managers of small companies in transport and warehousing	18,200	39%	7,080
13163	Entrepreneurs and managers of small companies in IT and telecommunications services	14,300	78%	11,120
13170	Entrepreneurs and managers of small credit institutions and financial, insurance and real estate brokerage	10,000	67%	6,670
13180	Entrepreneurs and managers of small companies in business and personal services	37,100	33%	12,370
13191	Entrepreneurs and managers of small companies in education, training and research services	1,200	39%	470
13192	Entrepreneurs and managers of small companies in health and social care services	7,400	33%	2,470
21111	Physicists	2,300	100%	2,300
21112	Astronomers and astrophysicists	300	100%	300
21121	Chemists and related professions	15,000	72%	10,830
21122	Chemists, informants and popularizers	21,200	72%	15,310

21131	Mathematicians	1,000	100%	1,000
21132	Statisticians	4,000	100%	4,000
21141	Software analysts and designers	140,000	89%	124,440
21142	System Analysts	24,400	89%	21,690
21143	Web application analysts and designers	10,200	89%	9,070
21151	Specialists in computer networks and communications	16,000	78%	12,440
21152	Database analysts and designers	10,000	78%	7,780
21153	System Administrators	10,200	78%	7,930
21154	Cybersecurity Specialists	20,000	78%	15,560
21161	Geologists	8,000	94%	7,560
21163	Geophysicists	1,000	94%	940
21164	Meteorologists	300	94%	280
22111	Mechanical Engineers	44,100	100%	44,100
22112	Marine engineers	3,200	100%	3,200
22113	Aerospace and Astronautical Engineers	9,300	100%	9,300
22114	Energy and Nuclear Engineers	7,000	100%	7,000
22121	Metallurgical Engineers	1,400	100%	1,400
22122	Mining Engineers	400	100%	400
22130	Electrical and Industrial Automation Engineers	23,300	100%	23,300
22141	Electronics Engineers	41,400	100%	41,400
22142	Computer and peripheral design engineers	2,000	100%	2,000
22143	Telecommunications Engineers	12,400	100%	12,400
22151	Chemical and petroleum engineers	8,400	100%	8,400
22152	Materials Engineers	2,400	100%	2,400
22161	Construction and Environmental Engineers	90,000	100%	90,000
22162	Hydraulic Engineers	4,000	100%	4,000
22170	Industrial and management engineers	23,000	100%	23,000
22180	Biomedical Engineers and Bioengineers	5,100	100%	5,100
22211	Architects	120,000	72%	86,670
22212	Planners, landscapers and specialists in the recovery and conservation of the territory	7,100	72%	5,130
22220	Cartographers and photogrammetrists	400	83%	330
23111	Biologists and related professions	30,000	67%	20,000
23112	Biochemists	100	72%	70
23113	Biophysicists	300	78%	230
23114	Biotechnologists	4,500	72%	3,250
23121	Pharmacologists	2,400	56%	1,330
23122	Microbiologists	300	56%	170
23130	Agronomists and foresters	6,300	33%	2,100
23150	Pharmacists	74,000	22%	16,440

24120	Medical therapy specialists	82,000	44%	36,440
24130	Specialists in surgical therapies	45,000	44%	20,000
24140	Laboratory Specialists and Clinical Pathologists	7,400	39%	2,880
24160	Specialists in diagnostic imaging and radiotherapy	13,300	67%	8,870
24173	Epidemiologists	1,000	72%	720
25141	Accounting specialists	122,400	72%	88,400
25142	Tax and tax experts	18,100	72%	13,070
25143	Financial specialists	40,000	72%	28,890
25311	Economic systems specialists	7,200	78%	5,600
25312	Business Economics Specialists	39,100	78%	30,410
25515	Restorers of cultural heritage	4,000	22%	890
26111	University professors in mathematical and information sciences	4,000	100%	4,000
26112	University professors in physical sciences	4,200	100%	4,200
26113	University professors in chemical and pharmaceutical sciences	4,500	100%	4,500
26114	University professors in earth sciences	1,200	100%	1,200
26121	University professors in biological sciences	3,000	39%	1,170
26122	University professors in agricultural, livestock and animal production sciences	2,200	39%	860
26123	University professors in medical sciences	5,000	39%	1,940
26131	University professors in civil engineering and architectural sciences	4,200	100%	4,200
26160	University professors in economics and statistics	10,000	100%	10,000
26211	Researchers and technicians with degrees in mathematical and information sciences	3,100	100%	3,100
26212	Researchers and technicians with degrees in physical sciences	5,300	100%	5,300
26213	Researchers and technicians with degrees in chemical and pharmaceutical sciences	5,100	100%	5,100
26214	Researchers and technicians with degrees in earth sciences	3,000	100%	3,000
26221	Researchers and technicians with degrees in the biological sciences	7,200	39%	2,800
26222	Researchers and technicians with degrees in agricultural, livestock and animal production sciences	2,000	39%	780
26223	Researchers and technicians with degrees in medical sciences	5,500	39%	2,140
26231	Researchers and technicians with degrees in civil engineering and architectural sciences	4,200	100%	4,200
26232	Researchers and technicians with degrees in industrial and information engineering sciences	4,300	100%	4,300

26260	Researchers and technicians with degrees in economics and statistics	4,000	94%	3,780
26321	Teachers of mathematical, physical and chemical sciences in upper secondary school	59,100	72%	42,680
26322	Teachers of life and health sciences in upper secondary school	25,000	33%	8,330
26323	Professors of technical and engineering disciplines in upper secondary school	25,400	67%	16,930
26324	Teachers of information science in upper secondary school	13,000	67%	8,670
26326	Teachers of legal, economic and social sciences in upper secondary school	30,000	28%	8,330
26332	Teachers of technical and scientific disciplines in lower secondary school	70,000	33%	23,330
31111	Geological technicians	2,100	72%	1,520
31112	Physical and nuclear technicians	1,200	72%	870
31120	Chemical technicians	35,200	72%	25,420
31130	Statistical technicians	3,000	72%	2,170
31210	Technical programmers	155,000	72%	111,940
31220	Experienced application technicians	150,000	72%	108,330
31230	Web technicians	8,100	72%	5,850
31240	Database technicians	4,400	72%	3,180
31250	Network and telematics system management technicians	15,000	72%	10,830
31261	Telecommunications technicians	24,000	72%	17,330
31262	Radio and television broadcasting technicians	1,400	72%	1,010
31310	Mechanical technicians	50,000	72%	36,110
31321	Ceramic product technicians	1,000	72%	720
31323	Metallurgical technicians	1,500	72%	1,080
31330	Electrical engineering	30,000	72%	21,670
31340	Electronics technicians	73,400	72%	53,010
31350	Civil construction technicians and related professions	166,500	72%	120,250
31360	Energy saving and renewable energy technicians	4,500	72%	3,250
31371	Technical draftsmen	97,300	72%	70,270
31372	Textile designers	3,300	72%	2,380
31373	Prospecting surveyors and draftsmen	1,400	72%	1,010
31411	Technicians in the operation and control of metal production plants	10,000	44%	4,440
31412	Chemical plant management and control technicians	4,200	44%	1,870
31413	Technicians in the management and control of paper production plants	400	44%	180

31414	Technicians in the operation and control of water treatment plants	10,000	44%	4,440
31415	Technicians in the management and control of automatic assembly lines	5,400	44%	2,400
31421	Thermal and electrical energy production technicians	5,400	44%	2,400
31422	Technicians in the operation of water and other fluids	13,100	44%	5,820
31423	Electrical distribution network operation technicians	6,300	44%	2,800
31510	Production technicians in mines and quarries	100	39%	40
31520	Construction site management technicians	25,000	39%	9,720
31530	Manufacturing Technicians	150,000	39%	58,330
31541	Food Preparation Technicians	11,000	39%	4,280
31542	Food Production Technicians	20,300	39%	7,890
31550	Service Manufacturing Engineers	10,000	39%	3,890
31611	Naval Commanders	5,500	44%	2,440
31612	Officers and Ship's Attendants	7,100	44%	3,160
31613	Naval pilots	700	44%	310
31621	Pilots and aircraft officers	8,000	44%	3,560
31622	Avionics technicians	2,000	44%	890
31623	Aerospace Technicians	1,300	44%	580
31631	Air traffic controllers	4,400	44%	1,960
31632	Airport Traffic Technicians	5,000	44%	2,220
31640	Railway traffic organisation technicians	20,000	44%	8,890
31650	Port traffic organization technicians	3,000	44%	1,330
31730	Medical equipment and medical diagnostic technicians	10,000	39%	3,890
31810	Plant Safety Technicians	10,000	33%	3,330
31820	Occupational safety technicians	31,000	33%	10,330
31831	Environmental Control Technicians	17,000	33%	5,670
31832	Waste collection and treatment and environmental remediation technicians	10,000	33%	3,330
32131	Audiometry technicians	2,300	33%	770
32132	Biomedical Laboratory Health Technicians	22,000	33%	7,330
32133	Medical Radiology Healthcare Technicians	22,000	33%	7,330
32134	Neurophysiopathology technicians	1,000	33%	330
32151	Prevention technicians in the environment and in the workplace	10,100	33%	3,370
32161	Opticians and optometrists	14,100	39%	5,480
32162	Dental technicians	31,200	28%	8,670
32211	Agronomists	13,000	33%	4,330
32212	Forestry technicians	2,400	33%	800

32220	Livestock	4,000	33%	1,330
32231	Biochemical Laboratory Technicians	19,100	39%	7,430
32232	Food Technicians	6,300	39%	2,450
32233	Veterinary laboratory technicians	1,500	39%	580
33121	Accountants	303,500	50%	151,750
33150	Technicians in the organization and management of production factors	70,400	33%	23,470
33210	Financial Management Technicians	110,000	56%	61,110
33230	Insurance agents	78,000	67%	52,000
33250	Stock and exchange agents, securities brokerage technicians and similar professions	2,200	67%	1,470
33310	Suppliers and purchasing managers	40,000	33%	13,330
33320	Warehouse and internal distribution managers	20,300	39%	7,890
33340	Sales and distribution technicians	164,400	33%	54,800
33350	Marketing Engineers	63,300	33%	21,100
33410	Freight forwarders and technicians of the commercial organization	83,500	27%	22,270
34411	Charts	53,000	44%	23,560
43110	Procurement managers	80,000	39%	31,110
43120	Warehouse management workers and related professions	285,000	39%	110,830
43230	Financial operations workers on behalf of the company or organisation	19,300	39%	7,510
43240	Statistical service officers	10,000	61%	6,110
91110	Armed Forces Officers	31,000	33%	10,330

1.2 Determining the share attributable to Mathematical Research from professions to sectors

Once the perimeter of professions and the respective intensity of Mathematical Research have been defined, this intensity was also estimated with reference to the various Ateco codes (to which the respective NACE Rev.2 codes have been referred, in order to ensure uniformity with the I-O symmetrical tables), which identify the sectors of which the Italian economy is composed: taking into account (i) both the percentage incidence of the different professions on each sector, (ii) and the score, identifying the intensity of Mathematical Research, previously defined for each profession, the intensity of Mathematical Research was determined on the sectors to which the professions of the perimeter belong.

Table A2. Perimeter of occupations that make use of Mathematical Research

NACE Rev.2 code	Industry	Total number of employees	Mathematical intensity	Number of employees impacted by Mathematical Research
M71	Architectural and engineering activities; technical testing and analysis	425,211	70%	297,200
J62_63	Computer programming, consultancy and related activities; Information service activities	532,271	62%	327,560

M72	Scientific research and development	56,305	52%	29,530
K66	Activities auxiliary to financial services and insurance activities	168,510	44%	73,650
J61	Telecommunication	115,334	38%	44,190
C19	Manufacture of coke and refined petroleum products	23,208	29%	6,710
C26	Manufacture of computer, electronic and optical products	138,441	29%	40,660
J58	Publishing activities	61,451	27%	16,830
C30	Manufacture of other transport equipment	137,835	25%	34,860
C21	Manufacture of basic pharmaceutical products and pharmaceutical preparations	130,974	28%	36,110
D	Electricity, gas, steam and air conditioning supply	150,549	27%	40,800
M69_70	Legal and accounting activities; activities of head offices; management consultancy activities	729,640	25%	180,730
K65	Insurance, reinsurance and pension funding, except compulsory social security	85,466	24%	20,200
E36	Water collection, treatment and supply	48,333	21%	10,320
B	Mining and quarrying	27,042	16%	4,270
C28	Manufacture of machinery and equipment n.e.c.	512,494	20%	103,690
U	Activities of extraterritorial organisations and bodies	17,356	24%	4,170
K64	Financial service activities, except insurance and pension funding	366,888	21%	78,840
C20	Manufacture of chemicals and chemical products	165,988	18%	29,370
H51	Air transport	28,051	16%	4,520
M74_75	Other professional, scientific and technical activities; Veterinary Services	280,615	24%	67,330
C27	Manufacture of electrical equipment	183,142	15%	28,020
C29	Manufacture of motor vehicles, trailers and semi-trailers	199,286	15%	29,890
H50	Water transport	42,380	14%	5,750
S95	Repair of computers and personal and household goods	42,783	14%	6,030
C33	Repair and installation of machinery and equipment	173,556	14%	24,580
M73	Advertising and market research	114,022	17%	18,920
H52	Warehousing and support activities for transportation	383,740	12%	47,940
C31_32	Manufacture of furniture; Other manufacturing	304,025	12%	35,900
C25	Manufacture of fabricated metal products, except machinery and equipment	594,731	10%	60,370
C22	Manufacture of rubber and plastic products	182,738	11%	20,240

C13-15	Manufacture of textiles; manufacture of wearing apparel; manufacture of leather and related products	428,642	8%	35,620
C23	Manufacture of other non-metallic mineral products	162,860	11%	17,540
P	Education	1,688,837	10%	176,500
C18	Printing and reproduction of recorded media	52,975	11%	5,880
C24	Manufacture of basic metals	232,585	9%	21,770
Q86	Human health activities	1,425,578	8%	119,270
C17	Manufacture of paper and paper products	100,703	9%	9,120
J59_60	Motion picture, video and television programme production, sound recording and music publishing activities; programming and broadcasting activities	58,525	8%	4,720
G46	Wholesale trade, except of motor vehicles and motorcycles	805,722	10%	79,010
H53	Postal and courier activities	171,739	8%	13,850
L	Real estate activities	143,890	6%	8,520
S94	Activities of membership organisations	182,032	6%	11,660
C10-12	Manufacture of food products; manufacture of beverages; manufacture of tobacco products	526,418	7%	34,710
F	Construction	1,621,938	7%	119,950
N77	Rental and leasing activities	47,122	9%	4,360
E37-39	Sewerage; waste collection, treatment and disposal activities; materials recovery; remediation activities and other waste management services	207,560	7%	14,150
N80-82	Security and investigation activities; services to buildings and landscape activities; office administrative, office support and other business support activities	772,121	3%	26,410
H49	Land transport and transport via pipelines	568,798	5%	29,500
O	Public administration and defence; compulsory social security	1,218,522	7%	82,870
N79	Travel agency, tour operator and other reservation service and related activities	55,699	4%	2,320
G45	Wholesale and retail trade and repair of motor vehicles and motorcycles	443,172	4%	19,750
N78	Employment activities	145,706	3%	4,550
G47	Retail trade, except of motor vehicles and motorcycles	2,098,711	4%	75,330
A01	Crop and animal production, hunting and related service activities	774,845	3%	24,960
R90-92	Creative, arts and entertainment activities; libraries, archives, museums and other cultural activities; gambling and betting activities	181,729	3%	5,430
C16	Manufacture of wood and of products of wood and cork, except furniture;	136,423	4%	4,990

	manufacture of articles of straw and plaiting materials			
A03	Fishing and aquaculture	20,786	3%	710
R93	Sports activities and amusement and recreation activities	178,803	1%	1,870
Q87_88	Residential care activities; social work activities without accommodation	565,569	1%	6,770
A02	Forestry and logging	31,684	2%	710
I	Accommodation; food and beverage service activities	1,556,552	1%	13,450
S96	Other personal service activities	528,235	1%	5,220
T	Activities of households as employers of domestic personnel; undifferentiated goods- and services-producing activities of private households for own use	590,493	0%	870

1.3 Applying the Input-Output Model

The model

In order to estimate the direct, indirect and induced impact, both in terms of Gross Value Added and employment supported by Mathematical Research in Italy, an Input-Output (I-O) approach was applied. The I-O approach consists of a linear model suitable for calculating the variations in the supply and demand of one sector in relation to the other sectors. The key concept is that the growth of one sector increases purchases by the other sectors, generating additional growth. This growth, in turn, causes further increases. The process is not endless but gradually decreases until it runs out. This approach is used, above all, in measuring the economic impacts of (public) events and investments, as well as in identifying “key” or “strategic” sectors.

The I-O approach is implemented using the so-called I-O symmetric tables, which provide a representation of the interrelationships between the different sectors of which a national economy is composed, through the use of a square matrix. It shows the dependence of each sector on the others, both from the point of view of supply and demand. The I-O matrix is expanded with additional items to calculate gross domestic product (GDP). These items include subsidies, wages, profits, imports, exports, expenses, and changes in inventories. The I-O matrices for Italy are published periodically by *ISTAT*.

Data:

- $\boldsymbol{A}$: Input-Output matrix; The rows represent the supply of goods and services by the sectors, while the columns represent the usage. The columns are normalized by dividing the values by the total output.
- $\boldsymbol{t}$: vector containing the total production by sector.
- $\boldsymbol{y}$: Vector containing the total final demand per sector.
- $\boldsymbol{I}$: identity matrix.

The sum of the intermediate supply (), where $||A \times t$A||<1, and of final demand () determines total production ():yt

$$A \times t + y = t$$

which can be rewritten as follows:

$$y = (I - A) \times t$$

with:

$$t = (I - A)^{-1} \times y$$

where:

$$(I - A)^{-1} = [l_{ij}]$$

it is called the inverse of Leontief.

Multipliers

The elements of the Leontief inverse matrix allow you to determine the output multipliers for each sector. Supplier linkage effects, or Type I multipliers, make it possible to determine direct and indirect effects. They estimate the impact on the supply chain of a manufacturer increasing the production of a given product to meet additional demand. To meet this additional demand, the manufacturer must in turn increase the amount of goods and/or services purchased from its suppliers to produce the product in question. These suppliers, in turn, increase the demand for goods and services and so on throughout the supply chain. These Type I multipliers are also referred to as direct and indirect effects. Type I multipliers could potentially underestimate the effect on the economy, as they do not take into account induced effects.

For this reason, in addition to direct and indirect effects, the so-called Type II multipliers also make it possible to determine the induced effects, also considering wages and household expenses, as well as intermediate supply and demand.

2. Sentiment Analysis and Topic Modelling

2.1 Introduction

The perception of Mathematical Research represents a crucial element to understand the positioning of mathematical sciences within the Italian scientific and cultural landscape. In a context characterized by growing global challenges and the need for technological innovation, the reputation and visibility of Mathematical Research directly influence public investment decisions, the orientation of scientific policies and the interest of civil society towards mathematical disciplines. However, the systematic understanding of how Mathematical Research is represented and perceived through the Italian media remains limited, making a structured and evidence-based analysis necessary.

The present Study addresses this gap through the analysis of a corpus of news extracted from Factiva, a database of journalistic news, in the period 2015-2025. The analysis aims to: (i) identify the overall tone (positive, negative, neutral) with which the Italian media address the topic of Mathematical Research, providing a quantitative evaluation of media sentiment; (ii) map the prevailing thematic contents, identifying which aspects of mathematics and Mathematical Research receive the most media attention and which narratives dominate public discourse.

The analysis adopts a unified perspective that considers the Italian media discourse as a whole, without fragmentation by specific application segments. Through the systematic examination of the Factiva corpus, the Study provides an empirical basis for understanding how Mathematical Research is perceived and represented in Italy, with significant implications for scientific communication strategies, research funding policies and the promotion of mathematical disciplines in the national context.

In recent decades, the growing attention to the social impact of research has posed new evaluation challenges, combining the traditional evaluation of the scientific impact of mathematics with the need to also consider the effects on society, the economy, and culture. Sentiment Analysis offers the possibility of monitoring public opinion on a large scale, of highlighting temporal and sectoral dynamics, of supporting strategic decisions based on empirical evidence. These techniques make it possible to capture not only objective data but also perceptions, opinions and emotions expressed through different textual sources, such as publications, social media, press releases and other relevant documents.

In parallel with the Sentiment Analysis activity, the most discussed topics within the news were identified through the use of Topic Modelling methodologies, in order to understand the temporal evolution and sectoral distribution of the dominant topics.

2.2 Work performed

This Study analyses the perception of mathematics in the Italian public opinion through Sentiment Analysis and Topic Modelling techniques applied to a corpus of news, journalistic articles and press releases concerning mathematics, Mathematical Research and its applications, extracted from the Dow Jones Factiva database.

The work is based on five distinct phases:

1) Defining keywords and queries
2) Data collection
3) Data cleaning and preliminary analysis
4) Sentiment Analysis
5) Topic Modelling

Step 1: Keywords and queries definition

The first step of the analysis aims to identify the most relevant keywords, which have been selected taking into account the discussions with *CNR*, *UMI* and all the other mathematicians involved. The keywords identified were defined trying to give continuity to the input-output analysis, ensuring consistent storytelling. The selected keywords are:

- Mathematics
- Mathematical Research
- Mathematical applications
- Funding for Mathematical Research
- Social Impact of Mathematics

Based on these keywords, three distinct queries were developed, constructed as Boolean combinations of keywords and alternative lexical forms, each designed to capture different facets of the theme (Table A3):

Table A3. Research queries

Query 1	**Query 2**	**Query 3**
Mathematics and social, educational and scientific contexts	Mathematics with real-world applications, designs, and impacts	Mathematics with a focus on research and applications

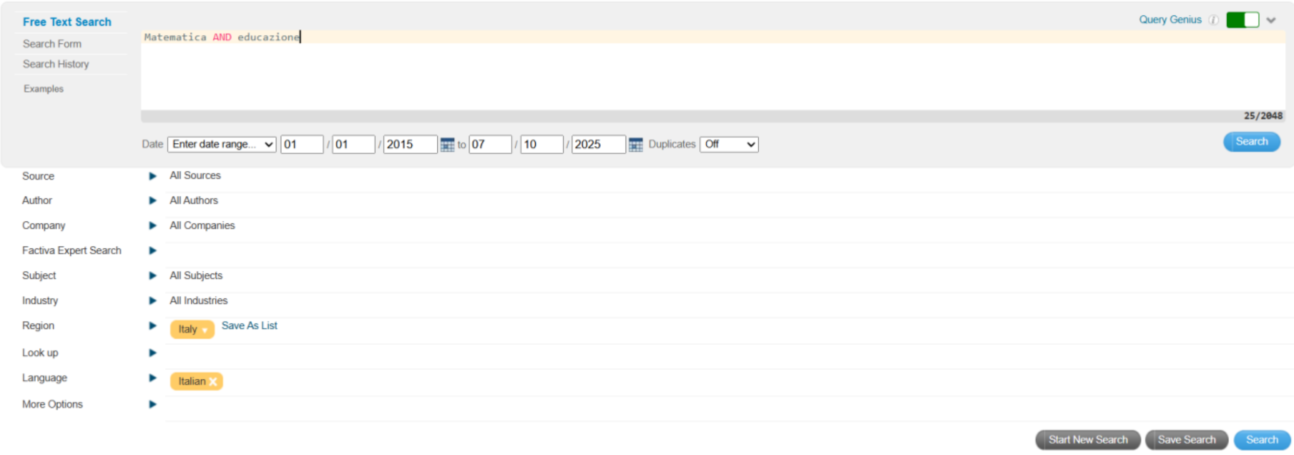
This multi-query strategy guarantees complete coverage of the news of interest and allows to cover a wide spectrum of application contexts.

Phase 2: Data collection

After the definition of keywords and search queries, the systematic collection of news and newspaper articles related to mathematics and Mathematical Research in Italy was launched, through the data provider Dow Jones Factiva. This database was selected based of the wide coverage of national journalistic sources and the availability of structured metadata, making it particularly suitable for the study of the media representation of specific topics.

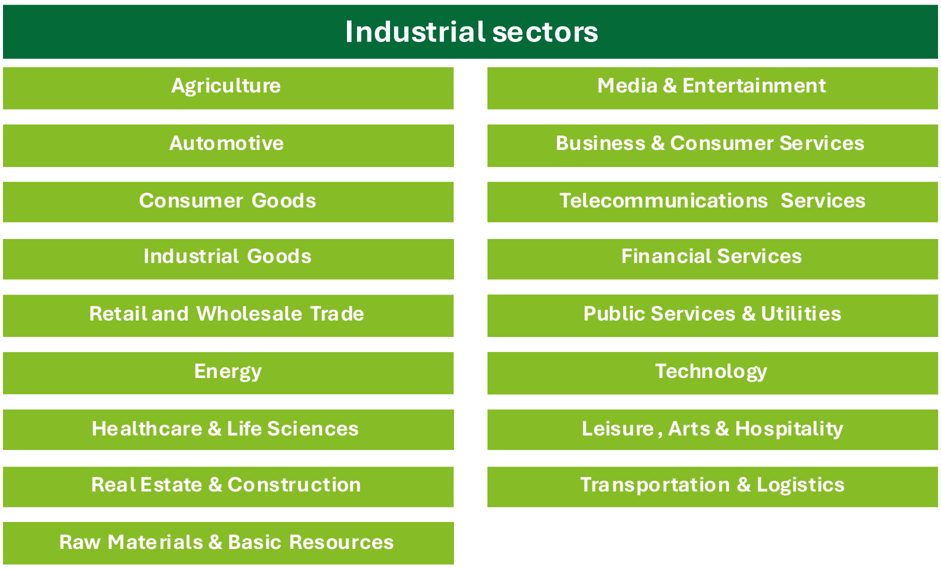
The database (Figure A1) was queried using the three previously structured queries, applying filters related to language (Italian), geographical area (Italy) and time frame (2015-2025). The query produced an initial corpus of news and press articles, including both the full text of the articles and the related metadata, such as publication date and the economic sector to which they belong, according to the classification proposed by Factiva (17 sectors, Figure A2).

Figure A1. Dow Jones Factiva Database



Source: Dow Jones Factiva.

Figure A2. Industrial sectors according to Factiva



Source: Dow Jones Factiva.

Following the extraction, the corpus was subjected to a phase of *parsing* and organization of the data aimed at building a structured dataset.

For each news item, the relevant variables were then defined, including the year of publication, the economic sector and the text of the article. The result of this process is a homogeneous dataset, suitable for the application of subsequent data cleaning and analysis operations.

Step 3: Data cleaning and preliminary analysis

The dataset obtained was subsequently subjected to a data preparation and cleaning process, aimed at transforming it into a quality dataset, suitable for subsequent computational analysis.

For example, duplicates, mainly attributable to republications of the same news item in multiple newspapers or slightly modified versions of the same article, have been identified and removed. This avoided distortions in subsequent analyses.

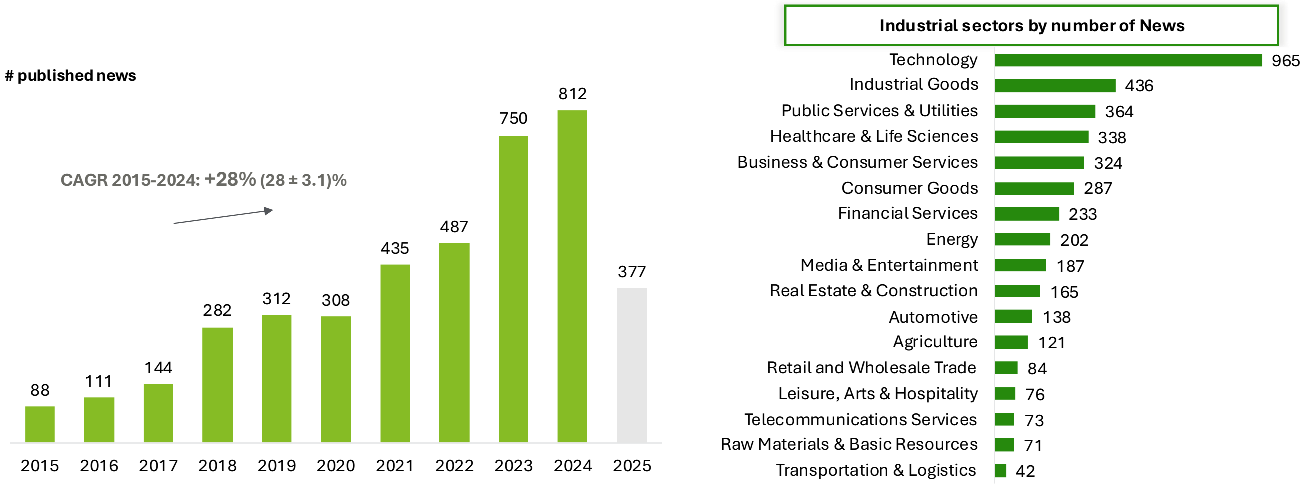
Preliminary analyses conducted on the sample obtained show a constant growth in the number of news published on mathematics in the period 2015-2024, with a compound annual growth rate (CAGR) of +28%. The technology sector emerges as the one with the highest number of articles published on the subject (Figure A3).

The data for 2025 were not included in the CAGR calculation as they were partial at the time when the analysis was carried out. The following formula was used to calculate the CAGR:

$$CAGR = \left(\frac{N_f}{N_i}\right)^{\frac{1}{n}} - 1$$

where N_f is the amount of news in 2024, N_i is the amount of news in 2015, and n is number of periods (9).

Figure A3. Distribution of news by year and by sector

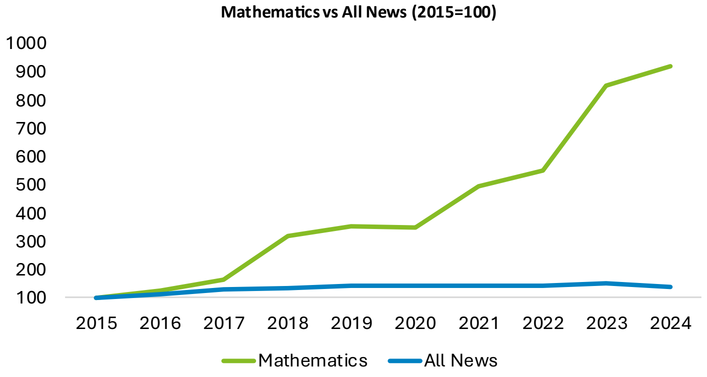


Source: Deloitte analysis on Dow Jones Factiva data. CAGR reported with 95% confidence intervals.

A spike in news is observed between 2023 and 2024, probably linked to the large-scale and mass spread of Artificial Intelligence and Large Language Models, a phenomenon triggered by the launch of ChatGPT on November 30, 2022.

To establish whether the observed growth of news on Mathematics is determined by a generalized growth of the news present in the dataset in this time frame, the evolution of the two quantities over time was graphically represented in Figure A4, through the construction of index numbers; In particular, 2015 was taken as the base year, setting a value of 100 for both variables, so as to allow a homogeneous comparison of the respective growth dynamics in the period considered. This approach makes it possible to clearly highlight the relative variations that have occurred over time, regardless of the initial absolute levels, facilitating the comparative interpretation of trends.

Figure A4. Growth of news on mathematics compared to that of all news



Source: Deloitte analysis on Dow Jones Factiva data.

Figure A4 confirms the significant growth in media coverage of mathematics over the period under consideration.

Step 4: Sentiment Analysis

Sentiment Analysis is a Natural Language Processing (NLP) technique that allows to identify and quantify the emotional tone expressed in a text. Through this approach, it is possible to distinguish content with positive, negative or neutral sentiment, and understand how opinions are expressed in the corpus of interest. In the framework of this Study, the sentiment analysis of news on mathematics allows to grasp the general perception and reputation of the discipline in the Italian media discourse.

A Transformer BERT-base model in Italian was used for the analysis[42] [43] , capable of generating bidirectional contextual representations of the text. Thanks to this architecture, the model captures the global meaning of sentences and the contextual relationships between words, overcoming the limitations of methods based on lexical dictionaries or word counts. Specifically, a model available on Hugging Face was used[44], pre-trained on general corpora in Italian and subsequently *fine-tuned* for the Sentiment Analysis task.

The classification of sentiment is carried out based on the overall representation of the document, producing a probability distribution on the three classes: positive, negative and neutral. To make sentiment interpretable along a continuous scale, a sentiment score was defined calculated as the difference between the probability of the positive class and that of the negative class. For the purposes of descriptive analysis, the continuous score was subsequently discretized through the application of a neutrality threshold, adopted to facilitate the synthesis of the results.

The application of Sentiment Analysis to the corpus has made it possible to obtain a mapping of the sentiment associated with mathematical news, highlighting positive trends (e.g. articles that underline results or innovations), critical signals (articles highlighting problems or criticalities), neutral areas (descriptive or informative news without judgment).

This representation allows for temporal comparison of perception, as well as sectoral analysis, allowing patterns and changes in the reputation of mathematics to be identified over time and across different economic domains.

Step 5: Topic Modelling

In this phase, a Topic Modelling technique was applied with the aim of automatically identifying the main topics covered in the dataset of news, articles and press releases related to mathematics and Mathematical Research, already subjected to the Sentiment Analysis phase. Topic Modelling allows to explore the latent structure of a corpus, identifying texts that share similar thematic content.

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[42] Wu, Yichao, et al. "Research on the application of deep learning-based BERT model in sentiment analysis". arXiv preprint arXiv:2403.08217 (2024).
[43] Alaparthi, Shivaji, and Manit Mishra. "BERT: A sentiment analysis odyssey". Journal of Marketing Analytics 9.2 (2021): 118-126.
[44] Hugging Face. neuraly/bert-base-italian-cased-sentiment. https://huggingface.co/neuraly/bert-base-italian-cased-sentiment

An unsupervised Topic Modelling approach based on contextual embeddings was adopted for the identification of the main themes, using the BERTopic framework[45].

The documents were represented through embeddings generated by a Transformer model, capable of capturing the global meaning of the text. In order to make the clustering process more efficient, the embeddings were subjected to a dimensionality reduction phase using UMAP (Uniform Manifold Approximation and Projection), which allows the intrinsic structure of the data to be preserved while reducing its complexity.

The reduced embeddings were then grouped through an unsupervised clustering algorithm (HDBSCAN), allowing the identification of thematically homogeneous groups of documents[46]. For each cluster, the representative keywords were extracted based on their importance within the cluster, providing an interpretable summary of the associated thematic contents. Documents initially identified as outliers by the model were reassigned to the semantically closest cluster, reducing the fragmentation of results and improving the overall coverage of the identified topics. Each cluster was then interpreted and associated with a topic, i.e. a thematic label that summarizes the content of the documents in the cluster.

The interpretation and naming of the topics were carried out based on the representative keywords and documents associated with each cluster. This process introduces a component of interpretative subjectivity. Furthermore, the results of Topic Modelling, as well as those of Sentiment Analysis, depend on the corpus analysed and reflect its characteristics, and can therefore be influenced by potential biases related to data selection.

The final analysis highlighted the presence of recurring topics attributable to different areas: school, university and education; work and companies; Artificial Intelligence and new technologies; physics and space; medicine and life sciences; STEM and gender equality; economy and financial markets; art and cultural events. These themes outline an articulated picture of the media representation of mathematics, highlighting its transversal role in scientific, technological, educational and economic-social fields.

2.3 Results

Sentiment Analysis

The analysis suggests that the prevailing sentiment of articles dealing with mathematics is neutral (73% of news). The presence of positive polarity is significant (26%), while a negative narrative related to Mathematical Research is almost absent (1%).

A possible interpretation of the prevalence of neutral sentiment in the corpus concerns the nature of mathematical news and scientific content, typically characterized by technical language and low overall semantic polarization.

Topic Modelling

The Topic Modelling analysis showed that the macro-topics that dominate the dataset in terms of frequency are:

1. Schools and university
2. Work and businesses
3. AI and quantum computing
4. Physics and astronomy
5. Medicine and life sciences

These five macro-categories together cover about 78% of the dataset, highlighting the thematic pillars around which the public narrative of mathematics revolves. In addition, the topic related to Artificial Intelligence and quantum computing is the one that records the most marked growth in the period analysed (CAGR 2015-2024 +64%).

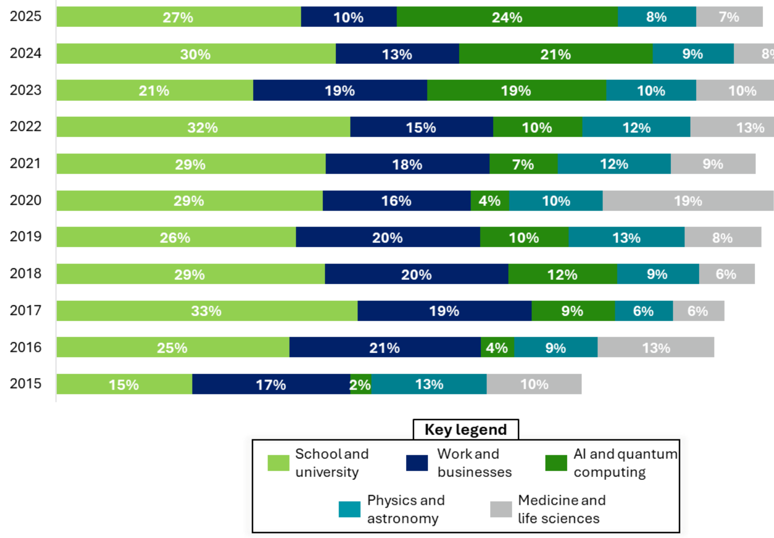
The granular analysis of the weight of the topics by year and by industry sector revealed interesting dynamics regarding the individual macro-topics.

For example, as Figure A5 illustrates, in 2020 "Medicine and life sciences" emerged as the second most frequent topic after "School and university", reflecting the importance of mathematics in health and epidemiological research during the Covid-19 pandemic.

[45] Scarpino, Ileana, et al. "Investigating topic modeling techniques to extract meaningful insights in Italian long COVID narration". *BioTech* 11.3 (2022): 41.
[46] Ajinaja, Micheal Olalekan, et al. "A Comparative Evaluation of Probabilistic and Transformer-Based Topic Models Across Diverse and Multilingual Text Corpora". Neural Processing Letters 58.1 (2026): 9.

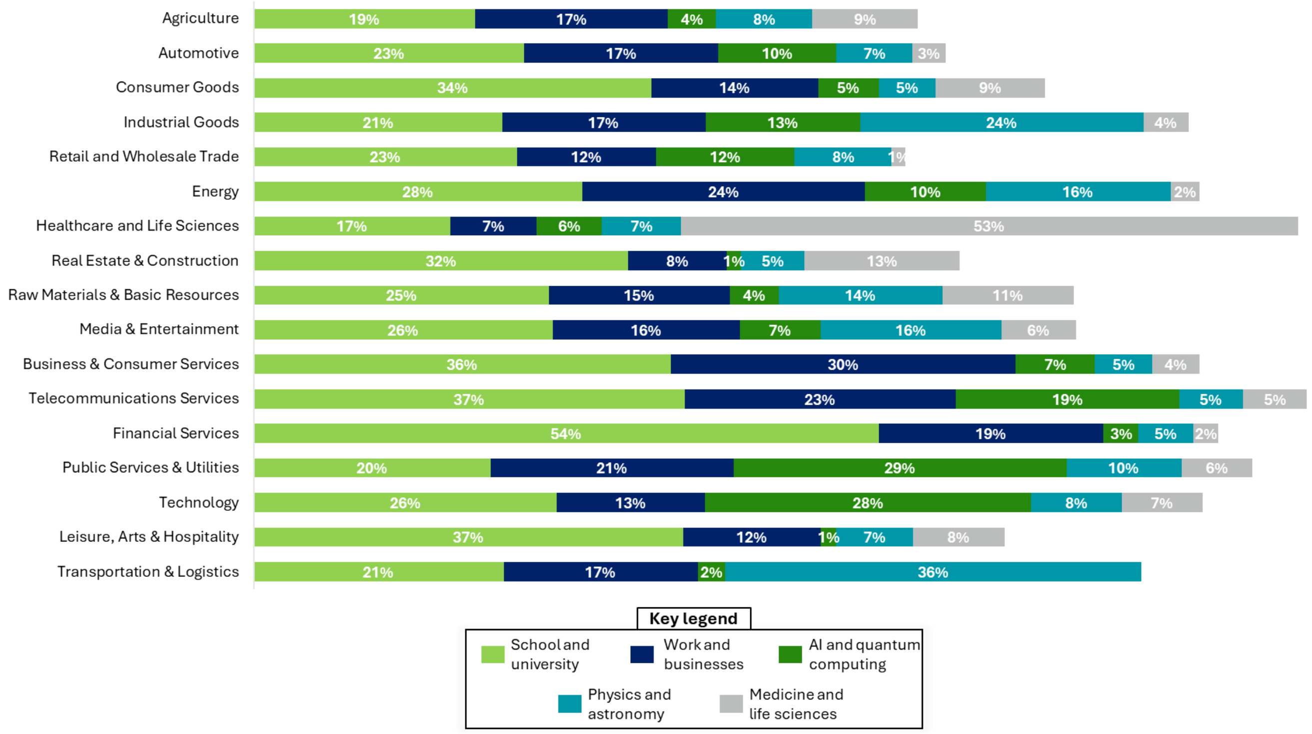
Furthermore, as far as the Technology industry is concerned, the predominant topic is "AI and quantum computing", as shown in Figure A6, confirming how mathematics is perceived as fundamental for contemporary technological innovation.

Figure A5. Topic Modelling – Weight per year of the 5 main topics



Source: Deloitte analysis on Dow Jones Factiva data.

Figure A6. Topic Modelling – Weight by sector of the 5 main topics



Source: Deloitte analysis on Dow Jones Factiva data.

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