

April 2024. Technological snapshot

Artificial intelligence in Catalonia

Artificial intelligence in Catalonia. Technological snapshot.

ACCIÓ
Government of Catalonia



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Carried out by

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Collaboration

Secretariat of Digital Policies. Directorate General of Innovation and Digital Economy

Barcelona, April 2024

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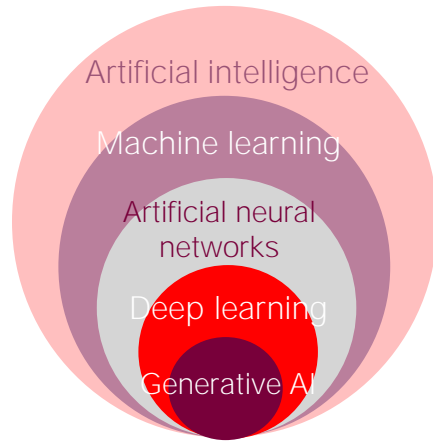
Executive summary of artificial intelligence in Catalonia (I)

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Artificial intelligence is a machine's ability to exhibit abilities similar to human intelligence, such as reasoning, learning, planning, and creativity.



AI disciplines



Main applications

Health	Industry	Marketing
Mobility & logistics	Agriculture	Cultural ind.
Energy	Society	Security
E-commerce	Finance & banking	Environment
Education	Cybersecurity	Art and creativity



Importance of AI

Customization of the user experience

Innovation and competitive edge

Help with decision-making

Automation and efficiency

Transversality



Boom of **generative AI**: models that take raw data and learn to generate high-quality contents



World Market

- With **annual growth amounting to 35.5%**, AI is expected to achieve a **1.85 trillion-dollar** market value by 2030.
- The main AI countries are the **United States**, **China** and **Japan**, while the **EU** is a reference for the implementation of the first specific law on artificial intelligence.



Opportunities stemming from AI

- Improved productivity, new capabilities and enhanced calculations
- Disruptive, cross-cutting, democratizing and accessible technology
- Key to the 4.0 and 5.0 revolutions
- Commitment to AI by public institutions and the private sector
- Technological cooperation with developing regions



Challenges stemming from AI

- Increased consumption of resources such as energy and water
- Changes in the labor structure and increasing inequalities and digital divide
- Increased cybersecurity risks
- A new geopolitical weapon in a fragmented world
- Generation of fake news putting political regimes at risk

Executive summary of artificial intelligence in Catalonia (II)

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488 companies along the value chain



173% more companies than in 2019.


€2,155 M turnover (0.8% of the Catalan GDP).


14,525 jobs.

43.9% of the companies are startups.

Highlights:

For developed technology:

 Machine learning (57.8%)

 AI platforms (31.8%)

By sector of application:

 Services (45.1%)

 Industry (40.8%)



Leading AI startups

Barcelona, the **leading** city in terms of **funding rounds** for AI startups in southern Europe

The **AI startups in Barcelona** complete, on average, **1 round** valued at **€2.1 M** every **18 days**



Attractive for AI-intensive international companies

1st region in **southern Europe** for **foreign investment** in the last five years (2019-2023).

Foreign investment in AI in Catalonia in 2023 (€289 M) accounted for **54.7% of the total** invested in **AI in the whole of Spain**.

87% of the 140 technological hubs of foreign companies based in Catalonia focus on AI.



Benchmarking Initiatives

CATALONIA.AI

AIRA

Salut/IA

CIDAI

XARXA RDI-IA

DCA

OEIAC

Aina

DIH-CAT



R&D excellence

3rd largest region in terms of **AI Horizon** funding

29 major technological and research centers



A unit of the **Ellis** network is based in Barcelona

1. Definition of artificial intelligence

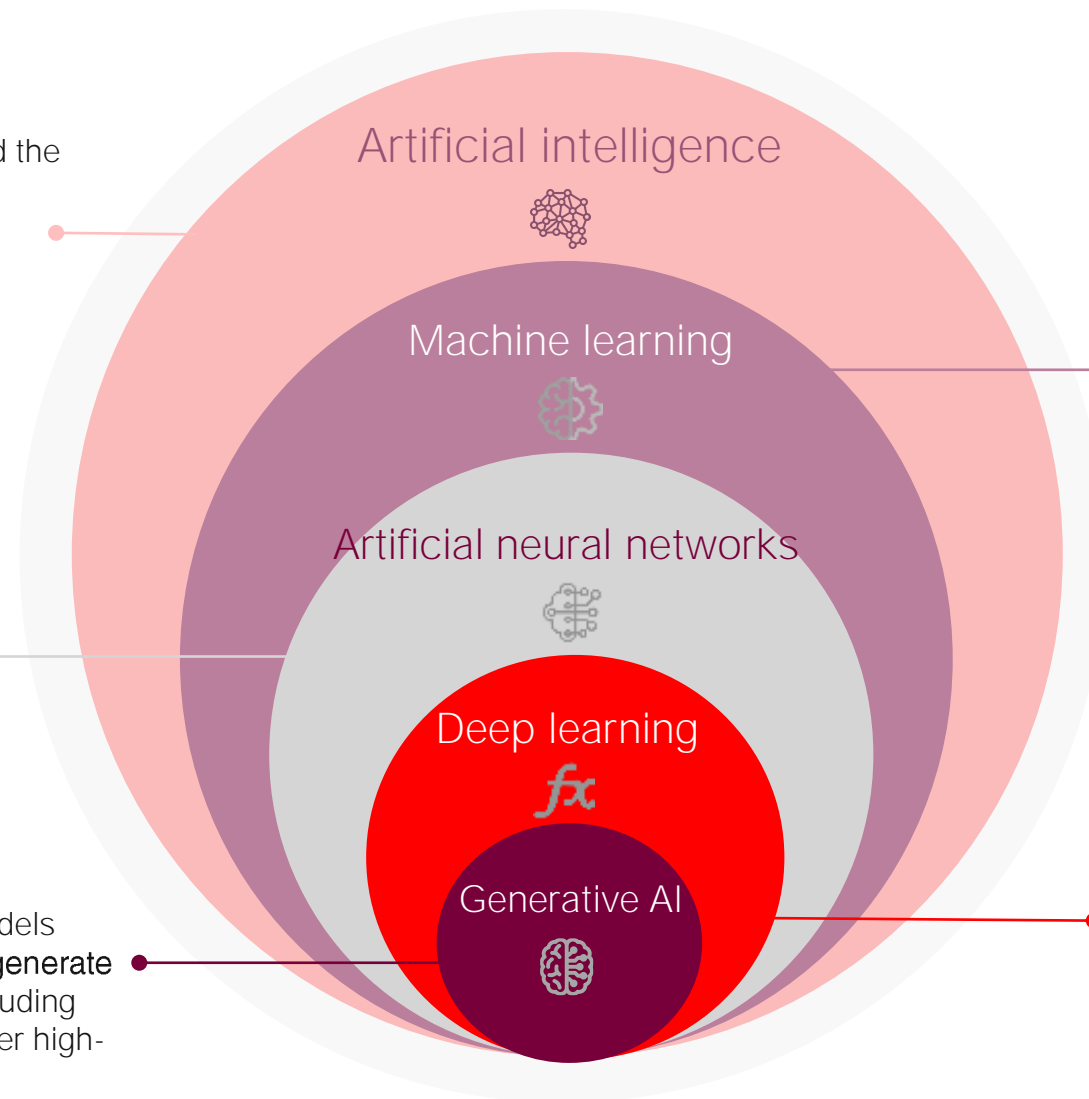
Artificial intelligence

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Artificial intelligence is a discipline that combines computing, data processing and the automatic management of knowledge to resolve complex problems.

Artificial neural networks form a subset of machine learning and they lie at the heart of deep learning algorithms. Both the name and the structure are inspired by the human brain, mimicking the way in which biological neurons communicate with each other. Artificial neural networks must be trained with datasets to learn and they can improve their accuracy as they process more data.

Generative AI refers to deep learning models which, based on raw data, can “learn” to generate more plausible results for each query, including texts, images, video, code, music and other high-quality contents.



Machine learning is a branch of artificial intelligence that focuses on algorithms for intensive data processing in order to learn complex patterns of reality so that it can be shaped. Some may gradually improve their accuracy as they process more data.

Deep learning is a kind of artificial neural network that uses more complex operators, and it is able to resolve more complex problems with higher quality and less computing time.

Convergence of AI and other technologies

8

The boom of artificial intelligence is linked to the synchronized maturing of several technologies, including:



Semiconductors and microelectronics



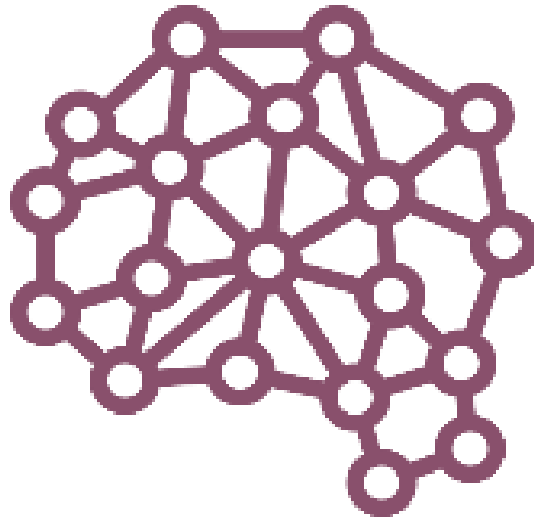
Data architecture



Wearable devices and smart sensors



Cloud and edge



New space

Connectivity and networks (5G)



Supercomputing



Quantum

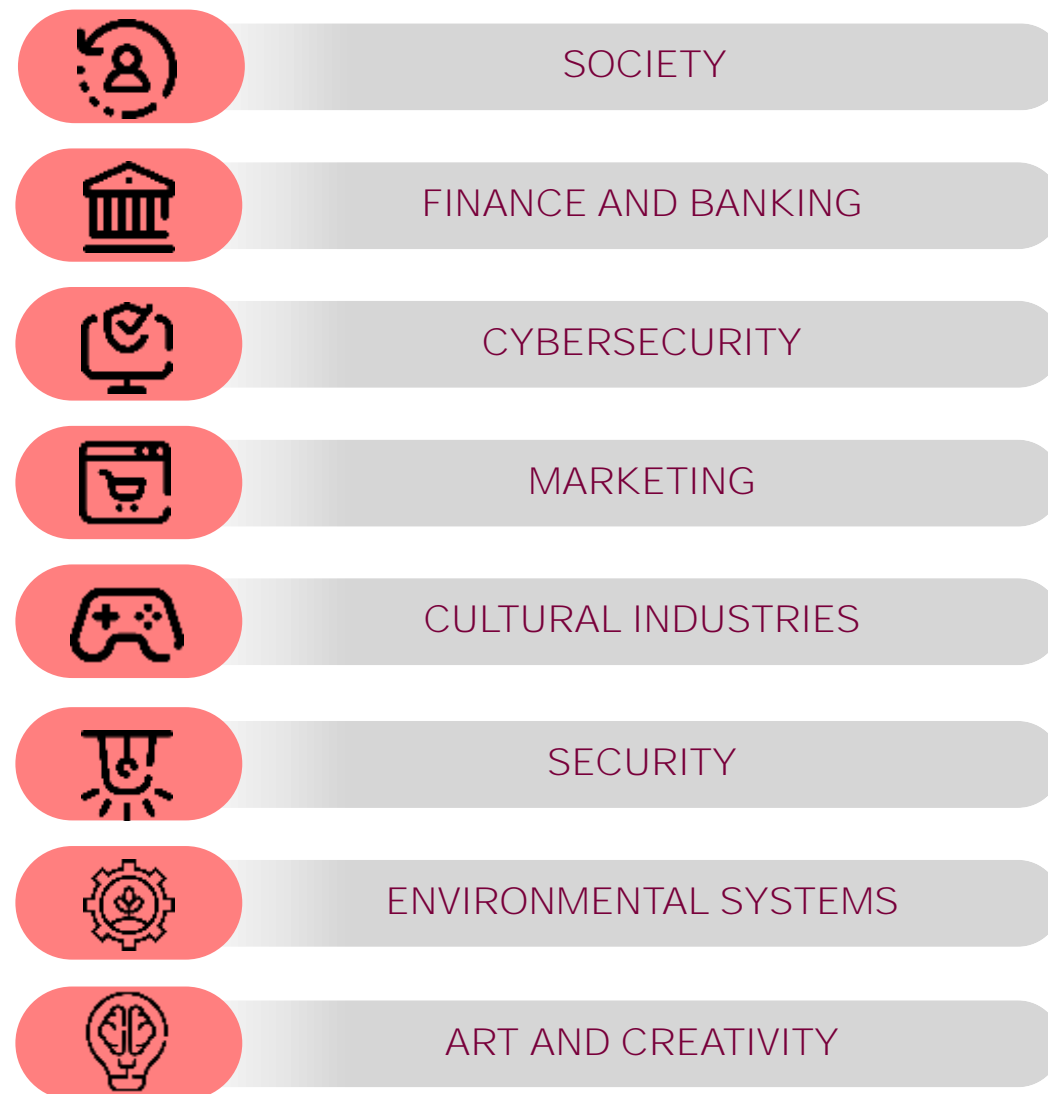
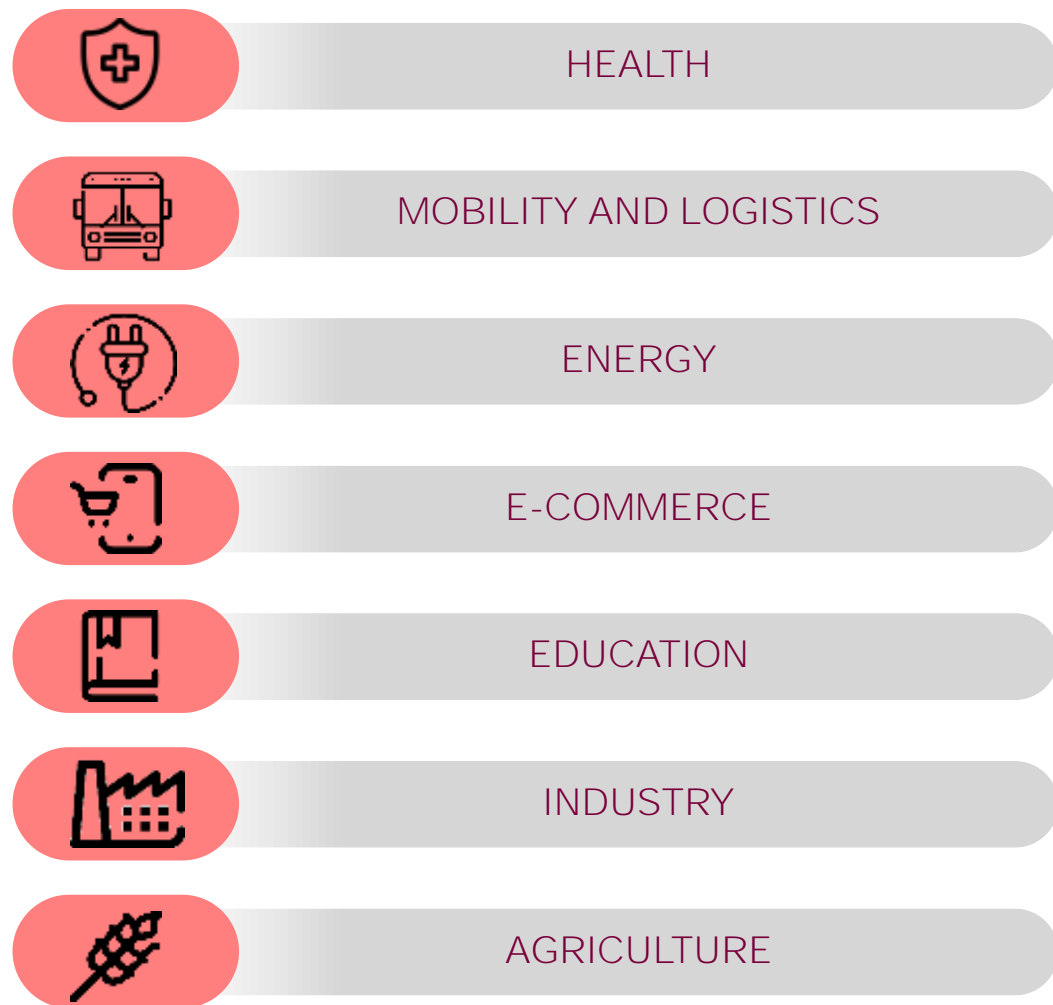


Blockchain



Applications of artificial intelligence

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Importance of artificial intelligence

10

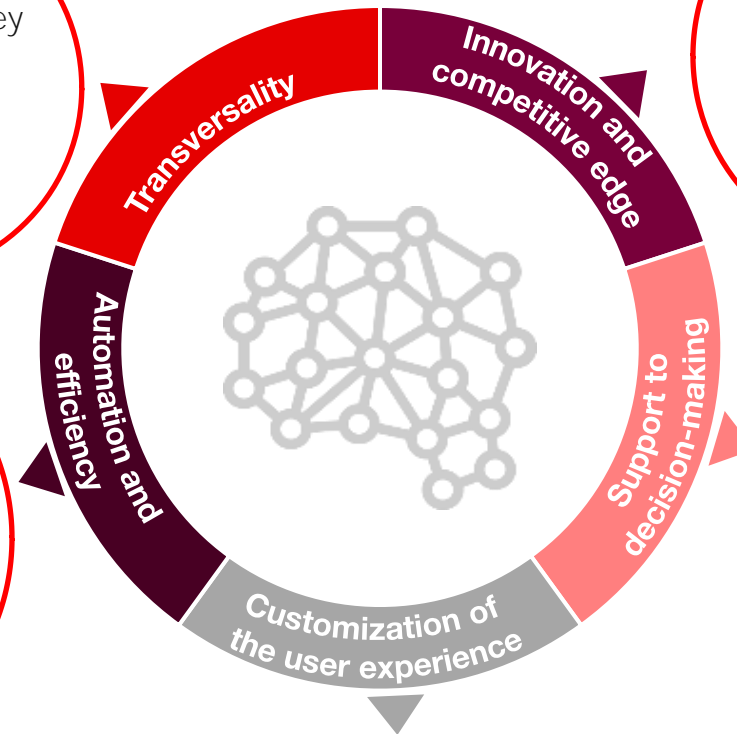
The impact that AI will have on the markets and business models will be far-reaching. AI will be key to the Industry 4.0 revolution and the creation of **added value in all market segments**. It's a technology from which many industries will benefit, including sectors such as cybersecurity, telecommunications, banking and e-commerce.

AI permits process and production automation, predictive maintenance and smart inventory and energy consumption management, as well as demand planning and the optimization of the entire supply chain. RPA (robotic process automation) or software robotics uses automation techniques in transactional tasks and it can accelerate the digital transformation.

In areas such as retail sales, marketing and e-commerce, **AI-based systems can help understand users'** preferences and behavior. This facilitates personalized recommendations and tailored customer service bots to improve the user experience and seek customer loyalty. In public administration, AI can use these customized recommendations to build proactive systems that improve citizen satisfaction by better meeting their needs.

AI has strategic value that can reduce costs and improve productivity. Industries that adopt AI technologies can acquire a competitive edge by being more streamlined, innovative and better able to adapt to rapidly evolving environments. AI permits faster and more accurate product development by simulating and modeling various scenarios. It helps identify design flaws, predict outcomes and rationalize the innovation process.

Smart decision-making support systems are complex systems that combine different predictive, descriptive or reasoning-based models that can process knowledge and data in an integrated manner and help organizations make decisions ranging from those on a more operational level, such as predictive maintenance, to more strategic ones, such as designing new products and anticipating potential unwanted scenarios.



Artificial intelligence in Catalonia

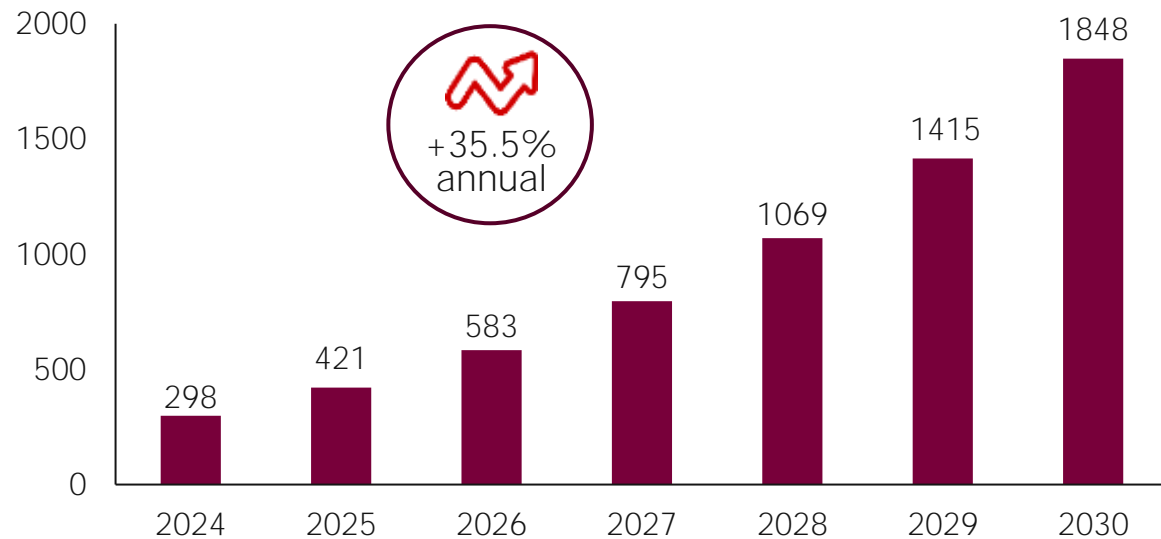
2. World artificial intelligence market

Global data and prospects for AI

12

On a global scale, a significant increase in the contribution of AI to the GDP is predicted until 2030, related to the sustained growth of investment and the development of AI by companies, which are placing increasing importance on it in order to enter new markets with new business models.

Evolution of the volume of the world AI market (thousands of millions of dollars)



With annual growth amounting to 35.5%, AI is expected to achieve a 1.85 trillion-dollar market value by 2030.



An increase in the GDP is expected in Europe, resulting in a total of 84 thousand million dollars, which will be reflected in annual growth amounting to 15.9% between 2024 and 2030.

Main regions of importance in the world

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All the regions will experience the benefits of AI by 2030, especially Asia and North America.



Asia

Has established itself as the leading region in the AI market

China, South Korea, Singapore and Japan have made major investments in AI R&D and implementation, placing Asia second in the global ranking.



The Americas

At the forefront of AI adoption and innovation

North America will hold the highest market share in the world until 2030 in terms of AI adoption, thanks to the development of generative AI.



Europe

Sustained growth until 2030 and great potential for innovation in AI

Europe is establishing itself as one of the most powerful regions in terms of AI innovation, with the United Kingdom, France and Germany as the leading countries.

The EU has a pioneering regulatory framework which is expected to bring advantages to local companies.



Leading global AI companies (by turnover)



3. Generative artificial intelligence

Definition of generative artificial intelligence

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Generative AI is the branch of AI refers to deep learning models which, **based on raw data, can “learn” to generate more plausible results for each query**, including texts, images, video, code, music and other high-quality contents.

- Automatic generation programs are programmed for use in a variety of fields, including the design of drugs, new material compositions and synthetic data generation.
- This technology uses non-supervised and semi-supervised learning to identify the abstract or underlying pattern of the input request to generate unique content, such as text, software codes, images, audio and video.
- An auto-generation program uses algorithms powered by machine learning/deep learning to create systematized and optimized human-like output.



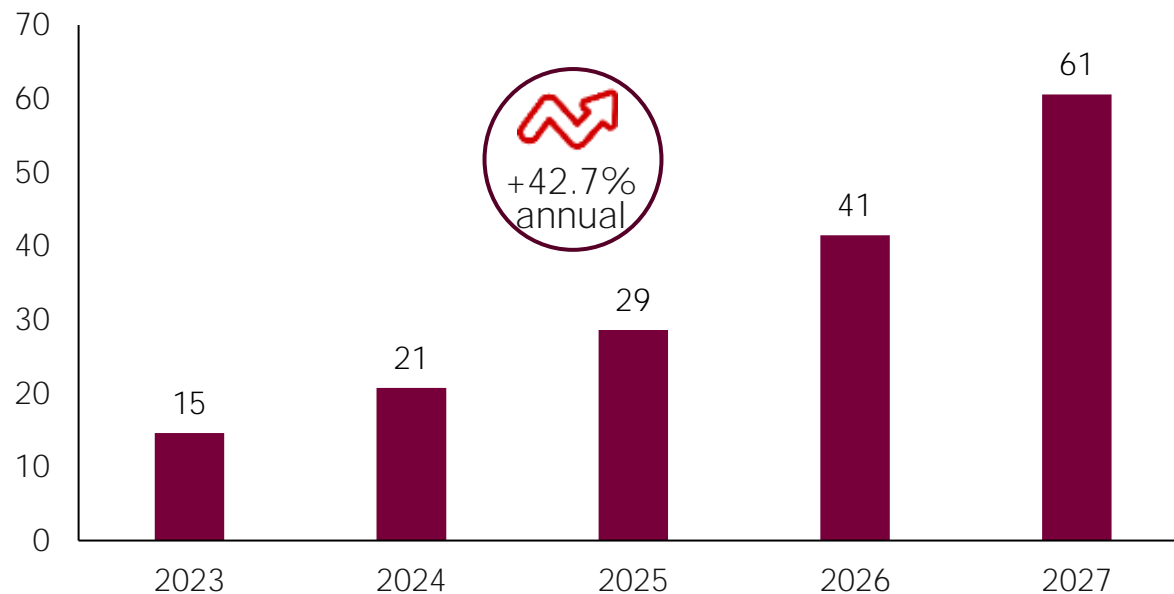
Sources: CIDAI, IBM, MIT, CBI, Dealroom and Databrick

Potential market for generative AI

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A significant increase in the potential market for generative AI is expected, thanks to the evolution of learning models that have led to major improvements in the creation of content, mainly in the form of text, images, audio and video.

Evolution of the global generative AI market (thousands of millions of dollars)



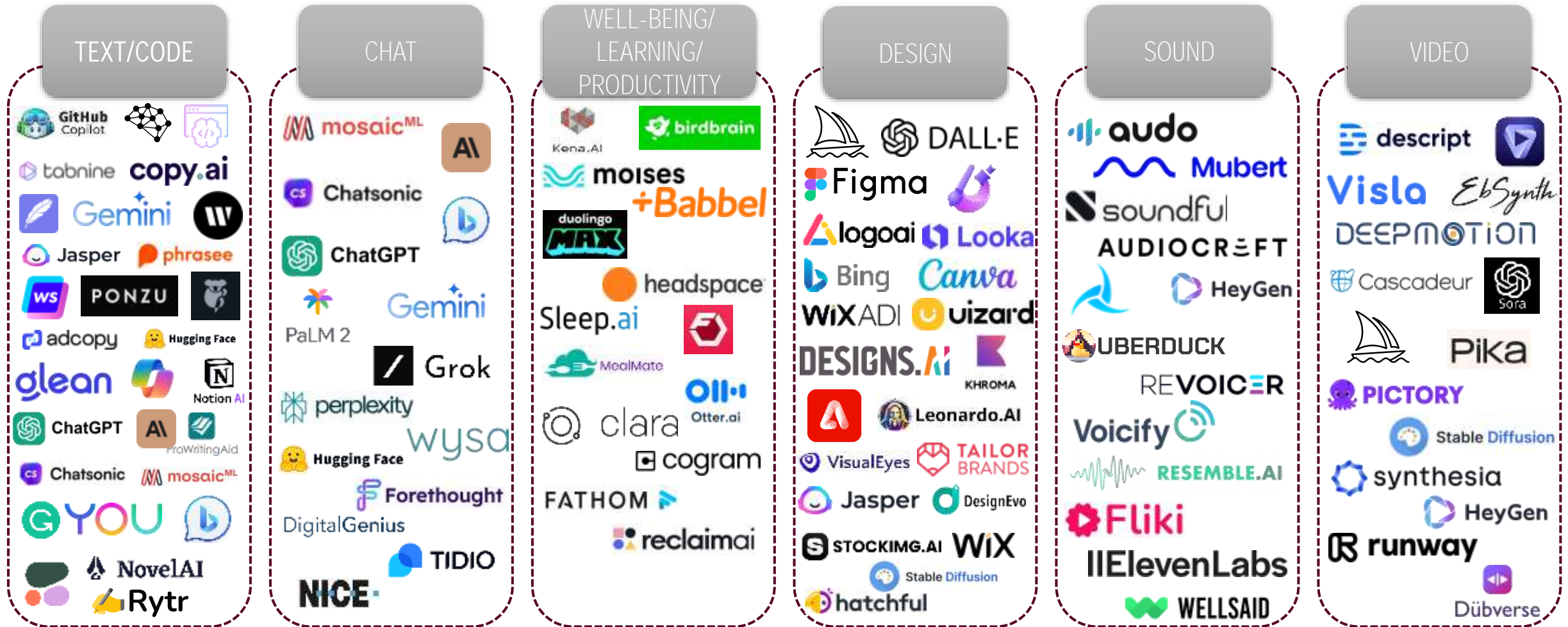
Growth of the market due to the rapid adoption of generative programs in various areas of application and industries such as the media, entertainment and information technology.

The improved self-generating models will increase usage and the applications in several new fields.



Main generative AI apps

18



Partial illustrative image.

Source: the authors

Impact of generative AI in the main regions

19

North America is the world leader in the adoption of generative AI programs.



Asia-Pacific

The regional market, which includes the technologically experienced and rapidly-growing economies of China and India, is expected to grow at the highest rate worldwide.

With platforms like ChatGPT blocked in China, local companies are producing native generative AI tools which are compliant with the strict local regulations and based on local reference data.

Homegrown Baidu has launched its generative AI chatbot called ERNIE Bot.



North America

North America has the highest number of patents submitted in the world, positioning itself as the leader in the global market.

The synthetic generation of text-based messages and images covers approximately one third of all the marketing communication of large companies in the region.



Europe

Europe is poised for rapid and high adoption, but new regulations for generative technologies have been proposed and they may have an impact on their development and implementation.

The debate on compliance with the directive on data protection and intellectual property is still going on.

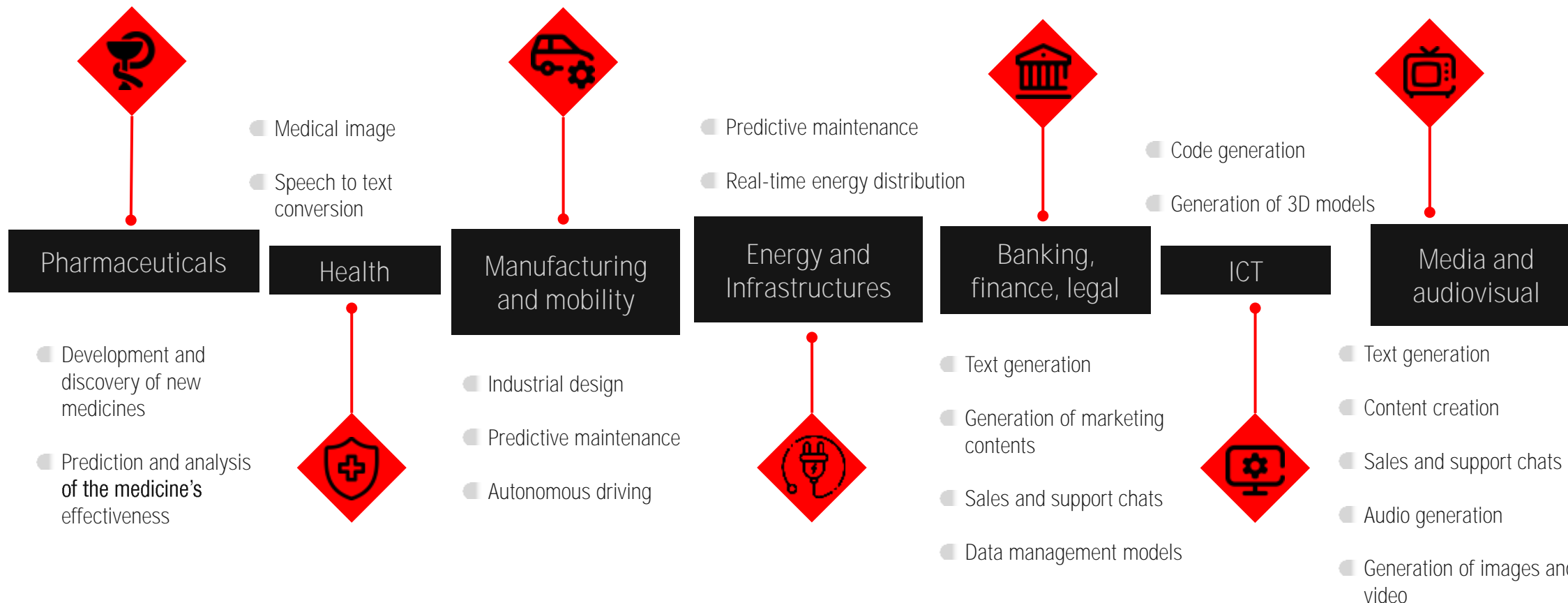
The Stability AI startup based in London has developed Stable Diffusion, a generative AI image generator.

Source: Frost & Sullivan

Applications of generative AI

20

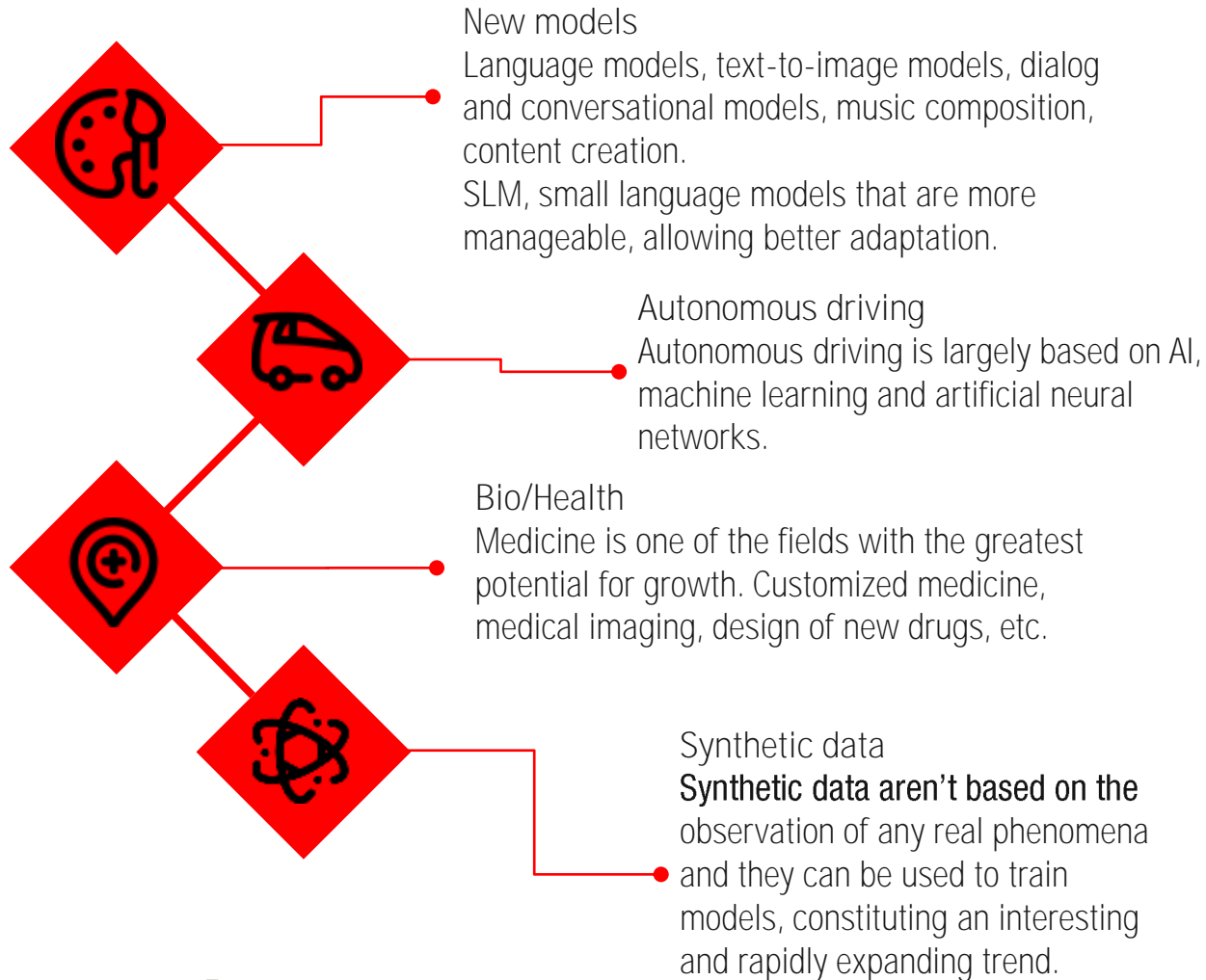
The main applications are expected in the field of written contents, support for content creation, video and audio generation. Code generation is another area in which it can prove highly useful.



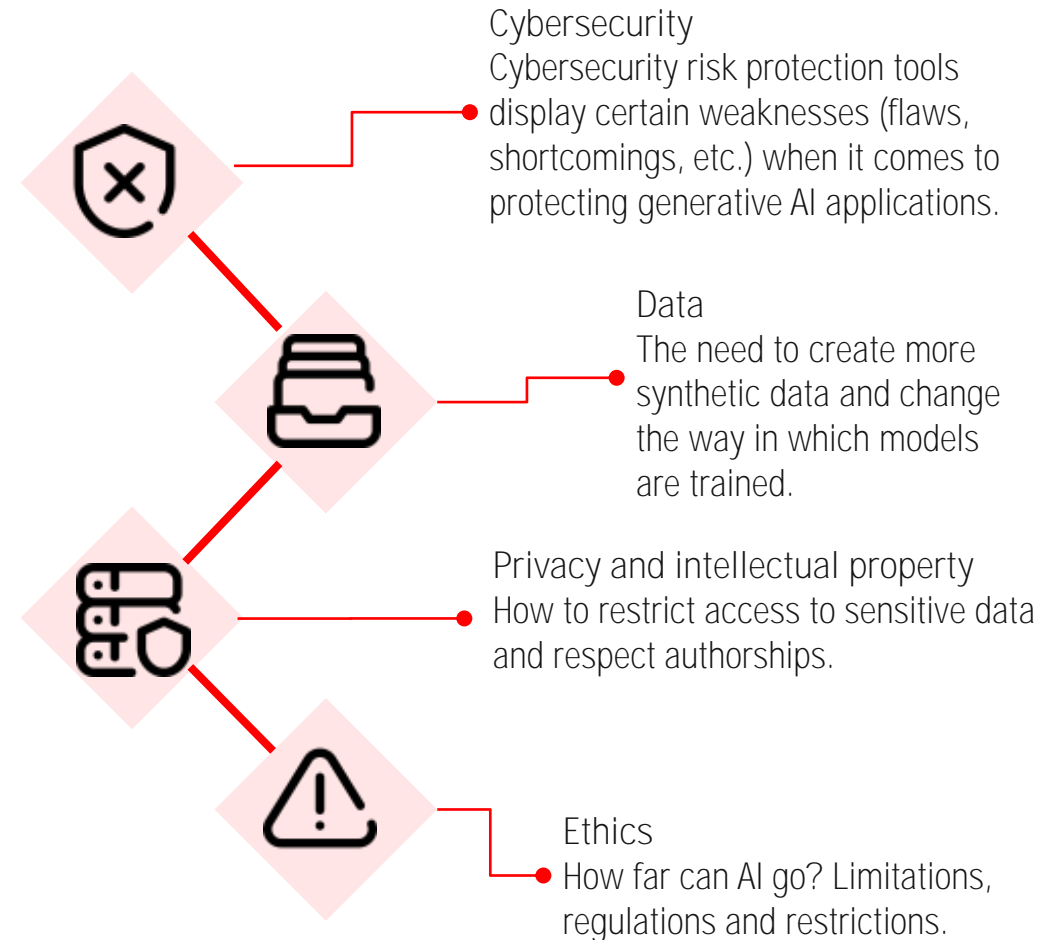
Trends and challenges stemming from generative AI

21

Trends



Challenges



Sources: Frost & Sullivan, CB Insights, McKinsey and Dealroom

4. Artificial intelligence ethics and regulatory framework

Ethics in AI. What risks does AI entail?

23

- AI offers great opportunities and endless applications in multiple fields. However, it's a technology that entails risks and doubts in the ethical field when it comes to applying it. The risks that AI may entail include:



Algorithmic biases: gender, ethnicity, origin, age, etc.

Inappropriate uses that threaten fundamental rights: facial biometric recognition, access to and use of private data, violations of copyright in the use of data for training, creation of fake images, news and videos, hacking, a lack of transparency in apps or devices using AI, etc.



Unpredictability and legal liability: AI displays great complexity, autonomy and self-learning capacity, thus posing a challenge in the legislative field (predictability of the standard); compensation for wrongful injuries or damage to a person or property; there is no clear regulation regarding copyright for AI creations.

Lack of human control over autonomous intelligent systems that use AI (e.g. autonomous vehicles).



Underuse and overuse of AI: lost investment opportunities regarding AI, lack of use (distrust) and excessive use (uselessness of applications) can entail budgetary and competitive risks.

Rethinking and automation of jobs: the use of AI will substantially impact and transform workplaces based on automatable tasks and precipitate the reshaping of others. Jobs regarded as automatable will undergo a loss of prestige.



AI Act: the European Union leading the world

24

- On 13 March 2024, the European Parliament approved a proposal for harmonized rules with regard to artificial intelligence (the so-called **“AI Act”**). The Regulation seeks to ensure that AI systems deployed and used in the EU are secure and that they respect fundamental **rights and the EU’s values**. This historic legislation also aims to stimulate investment and innovation in AI in Europe. Its application is expected to begin in 2026, with the exception of the most restrictive cases, which will apply as early as 2025.
- A layer of horizontal legal protection is established in the use and commercialisation of AI, with different prohibitions and obligations, depending on the level of risk of the AI systems: limited risk (with transparency and consumer information obligations), high risk (which must meet strict security and technical requirements for access to the market), and prohibited or unacceptable risk (which are not allowed, e.g.: cognitive-behavioral manipulation).



Categorization and examples of supplier obligations in accordance with the level of risk of AI systems



Limited	High Risk	Unacceptable
Obligation Transparency	AI security accreditation	Cognitive-behavioral manipulation
Recognition AI authorship	Technical guarantee and fundamental rights	Social score and predictive policing
Information for users	Reinforced Responsibilities suppliers	Recognition of emotions and biometrics

Source: Council of the European Union

Artificial intelligence initiatives in Spain

25

Digital Spain Agenda 2026

The National Strategy for Artificial Intelligence (ENIA) assigned **€600 M** of initial investment in the 2021-2023 period to over 250 projects

Territorial Technological Specialization Networks (RETECH)

The AI RETECH initiative is intended for 13 digital transformation projects throughout the territory.

€259 M in mobilized investments of the

€500 M of total investment allocated to the program

EECTI 2021-2027

The 23 strategic lines of the 2021-2027 Spanish Science, Technology and Innovation Strategy (EECTI) include the specific AI line.

Fund - ICO Next Tech

Initiative that acts primarily in the digital and AI sectors

Fund endowed with **€4,000 M**

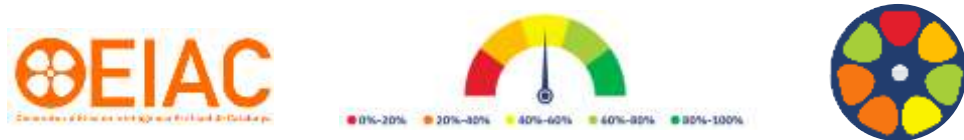
PRTR - Next Generation EU

Component 16: National AI Strategy with a **€540 M** budget is exclusively assigned to artificial intelligence.

KIT Digital

An instrument that subsidizes the implementation in companies of digital solutions such as AI to achieve significant progress in the level of digital maturity.

The OEIAC's PIO self-assessment model



In coherence with the European Regulation of the AI Act and within the framework of the Catalan Catalan.AI Strategy, the Catalan Observatory for Ethics in Artificial Intelligence (OEIAC) has implemented a PIO self-assessment model (Principles, Indicators and Observables) designed for any public or private institution and any user considering the use of AI technologies and wishing to evaluate the risks and benefits of using this technology. Using the answers to 70 questions/indicators based on seven ethical principles, the model provides observable and quantifiable results. This self-assessment model can **therefore measure the AI's degree of compliance with the principles and ethical guidelines** and generate an indicator/meter.

Catalan charter for digital rights and responsibilities

The Catalan charter for digital rights and responsibilities includes human rights accepted until now that require an updated implementation with their digital version (digital rights). Likewise, a perspective of expanding fundamental freedoms is taken into account in order to contribute to the construction of emerging rights. The digital rights and responsibilities proposed in the charter are addressed to society as a whole and all natural and legal persons, including companies, non-profit organizations and public institutions. It is a declaration of rights undergoing constant construction which is open to the public. The areas covered by the charter include universal Internet access; an open governance model; freedom of expression; digital innovation; data protection; guaranteed skills and digital inclusion; mechanisms for safeguarding digital rights; and ethics in the field of AI and algorithmic governance in the public and private sector.

Sources: OEIAC and Ministry of Digital Policies and Public Administration

5. Opportunities and challenges stemming from artificial intelligence

Opportunities and challenges stemming from AI

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Opportunities



Improved productivity, new capabilities and enhanced calculations



Disruptive, cross-cutting, democratizing and accessible technology



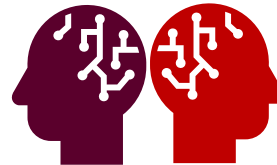
Key to the 4.0 and 5.0 revolutions



Public institutions and the private sector are committing to AI



Technological cooperation with developing regions



Challenges

Increased consumption of resources such as energy and water



Changes in the labor structure and increasing inequalities and digital divide



Increased cybersecurity risks



A new geopolitical weapon in a fragmented world



Generation of fake news putting political regimes at risk



Artificial intelligence in Catalonia

6. Artificial intelligence in Catalonia

Mapping of the artificial intelligence ecosystem in Catalonia

30



87.8% are SMEs.

55.3% are less than 10 years old.
43.9% are startups.

38.5% invoice more than one million euros and 16.8% invoice over 10 million euros.

27.3% are exporters.

Developed technology includes machine learning companies (57.8%) and AI platforms (31.8%), and the sectors of application include services (45.1%) and industry (40.8%)**.

**With respect to the mapping data obtained in 2019.*

***Companies may be classified for more than one technology and sector of application.*

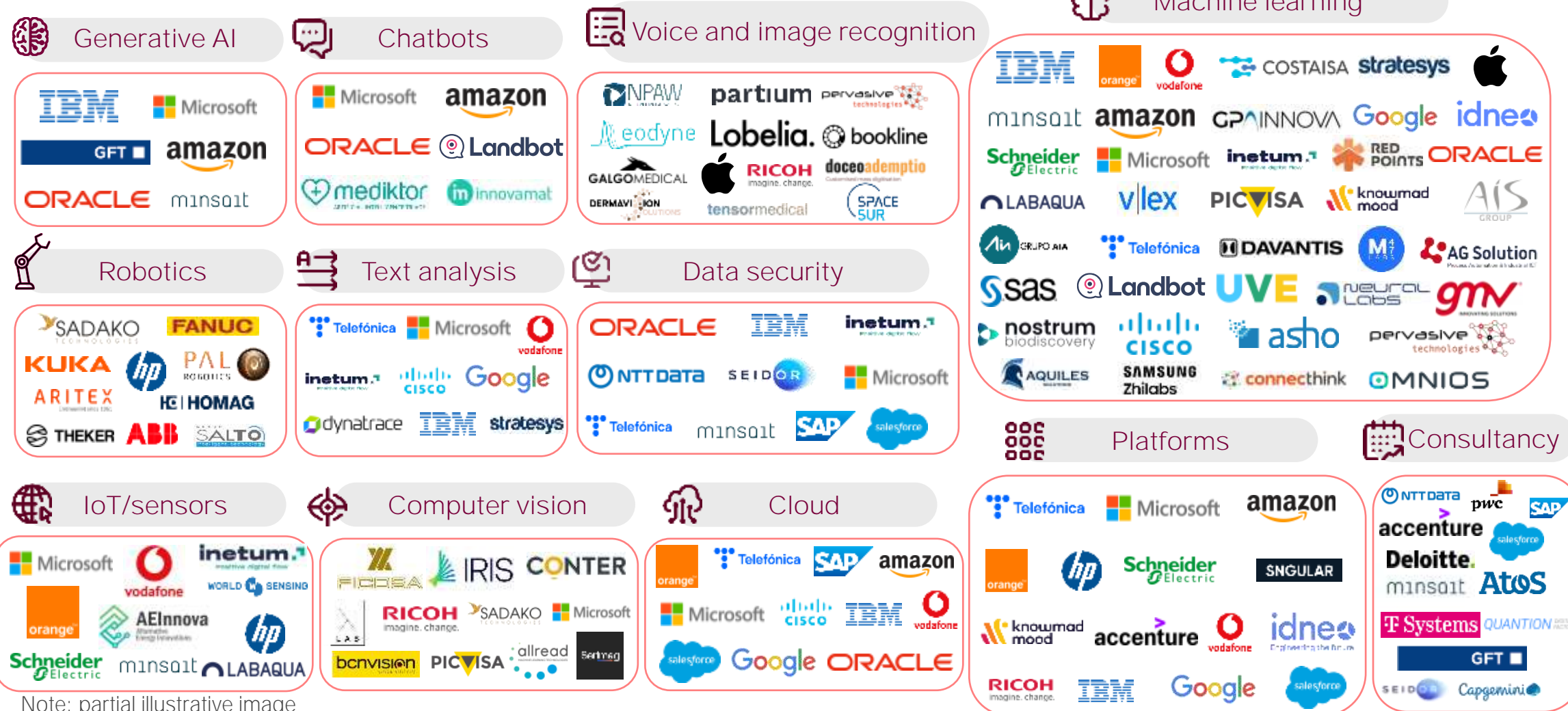


Source: ACCIÓ (2023 company data; turnover and number of employees in 2022)

Leading artificial intelligence companies in Catalonia (I)

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According to the area of technological specialization

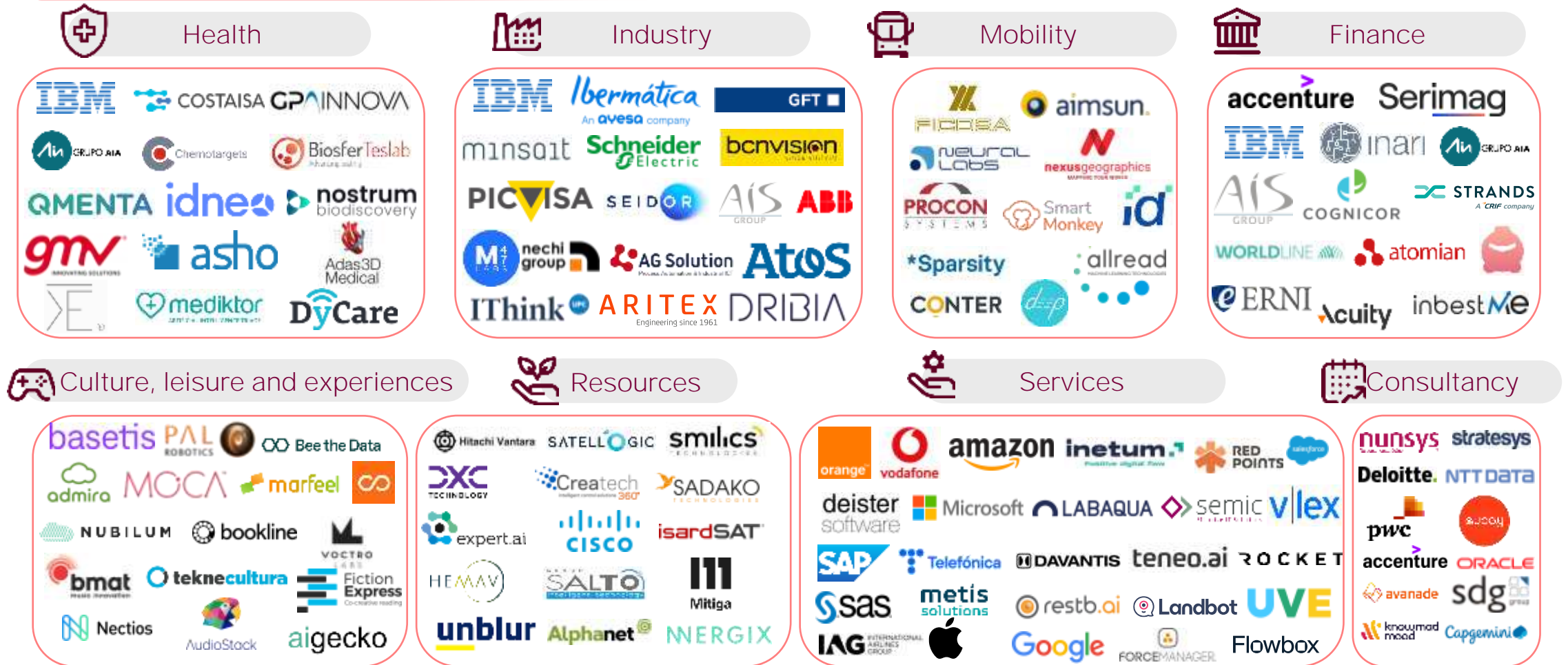


Note: partial illustrative image

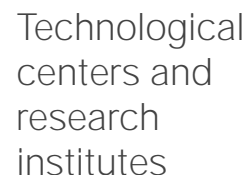
Leading artificial intelligence companies in Catalonia (II)

32

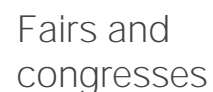
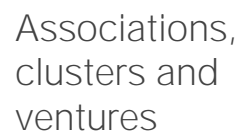
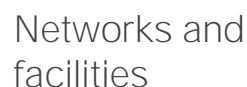
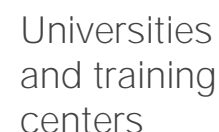
According to the sector of application



Note: partial illustrative image



+72 AI-intensive research groups



AGAUR AI research groups in Catalonia

34



Initiatives to promote AI in Catalonia

35



Actions to turn Catalonia into a hub of innovation, leadership and talent attraction and companies in the field of AI.



Partnership to promote excellent inter-disciplinary international research and talent management through new attraction and retention mechanisms.



Initiative that brings together the main emerging technological sectors in Catalonia in a partnership of innovative, visionary, disruptive and collaborative technological communities.



Axis of the Catalan AI strategy to promote the development of collaborative projects and the transfer of knowledge of innovative solutions in applied AI.



Initiative to study the ethical, social and legal consequences, the risks and the opportunities stemming from the implementation of AI from a transdisciplinary-transversal standpoint.



AI project that seeks to generate corpus and computer models of the Catalan language.



A connected network of assets, infrastructures and knowledge in Catalonia geared towards testing and experimenting with advanced digital technologies.



Program for the promotion and development of AI in the health system from an ethical standpoint, respecting privacy and ensuring compliance with fundamental rights and non-discrimination.



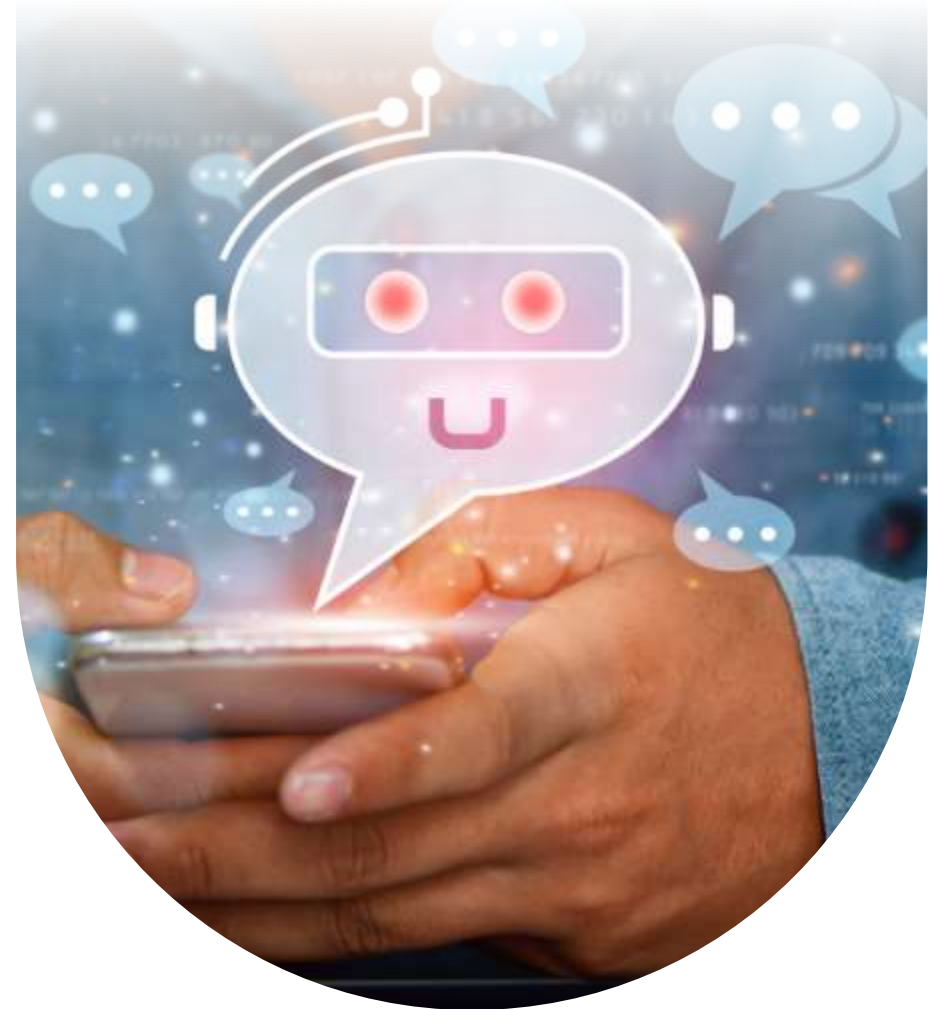
Instrument to equip the Catalan AI ecosystem with technological transfer mechanisms and knowledge valorisation.

The Government of Catalonia promotes the first response chat based on generative AI in Catalan

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- The Government has launched the first generative artificial intelligence chatbot in **Catalan, based on the artificial language of the Google Cloud's Vertex AI platform**. It's an experimental project created in partnership with the Secretariat of Telecommunications and Digital Transformation, the Ministry of Business and Labor, Capgemini and Google Cloud.
- The application of this generative artificial intelligence project in Catalan will begin to generate automatic responses to the queries, complaints and suggestions that citizens send to the Business Management Office (OGE) of the Government of **Catalonia**. **Given that it's an experimental system, in order to guarantee the quality of the information, the OGE staff will review the answers generated by the system.**
- The agreement between the technology companies and the Government will enable the rest of the market to exploit the generation of intelligent automatic responses in Catalan for any area and business sector.

This system seeks to reduce the response time to citizens and improve public services, with the aim of endowing the Administration with flexibility, innovation and **technological solutions focused on people's needs**. The aim is also to achieve greater content creation in Catalan based on generative AI and the new digital tools.



Source: Open Administration of Catalonia (AOC)

CataloniaConnects

Google Cloud



Vertex AI



ACCIÓ
Catalonia
Trade & Investment



Generalitat de Catalunya
Government of Catalonia

Catalonia is a benchmark in Horizon Europe AI research projects

37

AI projects in Catalonia

95 projects

65 million euros

3.5% of the European total

31.9% of the total for the whole of Spain

Ranking by regions

- 1 Île-de-France
- 2 Upper Bavaria
- 3 **Catalonia**
- 4 Community of Madrid
- 5 Attica



74 institutions



*the main ones are highlighted

Note 1: Includes Horizon Europe projects (2021-2023) related to artificial intelligence, machine learning, deep learning, natural language processing and computer vision.

Note 2: Catalonia is under-represented, given that the centers associated with the CSIC, such as the IIIA (located in Cerdanyola del Vallès), take into account all the projects and funding to the Community of Madrid.

Technological hubs in Catalonia focused on AI in 2023

38



140 technological hubs of foreign companies

+11% compared with the previous year



5,200 new jobs



€500 M
turnover

Some of the most representative hubs in Catalonia focused on AI:

AstraZeneca



Boehringer
Ingelheim

CISCO

dynatrace

FUJITSU



IBM

Microsoft

Nestlé

NTT DATA

ocado
TECHNOLOGY

ORACLE

PEPSICO



sanofi

Schneider
Electric

SEAT CODE

T Systems

VOLKSWAGEN
GROUP SERVICES

United States

(with 28% of all hubs) the main source country for investment in these centers, followed by Germany (17%).

59% of hubs

come from companies in European countries.

AI (87%)

is one of the technological fields in which hubs are developing their most frequent services.

Barcelona, 1st city in southern Europe in terms of funding rounds completed by AI startups

39

Barcelona is the **leading city in southern Europe** and the **6th most important European one** by completed funding rounds in artificial intelligence startups, behind only London, Berlin, Paris, Amsterdam and Munich and ahead of Stockholm, Zurich and Madrid.

Barcelona's startups have completed **105 rounds** valued at **225 million dollars** during the 2019-2023 period.

Main startups in Barcelona



Note: pre-seed and seed investment rounds and the A-C series are included; the data refer to the period from 2019 to 2023.

Top 10 European cities by completed funding rounds in artificial intelligence startups (2019-2023)



Barcelona's AI startups complete, on average

1 round valued at 2.1 million euros every 18 days

Source: the authors, based on Crunchbase

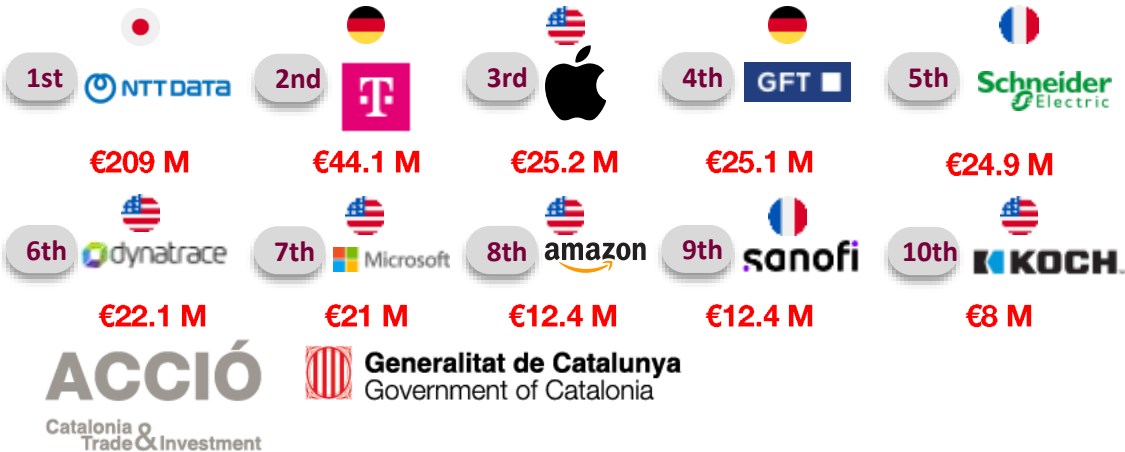
Catalonia, a priority European destination for AI FDI projects

Catalonia stood in 5th position as a destination for Foreign Direct Investment (FDI) in western Europe and in 1st position in southern Europe in the 2019-2023 period, with investment totaling 475 million euros and over 3,014 people employed in 31 projects.

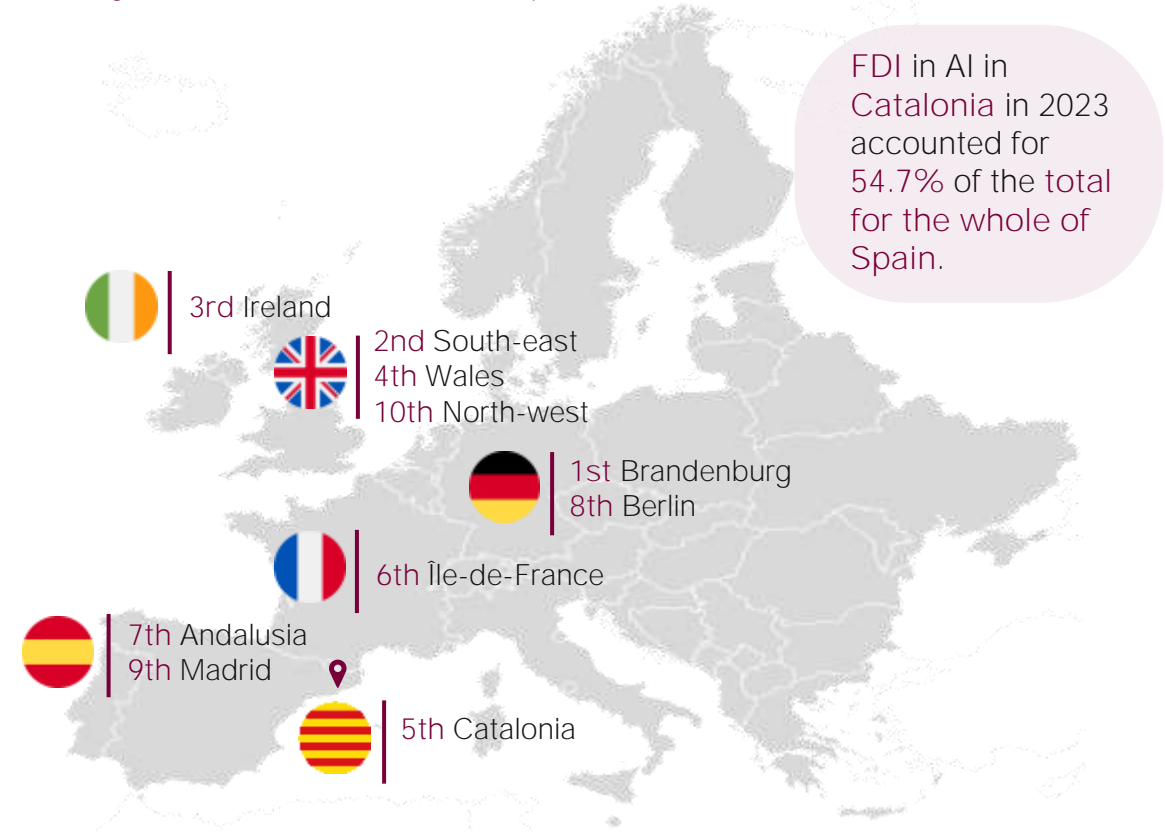
FDI in artificial intelligence in Catalonia (2019-2023)

Year	Projects	CAPEX (€M)	Employment generated
2023	7	289	1,648
2022	9	105	667
2021	12	69.7	571
2020	1	1.5	30
2019	2	9.5	98

Main investment companies in Catalonia and capital invested (2019-2023)



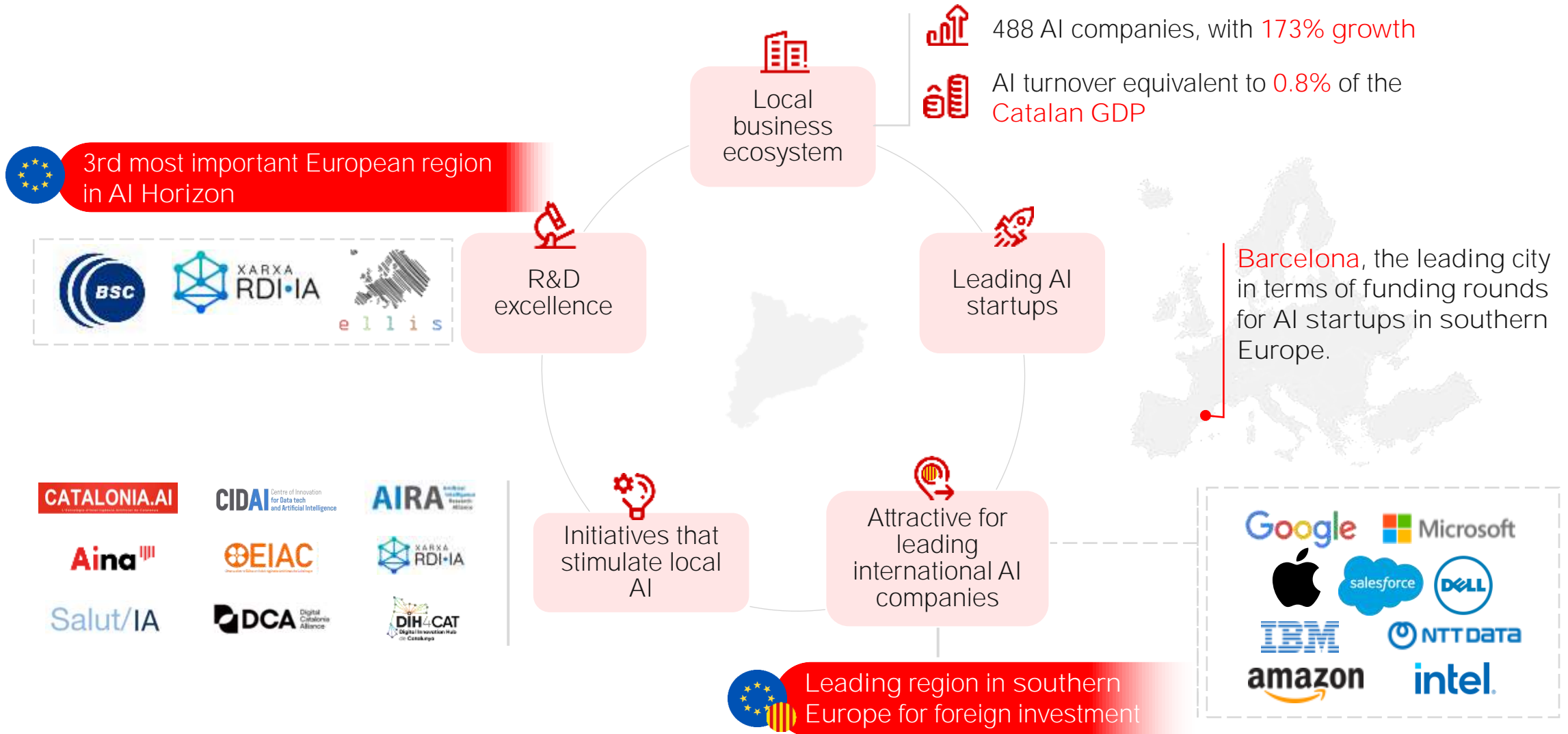
Main destination regions of FDI in AI in Western Europe, by volume of invested capital (2019-2023)



Source: the authors, based on fDi Markets

Catalonia, a dynamic artificial intelligence ecosystem

41



Since 2017 ACCIÓ has supported **253 AI projects, funded with 16 million euros**, accounting for **21.25%** of the total aid in the lines listed.

- ✓ 29 R&D Nuclei projects
- ✓ 13 INNOTECH projects
- ✓ 22 Techniospring projects
- ✓ 66 Startup Capital projects
- ✓ 132 Industry 4.0 projects

Provisional data 2017-2023



241 beneficiary companies



262 AI projects with the support of ACCIÓ



€15,957,402 awarded



21.25% of €75.1 M of aid granted



We have 188 Industry 4.0 advisers, **120** of whom are **accredited in AI**.

Strengths



Strong business fabric



Pioneering health system and ecosystem



Consolidated research system



Host for major events: MWC, ISE, Smart City, Advanced Factories, AI&Big Data Congress

Opportunities



Leadership in initiatives and projects



Development of the Catalonia.AI strategy



Increasing availability of aid and funding in AI projects



Creation and development of solutions for different economic sectors

Weaknesses



Network of small-scale AI technology providers



Human factor: lack of training and professional profiles



Poor availability of quality AI models in the recognition and generation of natural language in the Catalan language



Uncertainty regarding the legal risk and civil liability

Threats



Global market with big competitors



Lack of data quality.
Very long model validation cycles.



Significant technological cost.
Resistance to change.



Lack of secure sandbox-type testing environments

7. Success Cases in Catalonia

Success Cases in Catalonia

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The **Barcelona Supercomputing Center** opens access to MareNostrum5 to AI SMEs and startups



The CARLA simulator of the **CVC**, a benchmark for the development of autonomous driving



Microsoft drives the growth of ChatGPT from Barcelona



Dynatrace reinforces the development of AI from Barcelona



Batallé promotes a project to apply artificial vision to the meat industry



Insectius applies computer vision to the production of worms as the protein of the future



The **ICS** uses AI to improve breast cancer diagnoses



The **VHIO** and the **University Hospital of Bellvitge** create an AI-powered tool for brain tumor diagnoses



Omnios develops AI-based solutions for the optimization of companies' decision-making



IOMED, a benchmark in the processing of hospital data, completes a €10 M round



MEDIAPRO launches its artificial intelligence laboratory



AIS Group builds a system to predict air cargo demand with AI



CIDA - High Impact Project in sustainable micromobility with Bicing



Eurecat applies reinforcement learning to optimize energy consumption and reduce WWTP emissions



IAG Group has opened an AI laboratory in Viladecans with 150 employees



Acknowledgments of institutions

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CATALONIA. AI
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CIDAI
(Centre of Innovation for
Data Tech and Artificial
Intelligence)



CVC
(Computer Vision Center)



Eurecat



Google



IDEAI-UPC
(Intelligent Data Science and
Artificial Intelligence)



RDI·IA Network



Thank you!

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More information about the sector, news and opportunities:
[https://catalonia.com/key-industries-
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