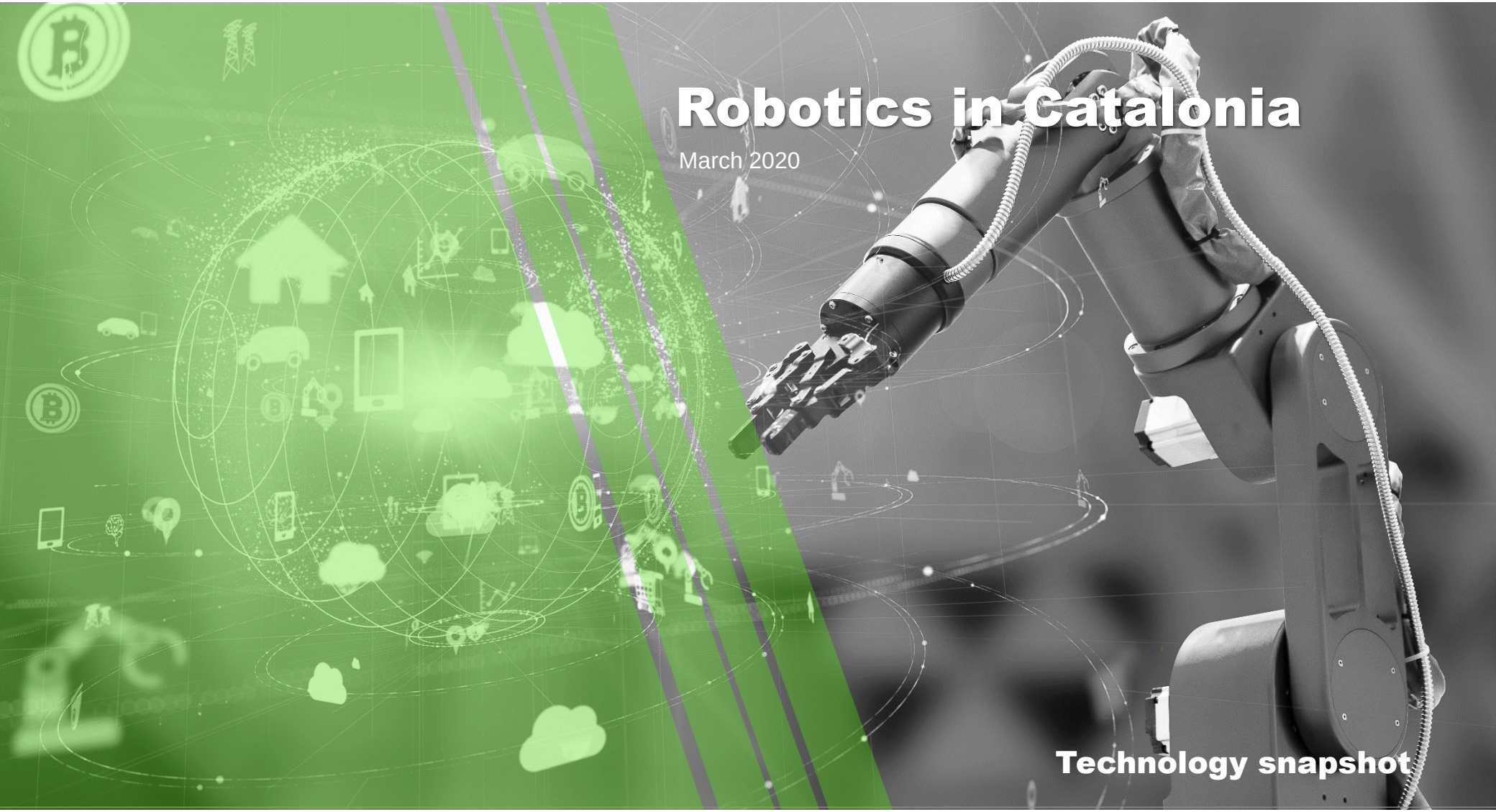


Robotics in Catalonia

March 2020

Technology snapshot

Catalonia Trade & Investment

Generalitat de Catalunya
Government of Catalonia

Robotics in Catalonia

ACCIÓ
Regional Government of Catalonia (Generalitat de Catalunya)

Execution
ACCIÓ Strategic and Competitive Intelligence Unit

Collaboration
Secretariat of Digital Policies, Regional Government of Catalonia (Generalitat de Catalunya)
EURECAT
ACCIÓ Innovation Unit

Barcelona, March 2020

Technology trends target

This study is part of a collection of reports on the different disruptive technologies detected in the ACCIÓ Technology Trends Target (2018), which are expected to have a great impact on Catalan society and its productive fabric in the years to come.

- Virtual reality and augmented reality
- Artificial intelligence
- Internet of Things
- DLT and blockchain

DIGITAL

- 3D printing
- Nanotechnology and new materials
- Robotics
- Quantum science and photonics

PHYSICAL

- Neuroscience
- Advanced drug design
- Omics
- Biotechnology and synthetic biology

BIOLOGICAL

- Big data
- Connectivity – 5G
- Cybersecurity

TRANSVERSAL

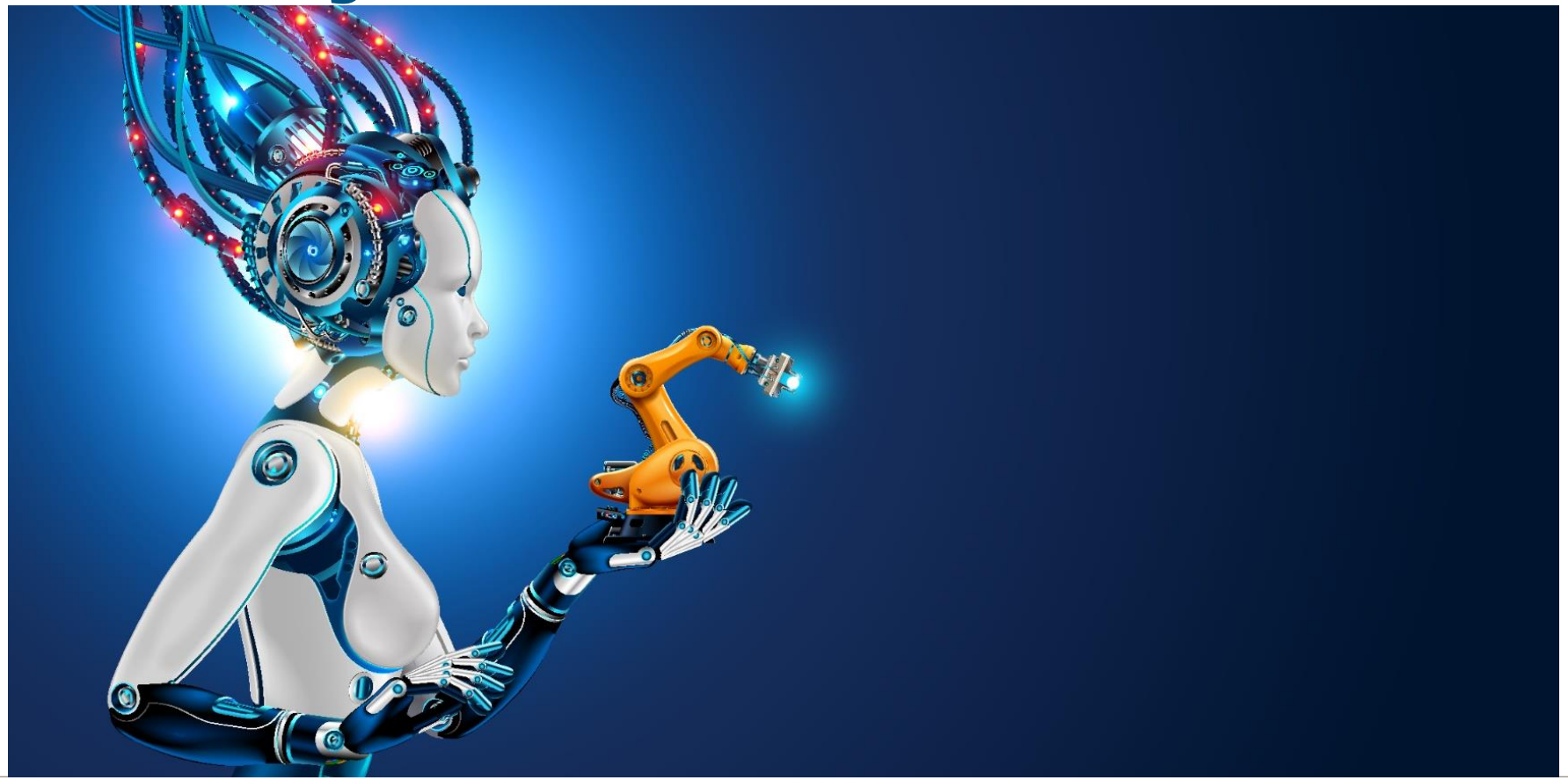
- Drones
- Connected vehicle
- *New space*

TECHNOLOGY HYBRIDISATION

The reports published as of 1 March 2020 appear in blue. Those pending publication appear in red.

Table of contents

1. Robotics. Relevance to the industry and main uses

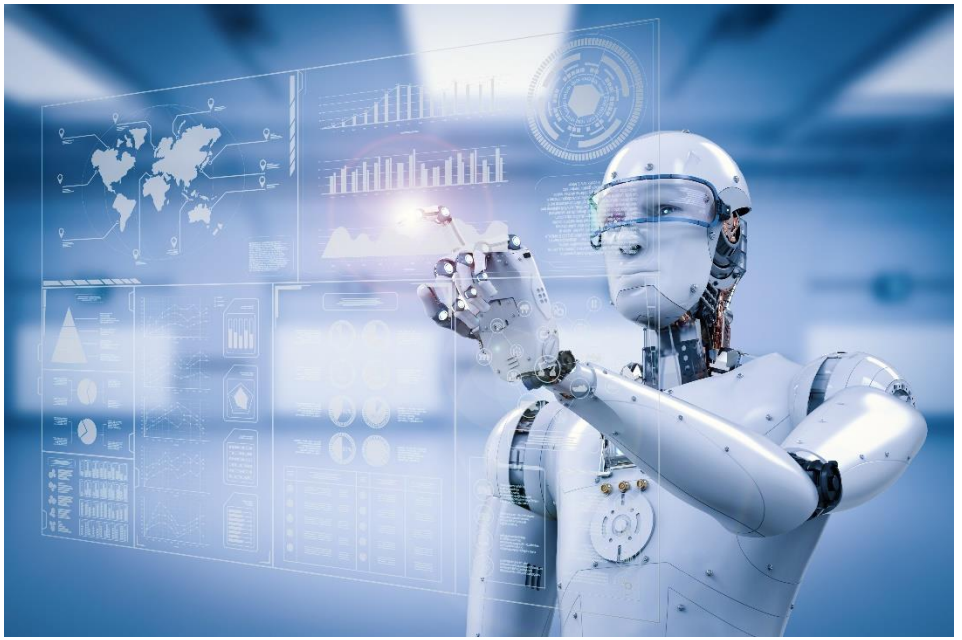


Definition

Robotics is the branch of engineering responsible for the inventing, design, manufacturing and operating of robots, where a ***robot*** is the name given to any articulated device or mechanism that develops movements or automatic functions in line with external instructions or with rules that have been incorporated into it.
Robots is a multidisciplinary field that overlaps with electronics, computer science, artificial intelligence, mechatronics, Internet of Things, 5G, nanotechnology and bioengineering.

Although the idea of creating machines that operate automatically dates back to Classical antiquity, this field was not substantially developed until the late 20th century.

Nowadays, robotics is a discipline that is growing significantly, given its implantation in many different industries. Furthermore, it is expected to continue progressing, as it is thought to be a key component in the transition to Industry 4.0.



Source: Ramos, Elcacho

Classification of robots

In line with the definitions of robots according to their application or use, they can generally be classified as follows:

Industrial robots. These are used in the automation of industrial processes. This, however, includes different types of robot: articulated, Cartesian, cylindrical, delta, etc.

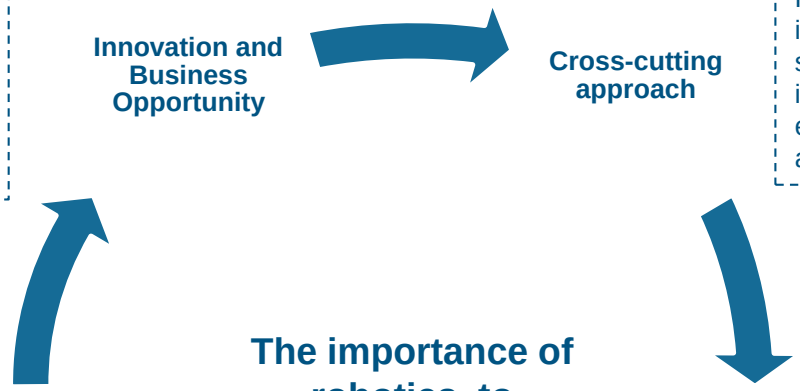
Humanoid robots. These are robots designed to resemble the body and movements of a human being. Their design can be for functional or experimental purposes. Most noteworthy in this field is **Sophia**, developed by the company Hanson Robotics.

Autonomous vehicles. These have a wide range of applications and are classified as land (such as cars) and air (drones). There are also AGV (*automated guided vehicles*), driverless vehicles for industrial environments that can transport components automatically.

Personal robots. This category includes the robots used in non-productive activities and designed for general domestic or educational use.

Source: SmartCatalonia

The importance of robots to industry



The sophistication of the robots and their integration with other technologies could promote new business models or applications in sectors not so closely related to industry and incorporate social and collaborative aspects.

Robotics is a cross-cutting technology and its applications, both present and future, supply a wide range of sectors such as industry, medicine, space exploration, education, or healthcare services. It can also help develop new business models.

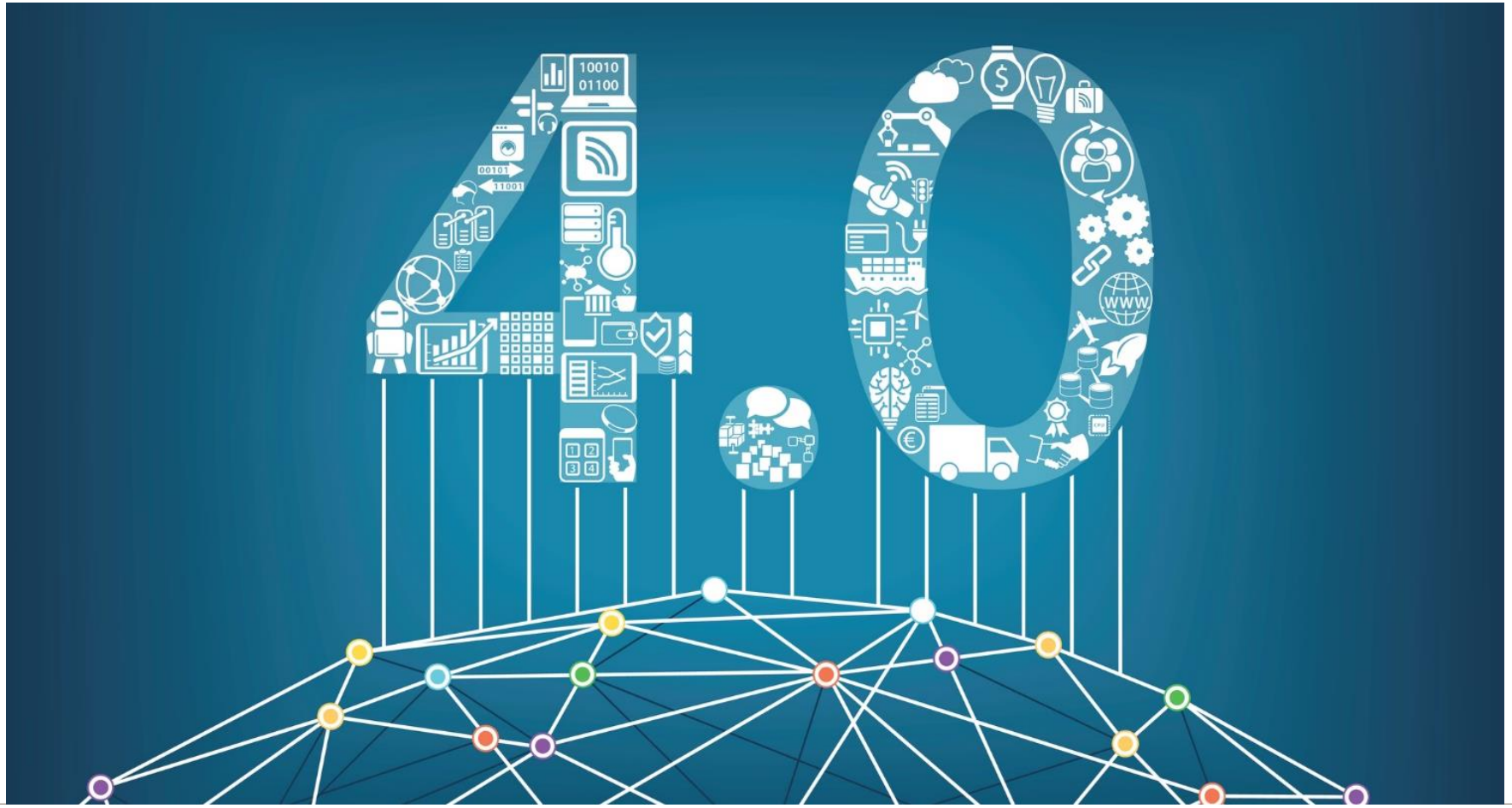
New areas of research and technologies, such as artificial intelligence, 5G, the Internet of Things, and new sensor materials and technologies have been combined with robotics to create advanced autonomous robots with greater possibilities of use.

Robotics can contribute towards the automation and innovation of many processes in both industry and other areas, and create new opportunities and business models. Furthermore, its application guarantees greater and better control over production processes, and with more flexible, adaptable environment.

The use of robots in the production process reduces human effort while improving safety conditions.

Source: own compilation

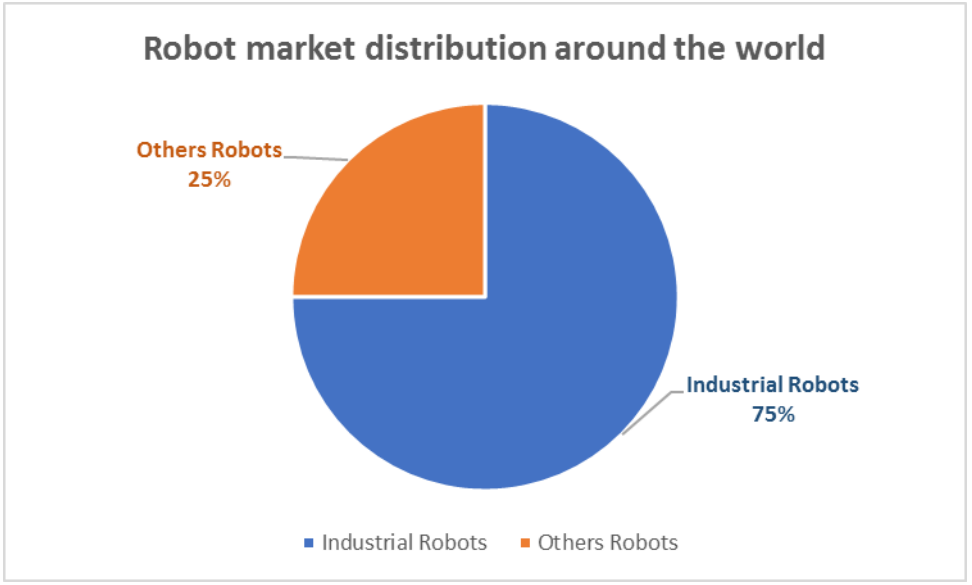
2. The global robotics market



Global market: current and future data

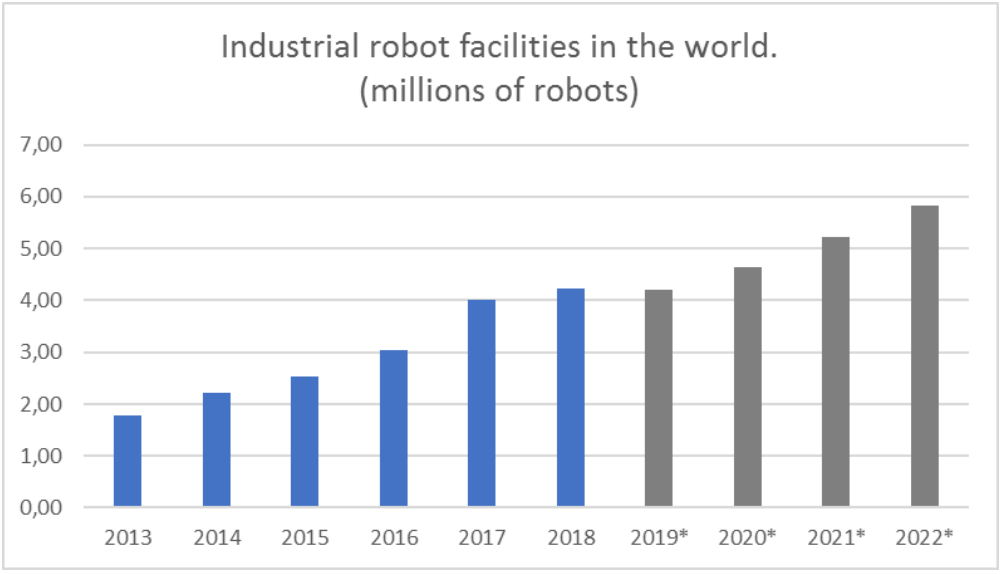
It is estimated that the global turnover of robotics industries amounted to 22 billion euros in 2018, and is calculated to exceed **50** billion in 2020.

The most important weight of this market lies in industrial robotics, which accounted for 16.5 billion euros in 2018.



Despite this, a change in weight is expected over the coming years as non-industrial markets mature.

What is more, some estimates believe that the sector will experience an annual growth of **12%** between 2020 and 2022. The following graph shows the growth in the number of industrial robots between 2013 and 2018, along with the growth forecast up to any 2022 (in millions of units):

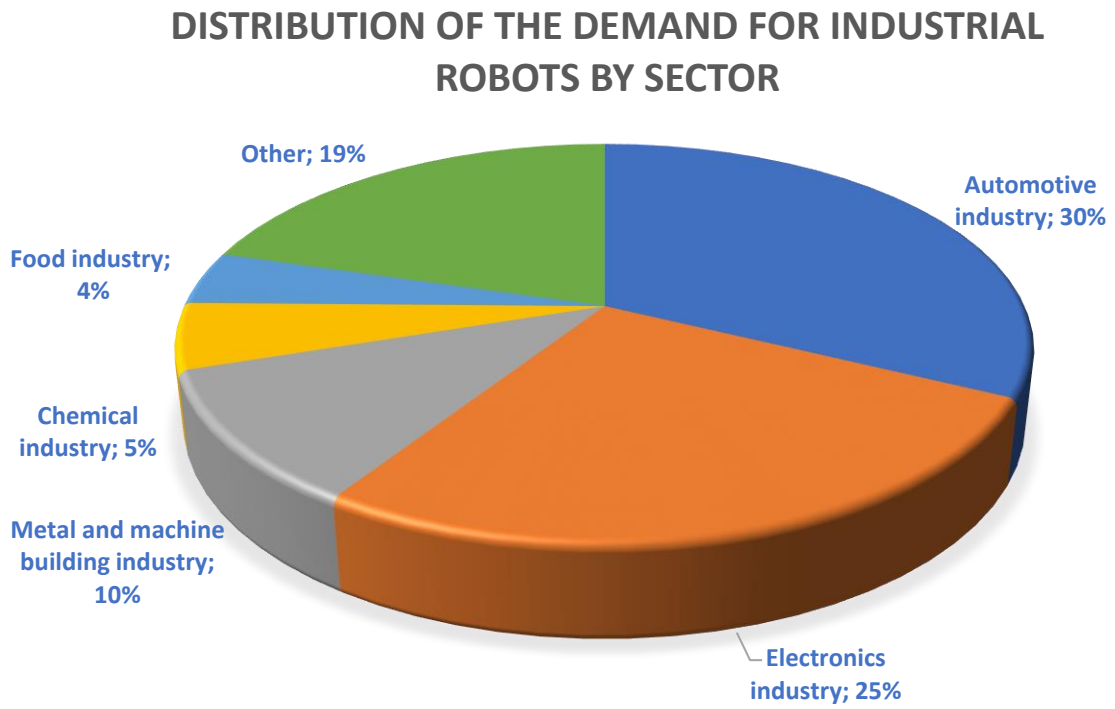


Source: World Robotics 2019

Sector-based distribution of industrial robots

Some recent studies indicate that returns on investment are possible for companies within six months with a minimum investment in industrial robotics.

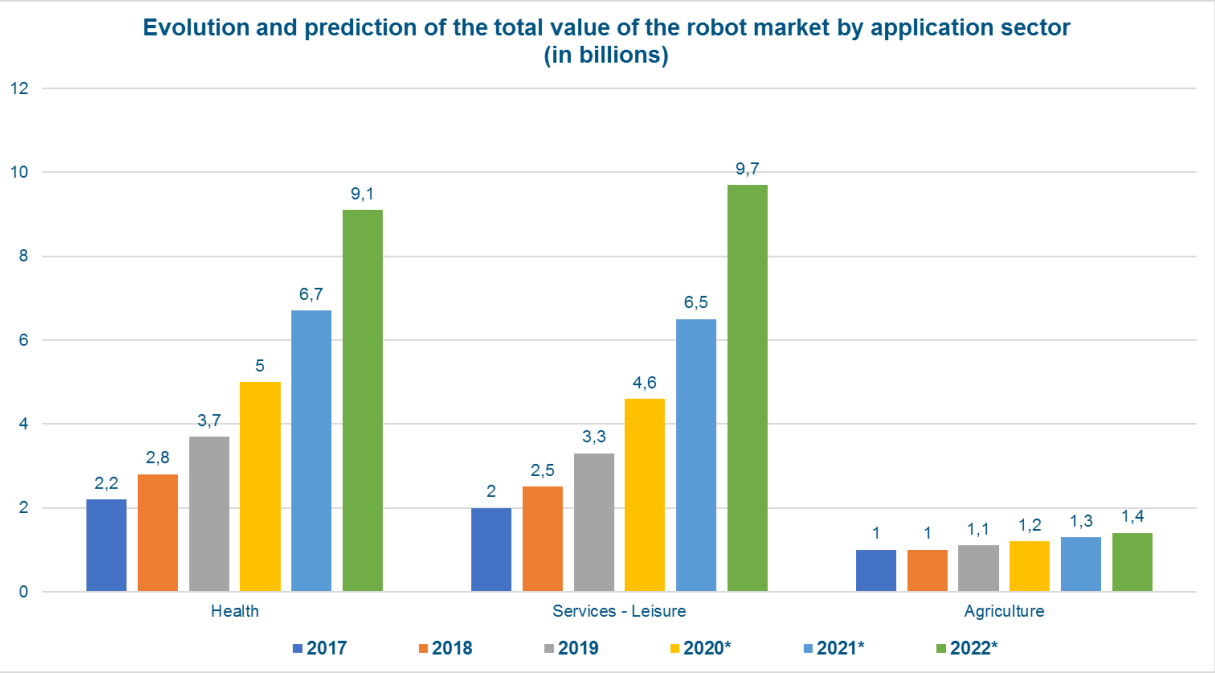
The most important client for industrial robotics is the automobile industry, which accounts for 30% of all annual installations. The following figure shows the distribution of industrial robotics installations according to demand:



Source: IFR. 2019

Global market: current and future data(III)

Within non-industrial applications, health and agriculture show noteworthy growth forecasts in the adoption of robotics over the coming years.



At present, the sector with the highest turnover is that of **health**, at $2.8 billion. Despite this, the forecasts indicate that ***domestic robots*** will exceed them.

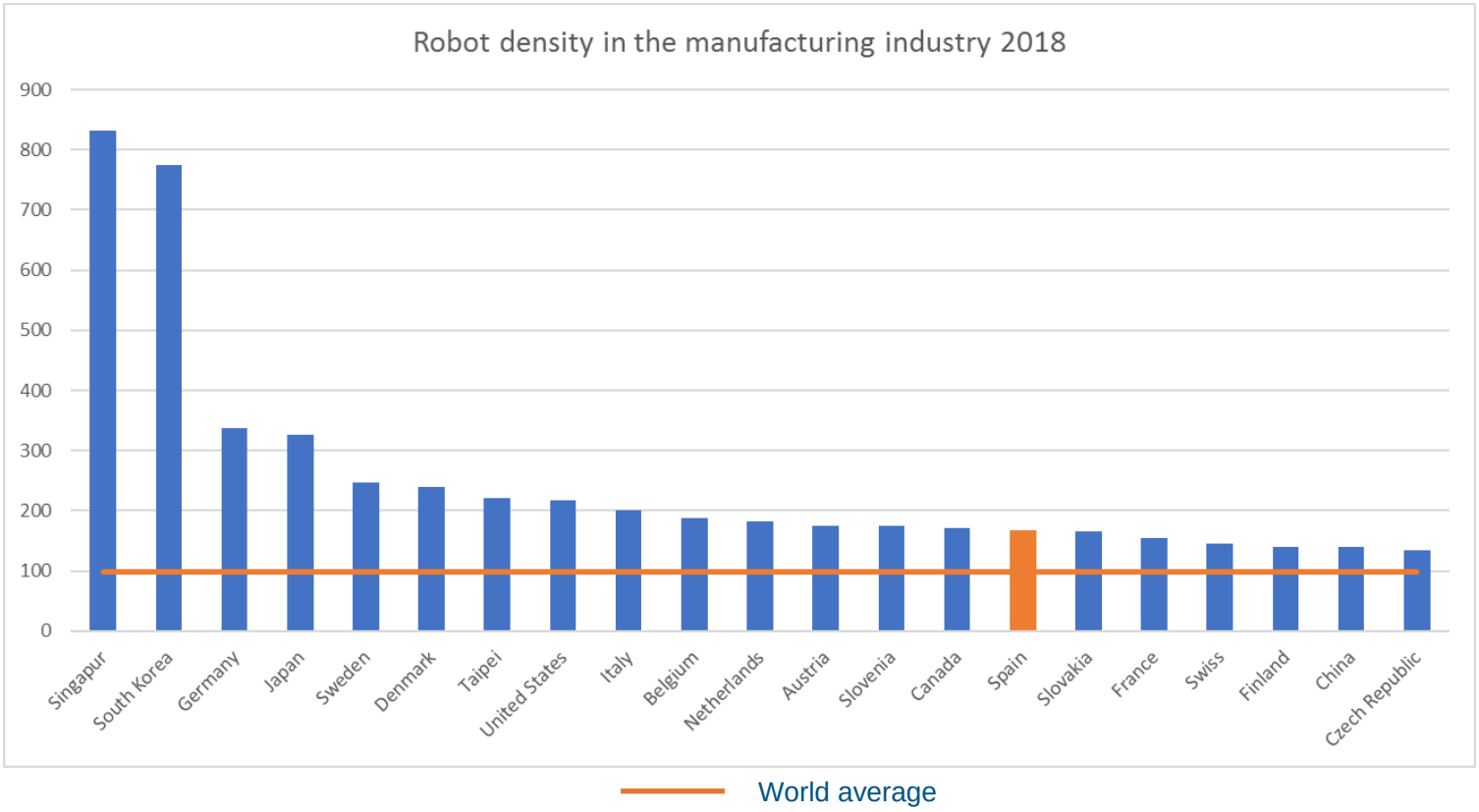
On one hand, it is estimated that ***agricultural robots*** might witness even higher growth, at an annual growth rate of 50% until 2022. The **specific needs** in agriculture due to the **environmental challenges** must be valued positively.

On the other, in the field of **medicine** ***medical service robots*** accounted for a turnover of 2.8 billion US dollars in 2018, and the number of units deployed is expected to grow at an annual growth rate of 40% until 2022.

Source: IFR

Main regions and relevant hubs (II)

The International Federation of Robotics establishes the following ranking of the world economies according to the density of robotics in industry (measured in robots for every 10,000 employees). Spain stands above the world average in this variable.



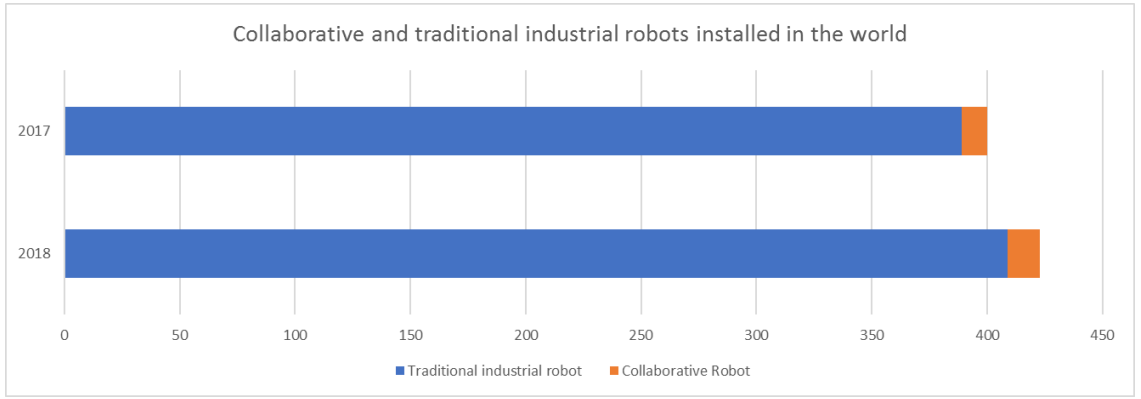
Source: International Federation of Robotics

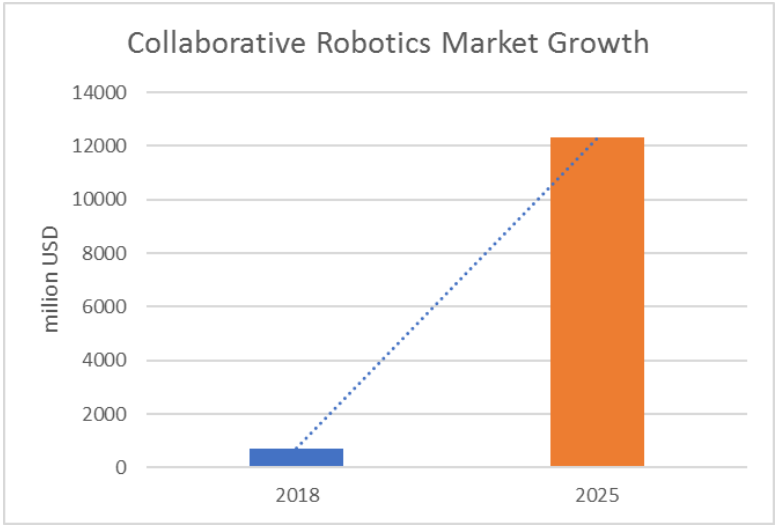
Main trends. Collaborative robotics (I)

One of the **main trends in the sector is the introduction of collaborative robots or *cobots***, which can share the workplace with people and learn new jobs. Collaborative robots are designed to perform jobs in collaboration with human employees. The so-called *cobots* are designed with a series of technical features that ensure the safety of employees when they are in direct contact with the robots, either deliberately or by accident. These features include light materials, rounded edges, and sensors at the base of the robot or on the joints to measure and control the strength and speed and make sure they do not exceed certain defined boundaries in the event of contact.

These robots do not replace people but help them.

Traditional Industrial Robots	Collaborative Robots
They are not aware of the environment	They see and understand their environment
Focused on precision and repeatability	Focused on flexibility and ease of use
Complex programming	Simple programming
Specific to certain tasks	Flexible, able to adapt to various tasks
Fast and powerful	Comparatively slow and less powerful





Source: SmartCatalonia

Main trends. Collaborative robotics (II)

The ***market for collaborative robots*** (*cobots*) will grow from 710 million dollars in 2018 to **12,303 million** dollars in 2025. The ***main factors*** encouraging the growth of the *cobot* market are:

- A significant **adoption rate** for *cobots* by small and medium-sized enterprises (SMEs) worldwide thanks to their benefits (**increased productivity**)
- The **improved human-machine interface** (HMI) and the capacity of the AI to **imitate human behaviour**
- A unique solution for a **safe working environment**
- Easy to install and program

Despite the significant media attention given to *cobots*, the number of installed units remains very low, at **3.24%**.

- In 2018, less than **14,000** of the over **422,000** industrial robots installed were *cobots*.
- From 2017 to 2018, installations of *cobots* increased by 23%.

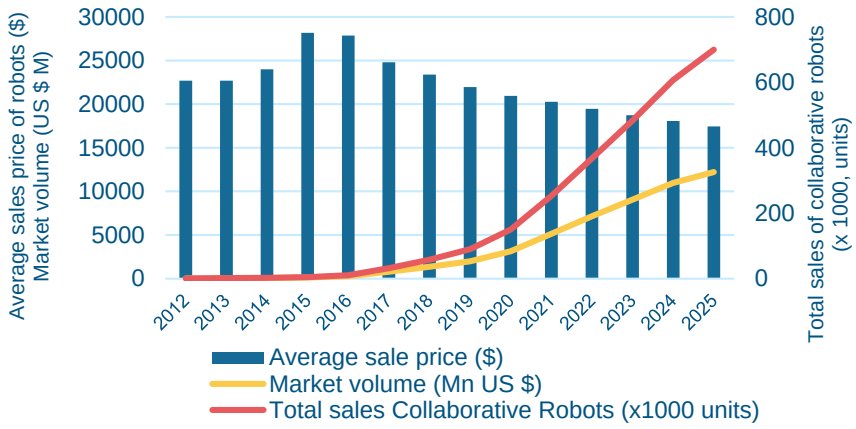
Growth associated to the **drop** in price of robots

The Asia-Pacific region has the most positive growth forecasts

Increase in demand in cars, health and electronics

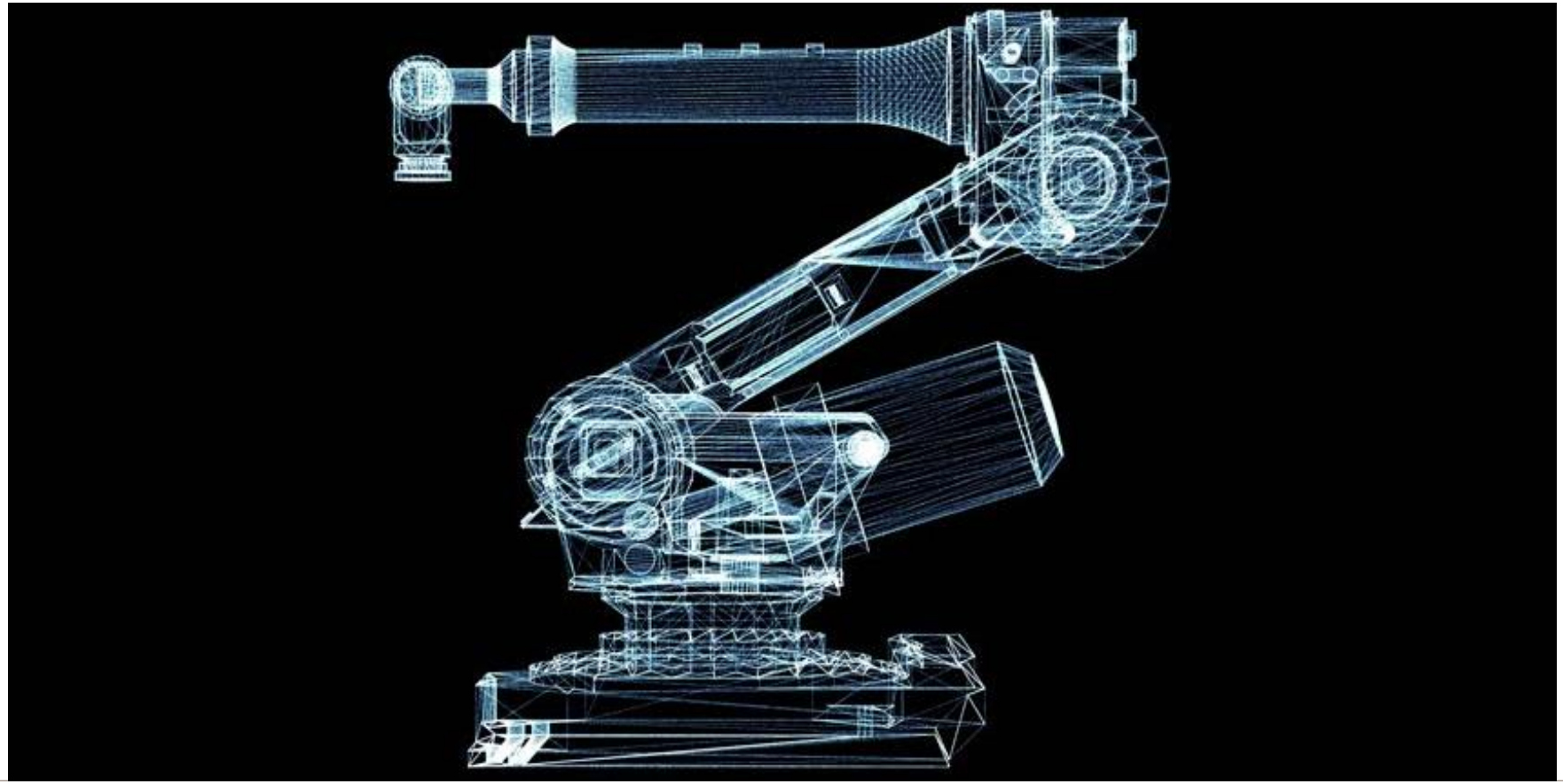
The **European Commission** highlights the fact that collaborative robots are a **unique technology** with the potential to improve the economy and society in Europe.

Foreseen market evolution for collaborative robots



Source: Markets and Markets, 2019; Vanderborght, 2020

3. Investment and patents in robotics



Top robotics companies worldwide and main startups

The top companies worldwide by turnover:

NOTE: the startups are sorted by the amount of the funding rounds

Source: technavio.com

The 10 most important funding rounds in 2019 relating to robotics were as follows:

- Bailian.AI, July 2019
  Round value: $45.45M
- D-Fend Solutions, September 2019
  Round value: $25.45M
- Outsight, December 2019
  Round value: $18.18M
- Skysys, March 2019
  Round value: $9.09M
- Karakuri, May 2019
  Round value: $8.18M
- Tonkean, October 2019
  Round value: $6.55M
- Freedom Robotics, July 2019
  Round value: $6.00M
- Robocorp, November 2019
  Round value: $5.09M
- Rob Surgical Syst., September 2019
  Round value: $4.55M
- Picnic, November 2019
  Round value: $4.55M

Direct foreign investment in robotics in Catalonia (2015-2019)

13
Projects

▲ 225% in relation to 2010-2014

59.1%
of the projects destined for Spain

€85.6
M of investment

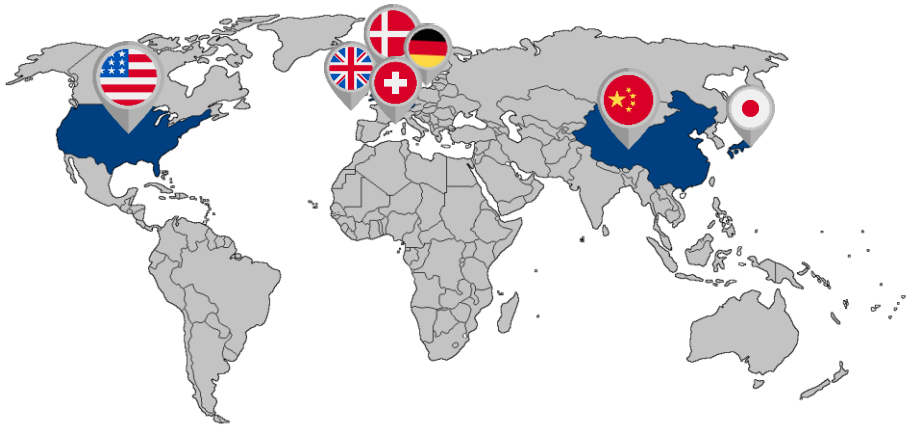
▲ 801% in relation to 2010-2014

55.1%
of investments in Spain

736
Jobs created

▲ 651% in relation to 2010-2014

60.7%
of the jobs created in Spain



Countries of origin of foreign investments in robotics in Catalonia over the 2015-2019 period

Position of Catalonia in Western Europe:

#4
Region in number of projects

#5
In quantity of jobs created

#10
In volume of investments

Position of Barcelona in Western Europe:

#2
City in number of projects

#3
In quantity of jobs created

#8
In volume of investments

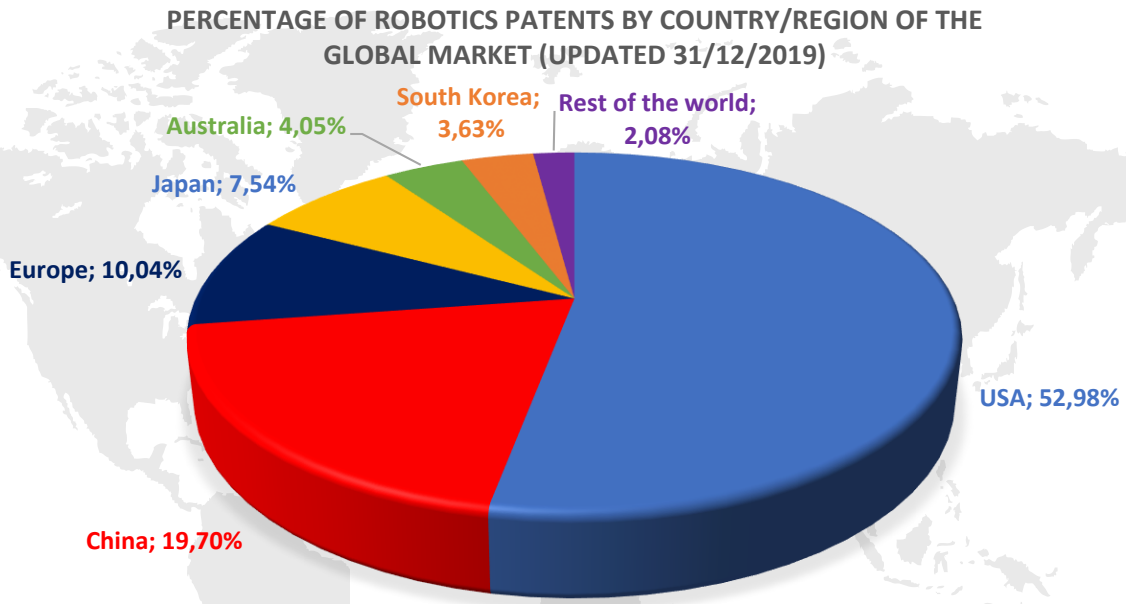
Main investors:

amazon ABB FANUC MiR TERADYNE ARBURG TOPCON Midea make yourself at home on robot

Note: the investment companies have been sorted by volume of investments

Source: fDi Markets

Global robotics patent market (I)



The United States leads the number of patents worldwide at present, with 366,307 patents, which is 52.98% of the global total. **China** ranks second, with a 19.70% share.

Europa is third with a figure of 69,399 patents, which accounts for 10.04% of the global total.

Main organisations:

Source: own compilation based on data by lens.org

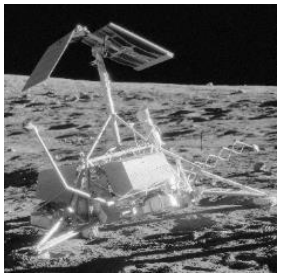
4. Main applications by demand sector. SDG

Main applications of industrial robotics

Industry. Industrial robotics means that certain industrial processes can be automated. The industry demanding the most is the automobile industry. Although 10% of all industrial jobs around the world are already automated, this figure is expected to reach 45% by 2025.

Automotive. By 2025, 10% of all vehicles around the world are expected to be fully autonomous.

Aerospace. Robots are a very useful tool for space exploration, as they can reach environments and obtain information from places that humans cannot reach. The first space robot was sent to the Moon over 50 years ago on the *Surveyor 3* mission.



Logistics. Autonomous vehicles to transport loads between different areas, robots designed to work safely in environments with operators.

Inspection and maintenance. The robots involved in inspection and maintenance work are normally used in environments or infrastructures without easy access by operators: Inspections of wiring or electrical, underground and sewerage installations, or the hulls of large ships.

Source: SmartCatalonia, Razor Robotics

Others applications of robotics

Education. Educational robotics is an interdisciplinary learning system that uses robots as encouragement among younger children.

Domestic. The continuous advances in robotics and home automation have led to the appearance of a wide variety of domestic robots such as cleaning robots.

Healthcare services. Healthcare robotics includes robots designed to help the elderly or people with some kind of physical disability in their everyday activities.

Health and medicine. Surgical and surgical assistance robots allow for highly complex surgical procedures to be carried out.

Exoskeletons can help people with mobility difficulties.

Security and military. Autonomous or remote control robots such as drones particularly stand out in this field. The number of military drones is soon expected to triple.

Finances. In 2020, robots are expected to make investments amounting to $2.2 trillion worldwide.

Agriculture. The introduction of robotics into this field is expected to be in the form of autonomous tractors, drones, and milking robots.

Source: SmartCatalonia

The risks and challenges of robotics

The development of robotics also poses certain doubts in meeting these Sustainable Development Goals that should at least be taken into account:

USE OF ENERGY

An industrial robot uses an average of 150 kWh a day, whereas an average family only uses 56 kWh in Europe and 14 kWh in Asia. The implementation of robotics would therefore represent a significant use of energy.

EMPLOYMENT

According to the study *L'impacte laboral de la Indústria 4.0 a Catalunya*, although 35% of jobs are highly likely to become automated, this does not mean that they will all be replaced by robots. What is more, in aggregate terms, the impact might even be positive, with a 0.7% increase in employment up to 2030. There will, however, be less employment in industry (-3.2%) and more in services (2.0%), and many jobs will disappear, whether or not they are repetitive or manual. Jobs will be transformed and employees will have to adapt accordingly.

TRAINING

Training (permanent, professional and university) must be promoted and improved in order to streamline the transition of human resources to the new requirements of Industry 4.0. Educational curricula and training programmes must therefore be created to prepare local talent for the design, construction and maintenance of these technological systems.

Source: Bugmann, Siegel, Burcin, Hernandez

Robotics and SUSTAINABLE DEVELOPMENT GOALS (II)

Goals 12 and 13
The introduction of robotics into agricultural and industrial processes would allow for a reduction in waste and refuse in these processes. Furthermore, robotics might allow for less pollutant production methods to be developed. Moreover, robots could be used to repair products that are currently disposed of when they break.

Goals 8 and 9
The introduction of robotics into the production network would improve the efficiency of industry. Robots can perform tasks that require a great deal of precision, withstand heavy loads, and acquire high levels of specialisation.

Affordable and clean energy
Robots could be used to manage small electrical energy generating units.

Zero Hunger
Robotics could help optimise the production of food thanks to the improvements introduced in both agriculture and the food industry. In the case of agriculture, robotics would allow for the conditions of the soil and the health of plants and animals to be monitored more closely, and decisions adapted to the local context.

Health and well-being
Robots can have many different applications in the fields of health and medicine (assistance in highly complex surgical operations, healthcare service robots for the chronically ill and the elderly, etc.). Furthermore, they could reduce transport costs through the implementation of flexible, on-line solutions.

Quality education
As has been observed, there are educational robots that encourage the development of certain abilities and skills in many disciplines. Robotics would also allow for a reduction in the costs of technical education and improve its effectiveness.

Clean water and sanitation
Robots could be used to control the conditions of water and help manage the water cycle.

Source: Bugmann, Siegel, Burcin

5. Robotics in Catalonia

Value chain segmentation in Catalonia

Within the robotics market, the players can be classified in line with the following value chain:

Auxiliary industries

Services, engineering, consulting, component manufacturing, programming, facilitating technologies, etc.

Manufacturers

Robot manufacturers.

Integrators

Engineering companies that design, build and install automated and robotic solutions.

Educational robotics

Companies dealing in educational robotics and training.

Players

Associations, clusters and public authorities.

Research & technology

Technology companies and centres conducting applied research and innovation in robotics.

Universities and training centres

Training in subjects related to robotics and automation.

Trade fairs and events

Trade fairs, events, congresses and business meetings to promote the technologies and their possibilities.

Smart labs

Space designed to test products, systems, architectures and concepts.

Field of application

- Industrial
- Service
- Personal
- Agriculture
- Health

Source: ACCIÓ based on SmartCAT

Main mapping conclusions

147 companies that work with robotics in Catalonia have been detected, 17.69% of which are start-ups.

Robotics in Catalonia

89.80% of the Catalan robotics ecosystem is formed by SMEs. Furthermore, 42.86% are less than ten years old.

It is estimated that there are currently 1,910 jobs in Catalonia and an annual turnover of 460.67 million euros directly linked to robotics.

36.05% of companies in the ecosystem are exporters. 9.52% have branches abroad.

Ecosystem segmentation[1]:

- **Integrators (33.33%)**
- **Auxiliary industries (28.57%)**
- **Educational robotics (22.45%)**
- **Manufacturers (15.64%)**

43.86% of companies in the ecosystem have an annual turnover of over one million euros.

[1]Some of the companies in the ecosystem are involved in activities from more than one segment of the value chain. This classification, therefore, is not exclusive.

Source: EIC (ACCIÓ) according to Informa 2018 data

Robotics companies in Catalonia

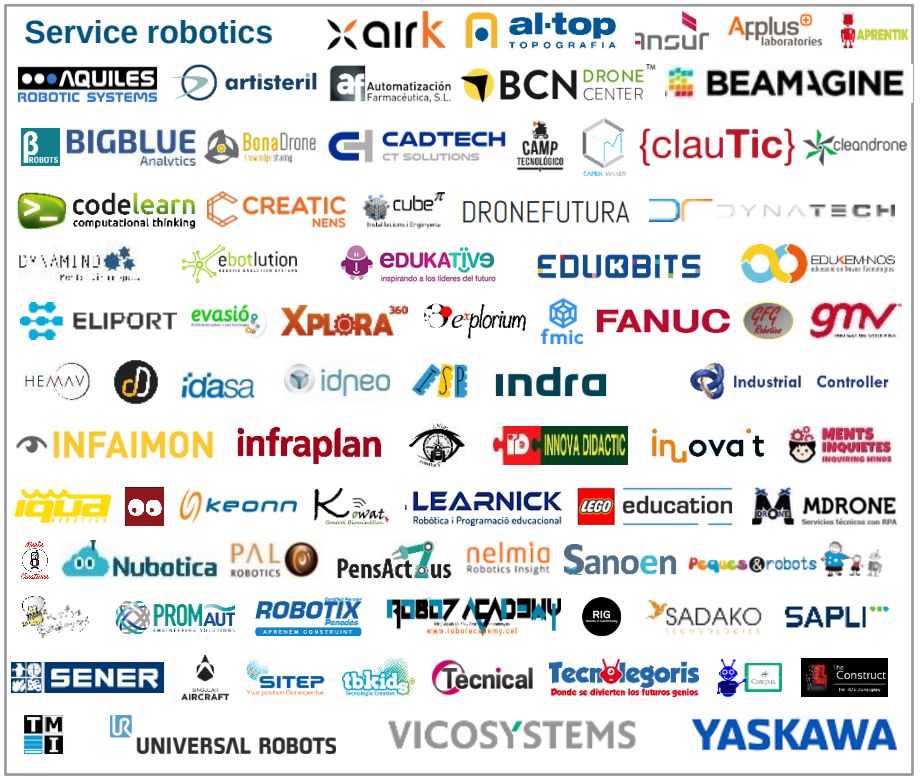
Partial illustration chart

Some of the companies in the ecosystem are involved in activities from more than one segment of the value chain. This classification, therefore, is not exclusive.

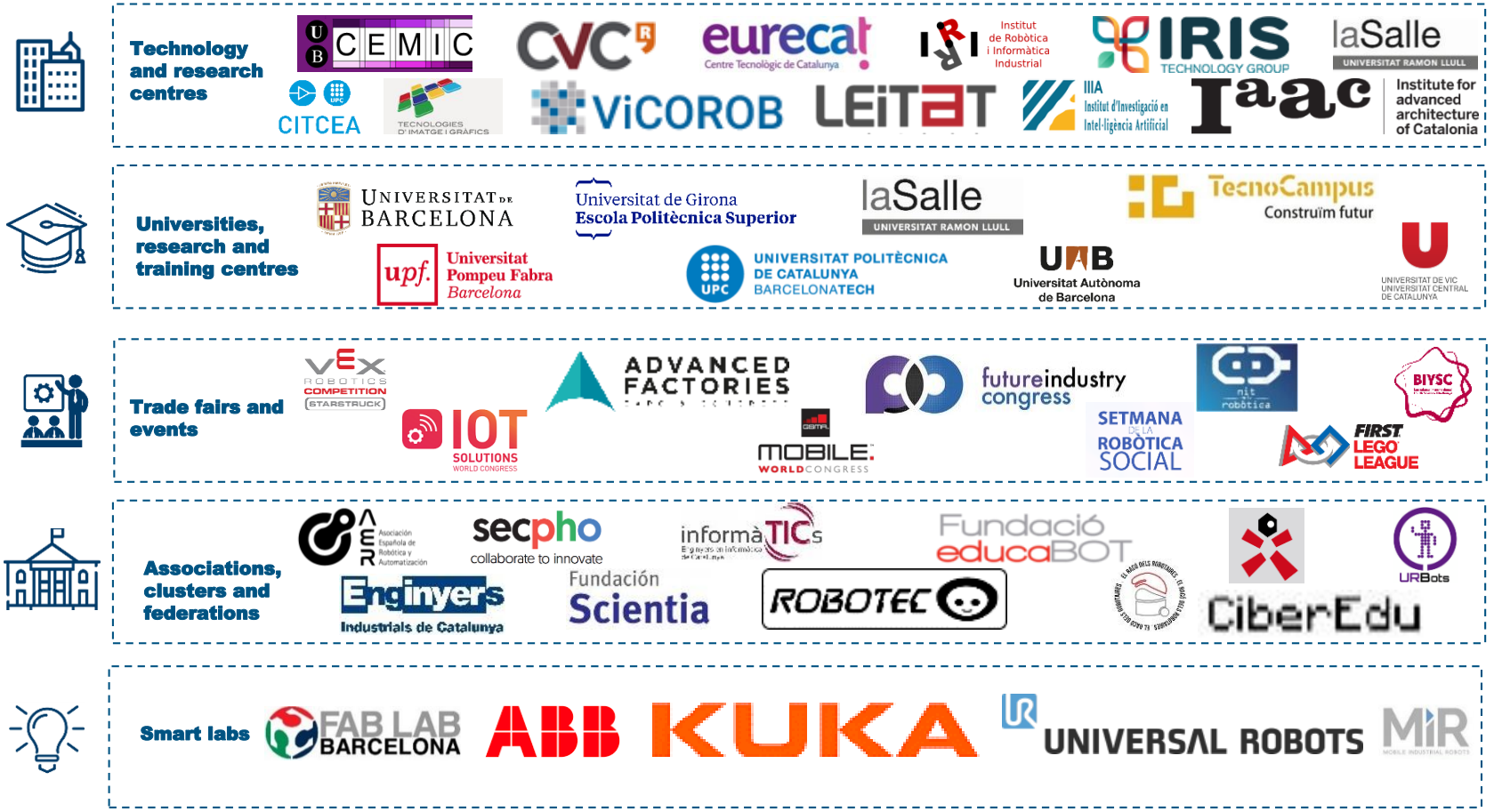
Source: EIC- ACCIÓ based on SmartCAT, Barcelona & Catalonia Start-up Hub

Robotics companies in Catalonia per application

Partial illustration chart



Others players in the robotics ecosystem in Catalonia



Source: ACCIÓ

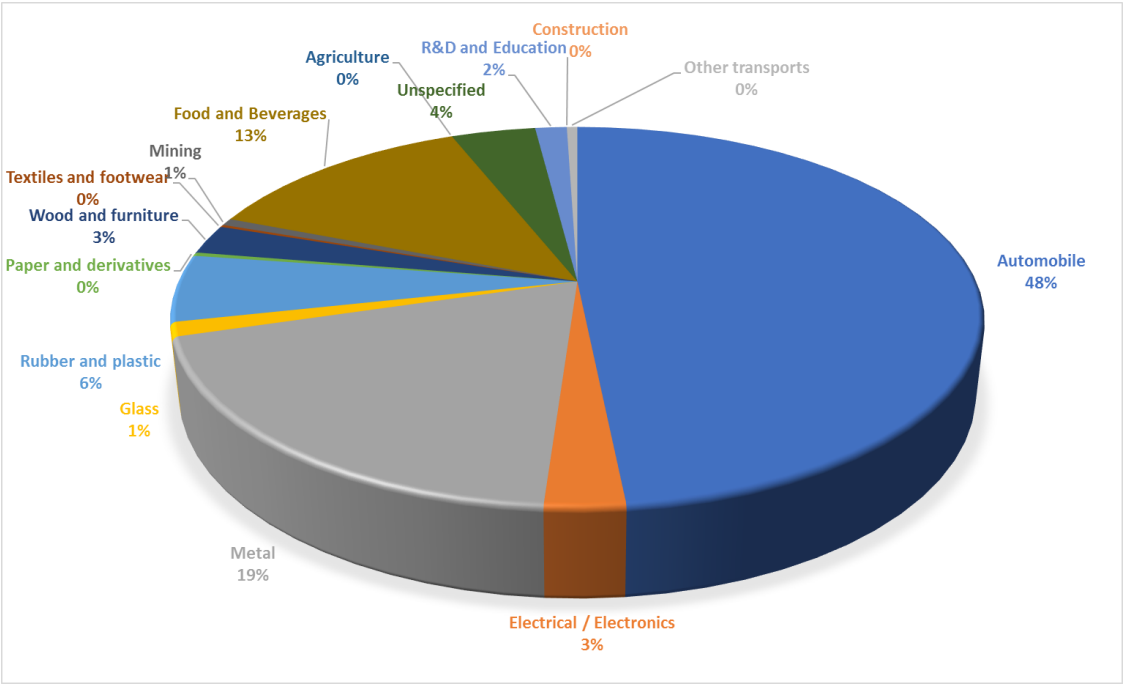
Robotics and the Catalan production network

The robot density rate in Spain, which stands at 168, is above the world average (99 robots for every 10, 000 workers).

Industry is one of the mainstays of the Catalan economy, as it accounts for 20% of GDP. The ICT sector in Catalonia is strong, and is easily supporting the economic growth. At present, **39.4%**of all Catalan companies have some kind of automated process (data from 2016).

According to the study by Torrent in 2018, robotisation of the Catalan SME represents:

- **higher volume of sales**, a 59.8% increase in relation to non-robotised companies;
- **more exports**, a 71.6% increase;
- **greater productivity** (14% variations) and
- **more employees** (53.1% higher employment).



Distribution of the use of robots per sector in Spain (2016)

The main robot manufacturers have head offices in Catalonia:

ABB FANUC KUKA MITSUBISHI ELECTRIC Changes for the Better STÄUBLI UNIVERSAL ROBOTS YASKAWA

Source: Torrent, ACCIÓ and ESTADÍSTICAS DE ROBÓTICA INDUSTRIAL EN ESPAÑA by AER-ATP

Robotics training in Catalonia (I)

Degrees

Specific degree in robotics

Degree in Industrial and Automatic Electronic Engineering

- Universitat Autònoma de Barcelona
- Universitat de Girona
- Universitat Politècnica de Catalunya BarcelonaTech
- Universitat Rovira i Virgili

Other degrees with robotics content

- UVIC — Degree in Mechatronic Engineering
- laSalle Universitat Ramon Llull — Degree in Electronics Majoring in Robotics
- Universitat de Barcelona — Degree in Biomedical Engineering

Training cycle

Higher degree:

Industrial Automation and Robotics

36 centres throughout **Catalonia**

Master's Degrees

Master's degree in Automated and Robotic Production CIM - UPC

Escola Tècnica Superior d'Enginyeria Industrial de Barcelona — Universitat Politècnica de Catalunya

Master's degree in Automatic Systems and Robotics ESTEIB. UPC

Universitat de Girona

VIBOT Joint MSc in Vision and Robotics

University of Burgundy (France), University of Girona (Spain) and Heriot-Watt University (United Kingdom)

Master's degree in Robotics

UVIC with eurecat Centre Tecnològic de Catalunya

Technology centres with robotics research line

Others players in the ecosystem and business cases in Catalonia (I)

Barcelona is the headquarters of the **first collaborative robotics hub in the world**, promoted by two multinationals from the sector -**Universal Robots and Mobile Industrial Robots** (MiR).

The **Robotics for Microfarms (ROMI)** is currently being developed at the **Fab Lab Barcelona** as part of the European Horizon 2020 programme.

Kuka has a technical centre in Catalonia that performs computer simulations, designs new functions, and tests new products.

Rob Surgical is a Catalan company that develops robots for minimally invasive surgeries, such as the **Bitrack System**.

Behind **Fanuc** is a large part of the robots that feed production in factories around the world. Fanuc has a centre in Catalonia.

ABB has a collaborative robotics innovation centre in Catalonia to develop new digital applications and tests.

Others players in the ecosystem and business cases in Catalonia (II)

Betarobots implements innovative projects in fields such as mobile robotics, industrial handling, artificial perception, the interaction of robots with people or with other machines, or the design and manufacturing of custom robotics.

Eurecat works on developing a mobile, collaborative and industrial handling robot capable of adapting to an industrial production environment.

Ribinerf is a family-run company with over 25 years of experience in artificial vision technology. The Ribinerf artificial vision-based solutions enable robots to operate in non-deterministic scenarios.

Wecobots is a company that deals in the integration of collaborative robots for industry.

Infaimon is a company that specialises in artificial vision and image analysis solutions for industry, with over 25 years of experience.

BcnVision deals exclusively in the design, installation and maintenance of artificial vision systems for the industrial sector.

Bibliographic resources (I)

- ACCIÓ. Agència per a la Competitivitat de l'Empresa, "Baròmetre de la Innovació a Catalunya 2018" (2019). Available at https://www.accio.gencat.cat/web/.content/bancconeixement/documents/informes_innovacio/Barometre-innovacio-2018.pdf
- Barclays Equity Research, "The rise of co-bots: sizing the market"
- Bugmann, G., Siegel, M., Burcin, R., "A role for robotics in sustainable development?" 2018. Available at https://www.researchgate.net/publication/261247263_A_role_for_robotics_in_sustainable_development
- Dealroom.co. Available at dealroom.co
- Elcacho, J., "Més d'un segle de cursa robòtica", *Theknos,* no. 172 (2013), Page 20-25.
- International Federation of Robotics, "World robotics 2019" (2019).
- Ramos, J.M., "Automation and robotics" (2008). Available at https://archive.org/details/ost-engineering-automation-and-robotics/mode/2up
- Razor Robotics, "8 industries that robotics will transform by 2025" (2017). Available at https://www.razorrobotics.com/8-industries-that-robotics-will-transform-by-2025/
- SMARTCAT, "L'ecosistema de la robòtica a Catalunya" (2018). Available at http://smartcatalonia.gencat.cat/web/.content/03_Actualitat/Actualitat_Noticies/documents/SmartCAT_ecosistema-de-la-robotica-a-Catalunya.pdf
- Technavio (2019), "Top 21 industrial robotics companies in the world 2019". Available at https://blog.technavio.com/blog/top-21-companies-in-the-industrial-robotics-market

Bibliographic resources (II)

- The Lens. Free and Open Patent and Scholarly Search. Available at https://www.lens.org/
- Torrent, J., Díaz-Chao, Á., “Coneixement, robòtica i productivitat a la pime industrial catalana: evidència empírica multidimensional” (2018), *3rd Catalan Congress of Economy and Business. Full papers*. Available at https://www.scipedia.com/public/Torrent_Diaz-Chao_2018a
- Hernandez, Gascon et al. “L’impacte laboral de la Indústria 4.0 a Catalunya”. Col. Papers de l'Observatori de la Indústria ; 3 (2018)
- Vanderborght, Bram ed. “Unlocking the potential of industrial human–robot collaboration. A vision on industrial collaborative robots for economy and society”. European Commission. (2020)
- Asociación Española de Robótica. “Estudio anual 2017 estadísticas de robótica industrial en España” (2017)

Bibliographic resources (III). Press

- Ara.cat, “El gegant de la robòtica Fanuc s’instal·larà a Sant Cugat” (2018). Available at https://www.ara.cat/economia/robotica-Fanuc-sinstallara-Sant-Cugat_0_1962403777.html
- Expansión, “Robot espacial” (2017). Available at https://elpais.com/elpais/2017/07/12/opinion/1499861750_019124.html
- Hisparobs, “PAL Robotics lanza ARI: el nuevo robot humanoide dotado de Inteligencia Artificial” (2019). Available at https://www.hisparob.es/pal-robotics-lanza-ari-el-nuevo-robot-humanoide-dotado-de-inteligencia-artificial/
- InfoPLC, “YASKAWA Ibérica inaugura su nueva sede central en Barcelona” (2013). Available at https://www.infoplc.net/noticias/item/101574-yaskawa-iberica-inaugura-su-nueva-sede-central-en-barcelona
- La Vanguardia, “ABB inaugura en Barcelona un nuevo centro de innovación para impulsar la robótica en España” (2020). Available at https://www.lavanguardia.com/vida/20200129/473210981023/abb-inaugura-en-barcelona-un-nuevo-centro-de-innovacion-para-impulsar-la-robotica-en-espana.html
- Viaempresa, “Barcelona estrena el primer 'hub' de robòtica col·laborativa del món” (2019). Available at https://www.viaempresa.cat/territori/barcelona-hub-robotica-collaborativa_2079053_102.html

ACCIÓ

Passeig de Gràcia, 129
08008 Barcelona
www.accio.gencat.cat
www.catalonia.com
@accio_cat
@catalonia_ti

See the full report here:

http://catalonia.com/.content/documents/robotics-in-catalonia.pdf

More information about the sector, news and opportunities:

http://catalonia.com/industries-in-catalonia/sectors/industrial-systems-smart-industry-and-3d-printing/smart-industry-and-3D-printing.jsp

For the full technological report, please send an e-mail to irodriguez@catalonia.com

Catalonia Trade & Investment

Generalitat de Catalunya
Government of Catalonia