Technology transfer and business:

Challenges and opportunities

The Collider

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About The Collider

The Collider is an innovation programme promoted by Mobile World Capital Barcelona that connects scientific and entrepreneurial talent to create disruptive technology-based startups that address society's and industry's challenges.

The programme focuses on the identification and business development of highly disruptive technologies such as Artificial Intelligence, the Internet of Things, Blockchain and Virtual Reality, fostering the development of new services for the future 5G network.

The Collider encourages the participation of prestigious research centres and universities to build new tech transfer mechanisms and supports the creation of digital startups.

A programme of

MOBILE WORLD CAPITAL™ BARCELONA

A new generation

Twenty years ago, the words “enterprise ecosystem” would have triggered absolute disbelief among many of us. Nowadays, they conjure up the idea of a constantly moving, bubbling mechanism that acts as a spearhead in the country’s technological progress.

Startups have unarguably become the carriers of new technologies to society. Mobile World Capital Barcelona has identified over 4,000 startups operating in Spain, which is fantastic news for the digital and technology sector and for the country itself. Barcelona and Madrid are the poles of creation, development and attraction for this type of company, making us a unique environment with two world benchmark hubs.

Despite this, we have also seen that these 4,000-plus companies are mostly are micro-enterprises, with less than ten employees and low growth capacity due to the lack of funding, the scarcity of talent, or the large amount of bureaucracy works against them, among others).

We are firm supporters of programmes such as The Collider -which specialises in creating startups with state-of-the-art technology and intellectual property- because we believe that it will help promote a new generation of business that will grow at a higher speed both in their local markets and internationally to reach scaleup status.

Success stories such as Privalia, which generated over one thousand jobs and recorded a turnover of more than 300 million euros in barely four years, or Ticketea, the workforce of which totalled 50 employees in six years and that took the leap to expand footprint in Germany, Italy and Portugal, are difficult to replicate if we do not allow this new generation of startups to flourish. The future businesses establishing a turning point in our environment share two distinctive elements that set them apart: their scientific basis and sustainable business models.

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This change of paradigm in the business sector will also be reflected in the area of corporate innovation by transforming the business-university relationship. The creation of synergies among these players is key in the world’s most advanced technological hubs, as it generates a new wealth as a result of good understanding between research and the market.

Identifying and activating these levers, which help startups go on to the next phase, and improving the relationship between universities and business are the challenges facing Spain, and a responsibility that must be shared by the country’s private and public organisations. It is therefore essential to support new models of innovation that bring deep tech solutions, science and entrepreneurship ever closer.

The result of this commitment towards the enterprise ecosystem will result in more jobs and the creation of a new network with sustainable business models and specialist clusters. Promoting tech transfer will lead to greater economic progress and the generation of added value for society.

Carlos Grau
CEO Mobile World Capital Barcelona

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Introduction

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The opportunities of technology transfer

At a time when words such as innovation, competitiveness, productivity, and technology are used by many businesses, resuming the concept of tech transfer seems more than appropriate. It is understood as the capacity to bring scientific and technological findings to the market.

Innovation is really important for businesses. Companies are concerned about the uncertainty of how the market will act over the next five years. They are concerned that part of their team is spending time on tedious tasks. They are anxious about losing money and market share because they are not progressing at the same rate as their competitors, and they are distressed about not being able to adapt to changes in the sector that might affect their business. Amidst all these concerns, businesses have forgotten that Europe -particularly Spain- has an extremely valuable asset that perfectly complements their desire to innovate: strong scientific and technological research.

European universities and research centres form part of the world elite in scientific production. There is also a major opportunity in Spain: our country stands 11th worldwide[1], and fifth in Europe in investigation. The 215,000-plus people who work in research and development in the country are a constant source of knowledge and state-of-the-art technologies.

The *sine qua non* condition for the tech transfer process certainly exists. However, there are several pieces in play (universities, research centres, companies, investors, Public Authorities), and they must all move in line with each other. Supporting a tech transfer strategy means supporting local research ecosystem. With the necessary support it can meet the needs of industry, the economy, and society.

The scarcity of information about new tech is one of the main barriers that companies who support innovation face. They are, however, unaware that discovering new technologies and unblocking new business opportunities is easier than it seems. The purpose of this document is to identify the economic and social opportunities behind tech transfer, the hidden engine of some of the greatest business achievements such as Apple, Fractus (the Spanish company that made mobile phone antennas invisible), or IMM Sound (which played a vital role in the launch of the Dolby Atmos sound system).

[1] Nature, 2019.

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What is tech transfer?

Solving the mystery

Even nowadays it is impossible to find just one definition to explain the tech transfer process. There are several definitions depending on the context and the players involved that, despite sharing certain features, are not the same. The Innovation Policy Platform, developed by the OECD and the World Bank Group, uses the definition of tech transfer given by Roessner (2000), who refers to it as “movement of know-how, skills, technical knowledge, procedures, methods, expertise or technology from one organizational setting to another”. Most commonly, the term refers to the transfer of such assets from universities and research centres to firms or public institutions.

For the COTEC Foundation (2003), this process is “the transfer of intellectual capital and know-how among organisations to be used in the creation and development of commercially viable products and services”. The World Intellectual Property Organization (WIPO) differentiates between technology transfer and knowledge transfer. The former refers to the “transfer of innovative solutions that are protected by different intellectual property rights”, whereas the latter is “a broader term that covers other areas of research, including social sciences, as well as less formal transfer mechanisms”.

“Tech transfer involves bringing added-value products to the market based on innovative or disruptive knowledge. This value is normally created by universities or public research centres, but it is ultimately businesses -which are permanently in contact with the client- that know how to translate this into good innovations.”

Josep Maria Pujals

Business Development Manager for Ponti

Given the wide variety of definitions, the following characteristics have been identified:

1. The technology transfer process always involves at least one technology provider and one recipient.

2. It can be horizontal (between companies) or vertical (between knowledge-generating players and companies).

3. Tech transfer leads to benefits (financial and non-financial) for both the provider and the recipient.

4. It consists of three major phases, although each player has its own system: technology assessment, evaluation of the results, and go-to-market.

"Public investment in research and development generates knowledge. The challenge of technology transfer is to transform this knowledge into market value."

Oscar Sala

Director of The Collider, the Mobile World Capital Barcelona tech transfer programme.

Mechanisms and players

Just as there is no one definition of technology transfer, there is no one process in which knowledge generated inside research centres reaches the market. It mainly depends on the negotiating parties and the context of the transfer. Generally, the main mechanisms behind this process are the following[2]:

- **Collaboration in R&D activities** between universities, and private companies in order to develop or improve products, services or specific processes.
- **Contractual agreements** establishing user rights for the findings. The Spanish Patents and Trademarks Office (OEPM) classified them as: non-disclosure agreement, material transfer agreement, licence (between public and firm), research and development agreement, and licence (firm and firm).
- **Spin-offs**[3] are companies created by the university community that have been based on research findings. By the end of 2017, a total of 93 spin-offs had been created in Spain. Some of these companies have both scientific and business talent in their teams.
- **Advisory and consulting services** by universities and public research centres in addition to their direct R&D activity.

"Technological transfer is linked directly to the research process: a vision we have taken our time to adopt here in Spain."

Roger Cabezas

Project Manager at the CERCA Institute

[2] The Innovation Policy Platform.
[3] CRUE Universidades Españolas. 2017

As indicated above, there are at least two players in the tech transfer process: the technology provider (normally universities and public research centres) and the recipient (businesses). There are other key players in the equation, who provide added value and act as driving forces:

Source: The Innovation Policy Platform.

Scientists and engineers

A direct source in knowledge generation in universities and research centres. They also play an active role in spin-offs and prototypes development. **157,815 people**[4] were working in scientific research and technological development in Spain in 2017.

Universities

These account for a significant part of tech innovation development. They also **devote their resources to making use of the knowledge generated in the classrooms and act as clear liaison with businesses**, tech transfer offices or science and technology parks. Universities also contribute towards the development of the knowledge society, with a strategy structured around the following three main areas: entrepreneurship, innovation and social commitment

Public and private research centres

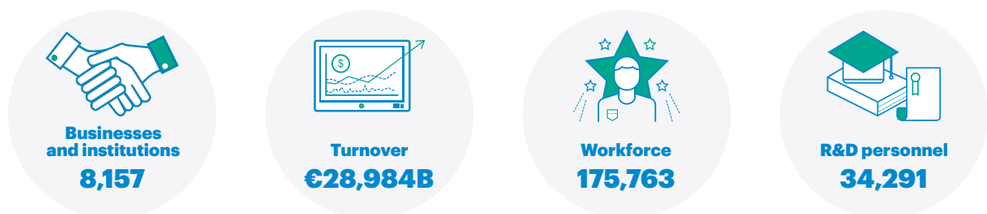
Their activity varies from scientific research to technological development with potential application to the production sector. There are public centres, such as the Spanish National Research Council (CSIC) or Barcelona Supercomputing Center (BSC), and private centres, such as Tecnalia Research&Innovation.

Technology Transfer Offices (TTO)

Knowledge transfer units at universities and public research centres that **act as liaison between business and academic worlds.** Their goal is to promote research and its application to the market. Also among its services is the management of patents, assistance in spin-off creation, and promotion of the tech portfolio.

Science and technology parks

The Spanish Association of Science and Technology Parks (IASP) defines these parks as **projects associated to a physical space for public or private entities**, the main goal of which is to encourage the generation of knowledge and to promote technology transfer.



Source: Spanish Association of Science and Technology Parks.

[4] Instituto Nacional de Estadística, 2017.

Incubators and accelerators

Both formats **offer a series of specific services to startups during the earliest phases of the company**, such as financing, mentoring, physical space, guidance, legal services and others. In Spain, most vehicles of this type linked to tech transfer are the property of a university. In fact, tech transfer is one of the main activities carried out often by university incubators (75%). The percentage is lower in the case of accelerators, standing at 33.3%[5].

Other intermediaries and venture capital

Intermediaries are platforms, centres or entities that **connect the technology portfolio with demand**, such as The Collider venture builder, an innovation programme of MWCapital, or the Dutch programme NLC. Venture capital is a basic element in the development of projects during their earliest phases. Access to capital (either public or private, or in the form of subsidies) during these phases can make the difference between producing a prototype that could, for example, revolutionise health to industry 4.0 sectors, to never leave the laboratory.

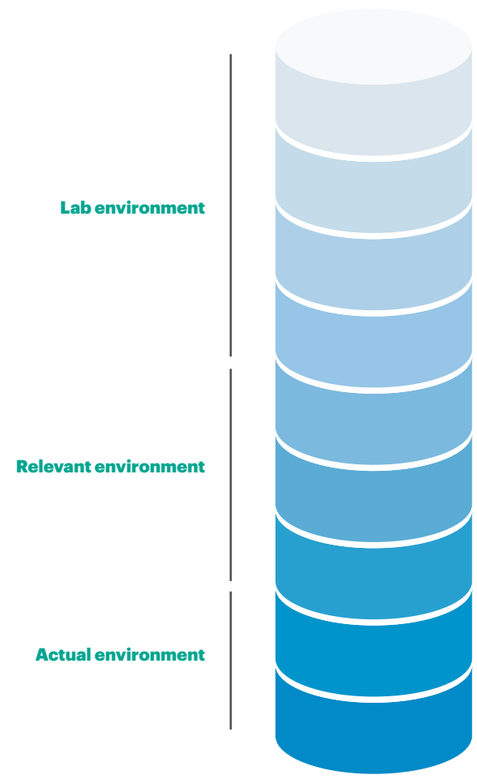
Corporations

These play an essential role in the tech transfer process. **They adopt new tech as a solution to their needs.** Also, being directly connected to the final clients lets them find the most suitable application for the technologies coming from a lab.

[5] Funcas, 2018.

Technology Readiness Level TRL

Technology Readiness Level (TRL) is **an indicator for the classification of technology according to its maturity.** It is also an indicator to bear in mind in any tech transfer process, as it helps value the state of technology and its future implementation and commercialisation. Created by NASA, the classification consists of 9 levels (where 1 is the lowest degree of maturity and 9 the maximum) that range from the conception of the idea to its commercial roll-out.



Source: European R&D Office.

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R&D in Spain: State of the art

Starting point

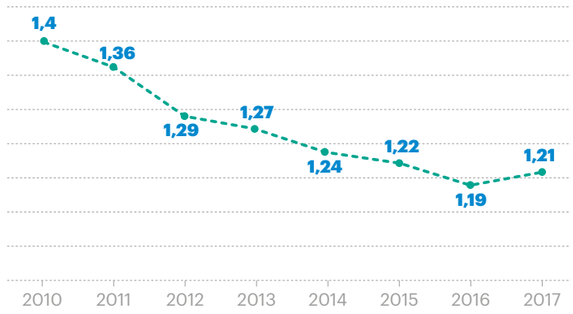
The evolution of the R&D indicators shows that, despite the Spanish economy being on the rise for the past four years, it has not yet had an impact on this sector. Although expenditure in research has grown, its part in Gross Domestic Product is progressing very slowly, widening the distance with other European countries.

In 2017 (latest data available), investment in R&D in Spain stood at 14.06 billion euros. This figure is a 6% increase on the previous year and is the third consecutive year on the rise. Even though these are positive figures, Spain has not yet been able to return to the 2008 figures, when R&D investment was 14.70 billion euros (1.35% of the GDP[6] for that year). Since then R&D investment has dropped to its lowest level in 2014(12.82 billion euros or1.29% of the GDP[7]).

The latest data from 2017 shows that the share of R&D investment in Spanish GDP stands at 1.21%, compared with the 1.19% of the previous year. This is the first time since 2010 that this indicator has positively changed trend. This slight improvement, however, contrasts with two basic data points:

- R&D is far from the target set by the European Union for 2020: which states that investment research and development should account for 2% of Spanish GDP.
- Spain is lagging in comparison to other European countries. Out of the 24 European countries included in OCDE statistics[8], Spain is 17th in terms of R&D/GDP ratio. Heading the European classification are Sweden (3.33%), Austria (3.16%), Denmark (3.06%), Germany (3.02%) and Finland (2.76%). In the world classification, Korea (4.55%) and Israel (4.54%) come before Sweden, followed by Chinese Taipei (3.31%) and Japan (3.2%).

% spending on R&D in relation to GDP



Source: National Statistics Institute.

[6] National Institute of Statistics, 2017.
[7] National Institute of Statistics, 2017.
[8] OECD, 2018.

Innovation capacity in Spain contrasts with its scientific results production, in line with the famous European paradox: Europe is the leader in scientific research but has great difficulty in transforming this knowledge into industrial innovation. Using the number of scientific publications as a unit of measurement, Spain produces 2.44% of the world's scientific publications and stands 12th in the world ranking with 96,517 publications in 2018[9], according to Scopus.

Scopus is not the only source of data to corroborate the potential of the scientific talent in Spain. In the world ranking produced every year by the prestigious journal *Nature*, our country stands eleventh. At European level, Spain stands fifth.

Top 10 most active institutions in scientific production[10]

- Spanish National Research Council (CSIC)
- Barcelona Institute of Science and Technology (BIST)
- University of Barcelona (UB)
- Autonomous University of Madrid (UAM)
- University of the Basque Country (UPV/EHU)
- University of Valencia (UV)
- Complutense University of Madrid (UCM)
- University of Santiago de Compostela (USC)
- Autonomous University of Barcelona (UAB)
- University of Granada (UGR)

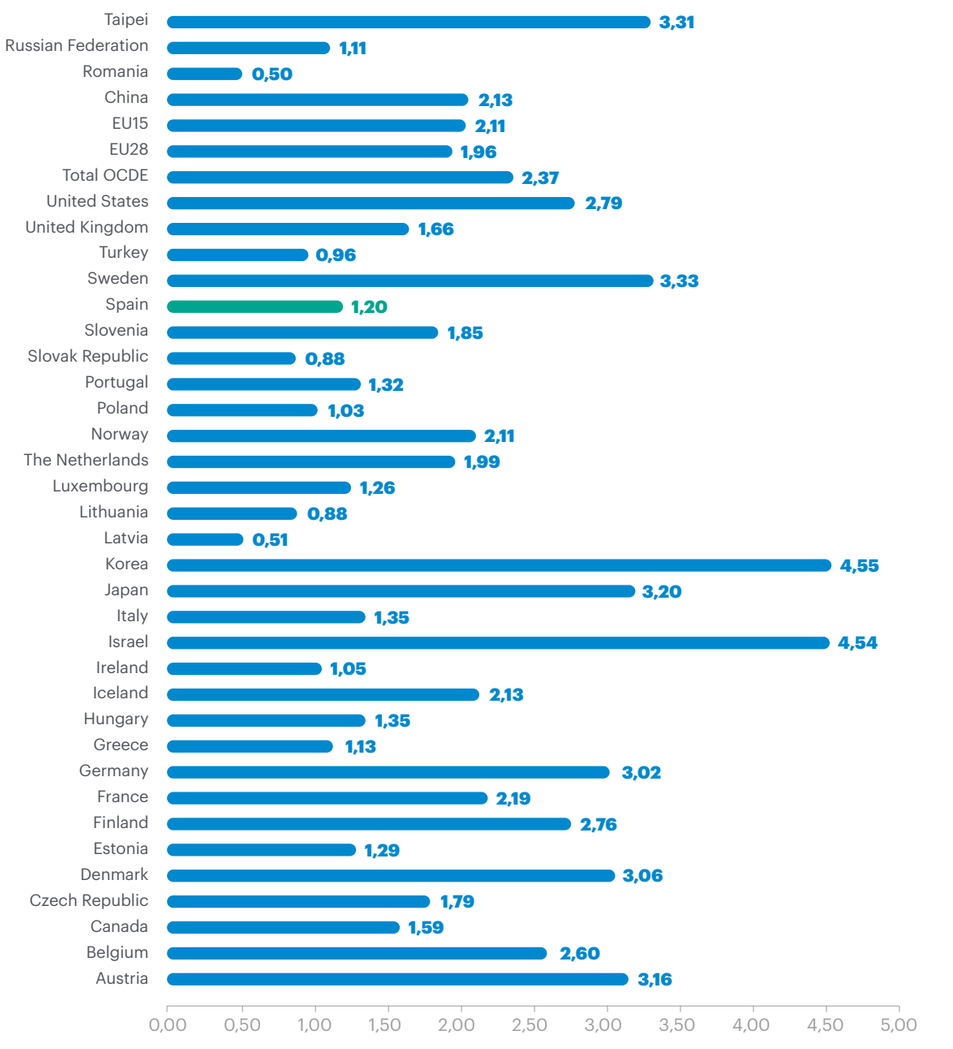
Business: the driving force of innovation

Private investment in R&D is an indicator that measures the degree of interest by business in tech transfer activities. The greater the spending on R&D, the larger are the possibilities of supporting additional sources of innovation outside the corporation.

In Spain, companies used **more than half their expenditure on R&D in 2017**, which is a total of 7.73 billion euros[11]. Of these 7.73 billion, 6.36 billion euros were equity from the corporations themselves. The remainder was funded primarily by the Public Authorities (675 million euros) and by foreign funds (672.4 million euros) and, to a lesser extent, by private non-profit institutions (14.3 million euros) and universities (3.05 million euros).

% Total internal spending on R&D in relation to GDP (2017)

At market prices



Source: National Statistics Institute.

[9] Scopus (Elsevier).
[10] Nature, 2019.
[11] National Statistics Institute, 2017.

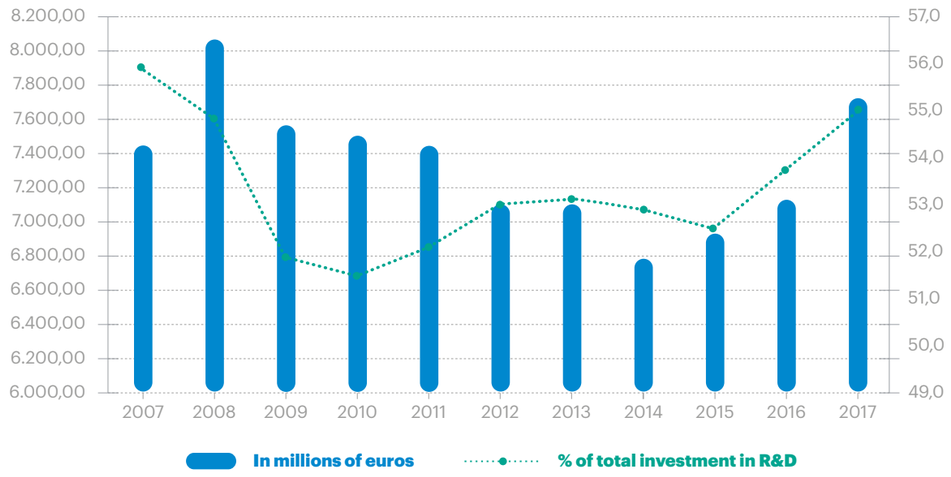
"If there is no innovation on a company's agenda, then it will find it difficult to progress because it is unaware of its challenges. Identify challenges is required to be competitive."

Josep Miquel Piqué

Executive Chairman of La Salle Technova Barcelona and of the International Association of Science Parks and Areas of Innovation (IASP)

As with the total investment in R&D, the indicators measuring company spending on research and development point to a slight recovery in 2017, which will be the first time since 2008 that the figure goes above 7.6 billion euros. The economic recession is also reflected in the number of Spanish companies involved in R&D: 10,179 (2017) compared with the 15,000-plus one decade before (2008).

Evolution in spending on R&D by companies in Spain (2017)



Source: National Statistics Institute.

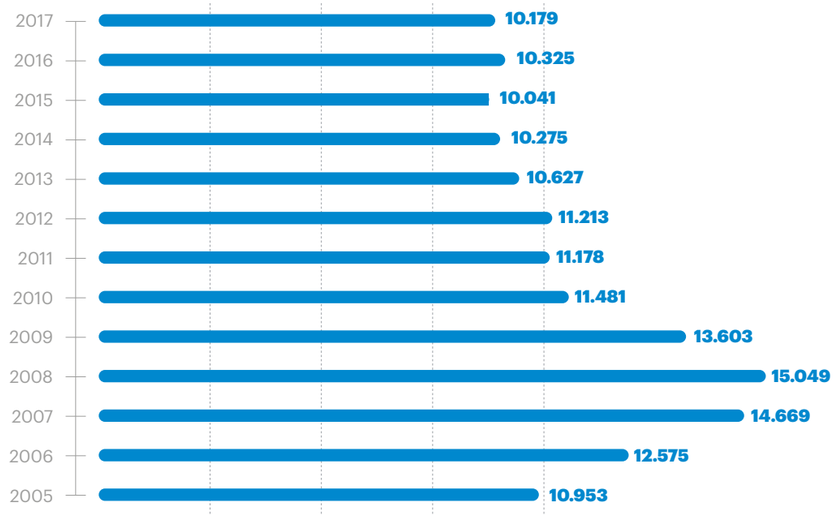
"Nowadays, companies need an open innovation strategy because becoming digitalised by yourself is almost impossible."

Joan Peset

Head of R&D+i for the infrastructures department at Comsa Emte

Despite this, there is an increasing number of companies that recognise the importance of innovation as a driver of growth and competitiveness in a global market. The social perception also leaves room for reflection: 78% of those surveyed by COTEC[12] "strongly agree" or "agree" with the statement "Spanish companies are investing less than they should in R&D+i".

Companies conducting R&D activities



Source: National Statistics Institute.

[12] COTEC Foundation and Sigma Dos, 2017.

Challenges and opportunities of innovation

Investment in R&D or in innovation strategies is not free of risks. In fact, the cost associated to it is one of the main barriers for business. The perception that there is no real demand in the case of innovations also hinders support for R&D. So, why do companies innovate?

The acquisition of R&D or internal R&D are two of the seven activities forming the so-called **technological innovation strategy in corporations.** Other activities under the wings of technological innovation are the acquisition of machinery, equipment and hardware or software, the acquisition of other external knowledge, training, the introduction of innovations to the market, and the design and other preparations for production and distribution[13].

Keeping these in mind, the main priorities of business in tech innovation strategy are the product, the processes, and employment[14].

Objectives of strategic innovations in order of importance:

- Higher quality of goods or services
- Wider range of goods or services
- Greater production or service provision capacity
- Larger market share
- Replacement of out-of-date products or processes

To a lesser extent, corporations also use tech innovation to meet the requirements of environmental, health or safety regulations, obtain greater flexibility in production or service provision, or reduce the cost of labour per unit produced.

Which barriers do they encounter?

- **The cost factors**

The lack of funds in the company, the high cost of the activities linked to innovation, and the difficulty in obtaining external funding.

- **The knowledge factors**

In this case, the scarcity of qualified personnel capable of performing innovation activities and the little information available on the market l.

- **The market factors**

Domination by established companies, along with the uncertainty regarding the demand for innovative goods and services.

[13] National Statistics Institute.
[14] Survey on innovation in companies.

What are companies that invest in R&D like?

Investment in R&D is formed by three types of activity:

Basic research

Experimental or theoretical work aimed at obtaining new knowledge without any market orientation. Its source lies in universities and research centres and, to a lesser extent, in the public authorities. However, it may also lie in the private sector, especially in more advanced companies who seek to prepare themselves for "the next generation of technology"[15].

Applied research

Work aimed at obtaining knowledge, but focused on practical, specific goals. This is a step beyond basic research, which often forms the basis for applied research. According to the definition by the National Institute of Statistics, "it allows for ideas to be put into action".

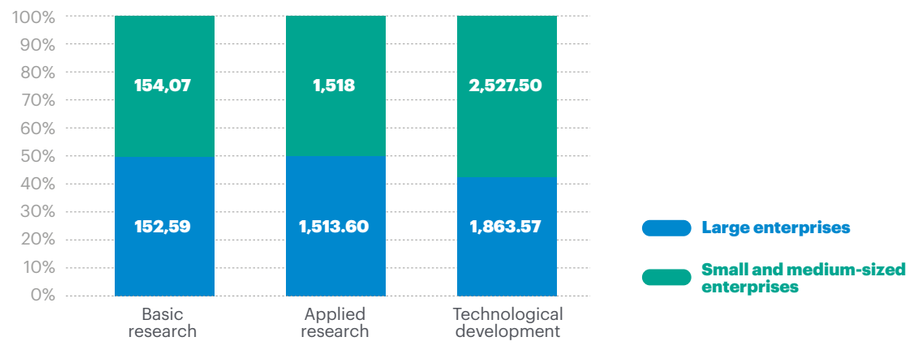
Technological development

Work based on the research results, **aimed at manufacturing new products or processes, or at improving existing ones.**

The investment effort of both large companies and SMEs focuses on technological development and applied research activities, as can be seen in the following graph:

Internal company spending on R&D

In millions of euros



Source: National Statistics Institute.

[15] National Statistics Institute.

At present, companies that are very active in R&D in Spain are those dealing in professional scientific and tech activities (25.1% of total expenditure). Those dealing in R&D services (23.3%), motor vehicle manufacturers (15%), the pharmaceutical industry (8.8%), and groups from the area of information and communications (8.6%), particularly the telecom sector.

The remaining sectors of the Spanish economy account for 20% of internal spending on R&D.

	Scientific and technical activities	R&D Services	Motor vehicles	Pharmaceutical industry	Information and communications
Number of companies	397,722	6,066	1,720	353	71,517
Internal spending on R&D	€422,37M	€392,05M	€252,24M	€148,24M	€145,19M
Personnel employed	1,056,615	51,103	157,799	42,653	481,155
	0,5%	9%	1,4%	4,4%	0,2%
Personnel in R&D[16]	5,197	4,639	2,220	1,868	1,062

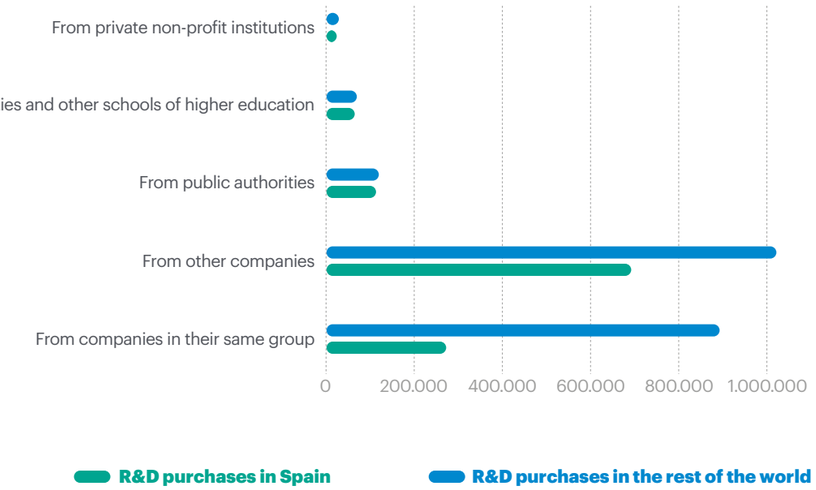
Source: National Statistics Institute.

[16] Note: The data relating to personnel working in research and development refers to full-time employees.

Main R&D providers

Businesses contact other businesses when they want to buy R&D, both inside Spain and abroad. The concept of the university as a provider of scientific and technological knowledge is still in its initial stages, as can be seen in the following graphs:

Where do companies buy R&D?



Source: National Statistics Institute.

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Why is tech transfer important?

Understanding the global innovation ecosystem

In 1996, two PhD students worked together on a digitalisation project for Stanford library, which received funding from the National Science Foundation. The students were called Larry Page and Sergey Brin; their research project was BackRub and, in just two years, it was renamed Google. **In barely twenty years this university project became the most powerful company in the world.**

Another world-famous example: Apple. The US company was not started in a university, but its stellar growth -boosted by the launch of the iPhone- is closely linked to research ecosystem, and to the vision and financial support of the US Government. Starting with the internet, designed by J.C.R. Licklider before he joined the military agency ARPA (from which ARPAnet was created); followed by the voice-controlled assistant Siri, the development of which is the result of a request by DARPA to the Stanford Research Institute; or multi-touch screens that were created by John Elias and his PhD student Wayne Westerman at the University of Delaware during their investigation of neuromorphic systems. Lithium batteries, the iPod clickwheel, or LCD-TFT screens are other inventions that have marked the course technological evolution of the past decades.

Although Google and Apple are extremely famous, the terms Hyperloop and Virgin Hyperloop One are also likely wide known. The former is the trade name for the ultra-high-speed transit system designed by Elon Musk in 2012. The latter refers to the private company that is developing this transit system with other corporations around the world.

There are now at least six companies worldwide developing Hyperloop; two in the United States, one in Holland, another in Canada, another in Poland, and one in Spain: Zeleros. Zeleros was created in a Polytechnic University of Valencia (UPV). Its founders, David Pistoni, Daniel Orient and Juan Vicen, presented their Hyperloop UPV project at the international competition organised by Musk in 2012 and won the prize for the Best Concept Design and Best Propulsion Subsystem, putting Spain in the world race for Hyperloop development.

Almost unnoticed, with very few resources and no great investments, the three students had just marked a turning point in the Spanish transport industry. In 2015, the team formed a company to speed up the commercial development of its project in Europe. Since then, it has received the support of Angels (the investment fund of Juan Roig, owner of Mercadona) and of the business angel Alberto Gutiérrez, co-founder of Plug and Play Spain.

Virgin Hyperloop One and Zeleros are competing for the same technology, but not in the same conditions. The former has the support of the Virgin group, a conglomerate of financial services, travel, video-game, beverage, telephony and even space flight companies. In May 2019, the US company registered a document with the Securities Exchange and Commission to indicate its intention to raise almost 225 million dollars in funding (172.2 million dollars of which were already secured). The latter opened a round of funding in mid-2019 to raise 5 million euros in order to progress in the commercialisation of its prototype and be able to transport passengers by 2027.

The example of Zeleros poses some uncomfortable questions: How many more Zeleros might there be in Spain? **How many highly innovative projects have fallen into oblivion in a Spanish university?** From which research centre or university will the next Zeleros come? And who will be there to provide enough support to turn it into a sustainable company?

The same questions apply to other cases in Spain. Did you know that the company that enabled mobile phone manufacturers to hide their antennas inside the phones is Spanish? Did you know that the technology it developed has become a world standard and that since 2009 it has been in legal disputes with companies such as Samsung, LG, Blackberry, ZTE and HTC?

Fractus is the company playing the leading role in this story. It is a spin-off from the Polytechnic University of Catalonia (UPC), founded by Rubén Bonet and Carles Puente in 1999. That same year, the team patented the first fractal antenna in the world, a technology that ran like wildfire among the main telephone manufacturers and caused the first legal disputes due to patent infringement. Fractus reached agreements with all those involved except Samsung, who was forced to pay 41 million dollars in compensation to Fractus by order of a court in Texas.

During its first ten years, Fractus worked on the manufacturing of multi-band antennas. In 2009, the company generated revenues through the granting of patent licences. The company claims to have a portfolio of intellectual property rights for more than 40 inventions protected by over 120 patents and applications in the United States, Europe and Asia[17].

A large part of these patents also protects the technology in base station antennas, says Fractus[18]. The group has therefore filed lawsuits for patent infringement against the US firms AT&T, T-Mobile, Sprint and Verizon. Fractus has the support of the ICF (Catalan Finance Institute), the investment company Nauta Capital, and several business angels.

Another case exemplifying the potential of the Spanish scientific talent pool is Dolby Atmos, a surround sound technology that allows up to 128 audio tracks simultaneously with sound distribution in the required position. Some of the components of this famous sound system, which is used in many cinemas, are made by the Catalan company IMM Sound.

[17] About Fractus.
[18] La Vanguardia [Barcelona]. 11 April 2018.

With headquarters in Barcelona, IMM Sound was a spin-off from the Barcelona Media Innovation Centre at Pompeu Fabra University (UPF) before becoming part of Dolby Laboratories in 2012. Although it took seven years to shape the project at the Barcelona Media Innovation Centre, IMM sound was set up in 2010. In the two years that it operated alone, the company sealed distribution agreements with GDC Technology and had already installed its sound system in around thirty cinemas worldwide owned by groups such as Cinesa or Gaumont-Pathé[19].

Spanish business has access to scientific talent pool that generates quality knowledge and that is playing an active role in tech findings of the utmost importance. There are 82 universities in the country (50 public and 32 private)[20], twelve of which are among the 500 best universities in the world[21]. Over 157,800 people (79,285 full time) are university personnel working in R&D, out of the 215,713 people working in this area nationwide (including the Public Authorities and businesses). Failing to use these resources relegates Spanish science to a back seat, and businesses are doomed to lose competitiveness and the country to not capitalise upon one of its most valuable assets. Tech transfer is the response to counteract this effect.

Tech transfer opens a range of opportunities to the entire innovative ecosystem. In general, it ensures the continuity of the scientific activity, which requires financial resources to continue with its basic and applied research and tech development work. For businesses, it is a source of competitive, economical innovation **capable of solving sector-based challenges**, and contributing towards their sustainability.

For the country, it is a significant economic and social driver due to generation of the quality employment and new businesses. Tech Transfer also contributes into solving the social challenges, agreed by the United Nations in the 17 Sustainable Development Goals (SDG). Science support by public and private sectors is fundamental to nourish technological progress and sustainability. Without it there will be no economic growth or development.

[19] Expansión [Barcelona]. 10 May 2012.
[20] Ministry of Education and Professional training.
[21] QS World University Rankings.

Over one hundred years of research: Science and technology in Spain

1854
Manuel García invents the laryngoscope.

1859
The prototype submarine by Narcís Monturiol remains underwater for over two hours.

1906
Santiago Ramón y Cajal and Camillo Golgi share the Nobel Prize in Medicine for their work on the structure of the nervous system.

1920
Juan de la Cierva builds his first autogyro in Madrid.

1938
Engineer Alejandro Goicoechea begins development of the Goicoechea-Oriol light articulated train, popularly known as the Talgo.

1973
Manuel Jalón Corominas, who also invented the mop, invents disposable hypodermic needles.

1989
CSIC researchers Javier Borderías Juárez and Margarita Tejada Yábar register the patent for "gulas" (ersatz eel).

1991
Margarita Salas and her team at the CSIC obtain the US patent to protect the phi29 DNA polymerase method. It is now one of the most profitable patents of the CSIC.

2011
The team of CSIC researchers who developed tolerable varieties of wheat for most people with gluten intolerances sells the patent to a British company.

2014
Researchers from IMDEA Nanociencia, the Institute of Material Science of Madrid, the University of the Basque Country, and the Autonomous University of Madrid publish an article describing how to create a magnetic field from graphene.

2015
A team of engineers and surgeons complete the prototype for the first surgical robot with 3D vision created in Spain. The University of Cordoba coordinates the project.

2016
The CSIC presents the first exoskeleton for children with spinal muscular atrophy.

2017
Teams of scientists from Galicia and Catalonia synthesise the longest and finest graphene nanoyarns in the world. Their application in quantum computing and photonic science is relevant.

Economic and social impact: the opportunities of technology

Knowledge-based solutions

Tech transfer is fundamental for unlocking the potential of Spanish science. Only a minimal part of the findings by national researchers reach the market. It leads to a loss of valuable assets for businesses and for society. The major opportunity consists of transforming this knowledge into solutions that respond to sectorial challenges.

A window open to new technologies

Tech transfer is a window to innovation and disruptive technologies that are not yet in the market. It can help companies not only to generate new products and services but also be capable of solving short, medium and long-term goals in a VUCA (volatile, uncertain, complex, and ambiguous) environment.

Source of innovation

Innovation and R&D are essential for business competitiveness and sustainability. Tech transfer is a source of innovation that allows for the incorporation of talent, ideas, technology and operating methods from universities and technology parks in an economical, flexible way.

Economic impact

The extensively disruptive nature of tech transfer is a very interesting economic opportunity for businesses, which leads to the launch of new products and services with a high added value.

"We are aware of the great potential in promoting collaboration between universities and academia and the business world to ensure all ideas and disruptive technologies generated in universities and research centres become a reality and reach the production network, as this remains insufficient."

Emilio Martínez Gavira

Corporate Entrepreneurship Manager at Enagás

Social impact

The function of a company is not limited to its own profits, but instead it also has a duty to society. In this setting, the company acts as a key player in ensuring the scientific and technological discoveries reach, impact and transform society.

Retaining talent and generating employment

Private support for R&D and public policies that are committed to research not only strengthen and enhance the pool of scientific talent in this country, but they also help retain it, avoiding the flight of talent and contributing towards the creation of quality employment.

A new business culture

Working and collaborating closely with scientific and technological teams is an opportunity to incorporate a new mindset into the company: acquiring a new vision to tackle complex challenges, learn new ways of operating, and gaining flexibility and agility.

A form of growth of the research system

Greater collaboration between universities and research centres and businesses ensure a greater number of resources for R&D, which in turn means a system that is more capable of continuing researching and discovering new findings that have an economic and social impact.

« »

"Cross education is a must. Scientists are asked for a part of the knowledge they generate to be transferable, whereas the business culture must change to incorporate technology that focuses on these three goals: economic growth, social growth, and prestige."

Eduard Alarcón

Vice president IEEE CAS Society. Professor at the UPC

Spanish Technology transfer in figures

Tech transfer activity in Spain has been rather discreet over the past decade. Things, however, are changing. Experts agree that the historic distance between research ecosystem and businesses is beginning to narrow, driven by a greater desire by both players to understand each other and strengthen links.

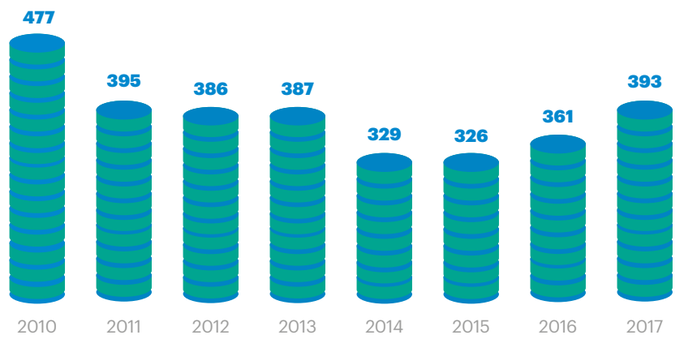
The latest data from the report Research and Knowledge Transfer in Spanish Universities, produced by CRUE using 2017 data, indicates that the revenues generated by tech transfer are no longer dropping, although their recovery remains slow in relation to previous years. In 2017, **the total revenues received by universities through outsourced R&D was 393 million euros**, 8.8% up on the previous year but 84 million lower than 2010 figures. The report gives certain key ideas, such as:

- Despite the fact that the total sum of outsourced R&D grew in 2017 (393 million), the average price of R&D on commission dropped from 44 million euros per contract in 2010 to 32 million euros per contract.

- Many R&D contracts signed by universities are with private entities (70%), which provides 71% of the turnover. Moreover, proximity is key in tech transfer: 67% of university-private entity interactions took place in the same autonomous community.

Total sum of outsourced R&D

In millions of euros

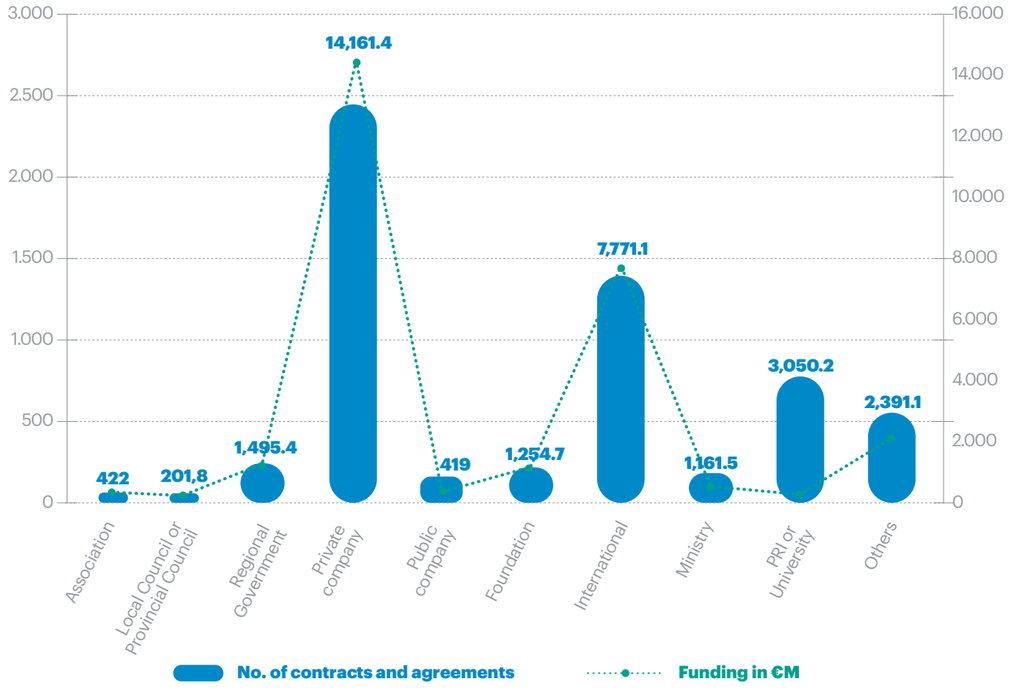


Source: CRUE 2017.

- Figures regarding the protection of research results continue to drop. Between 2016 and 2017, patent applications from universities fell by 15%, from 609 to 529. During this period, invention notifications dropped by 8.7% to 1,097. The impact of the financial crisis, the new Patents Law or the end of the PETRA Programme are just some of the factors explaining these figures, according to CRUE. Furthermore, the report suggests that the evolution of the patent portfolio reflects a certain containment in their accumulation, "which might be interpreted as better and more attentive management of their value and repercussion". Non-disclosure agreements, however, rose from 806 to 929 in one year.

The Spanish National Research Council, which includes a total of 120 centres and units (67 of its own and 53 joint centres sheds some light about tech transfer in the country. Although **the number of tech transfer contracts, agreements and programmes signed by the institutions belonging to the CSIC has increased over the past four years, the funding of these contracts and agreements has decreased slightly.**

Valid contracts and agreements of the CSIC and its contracting entities



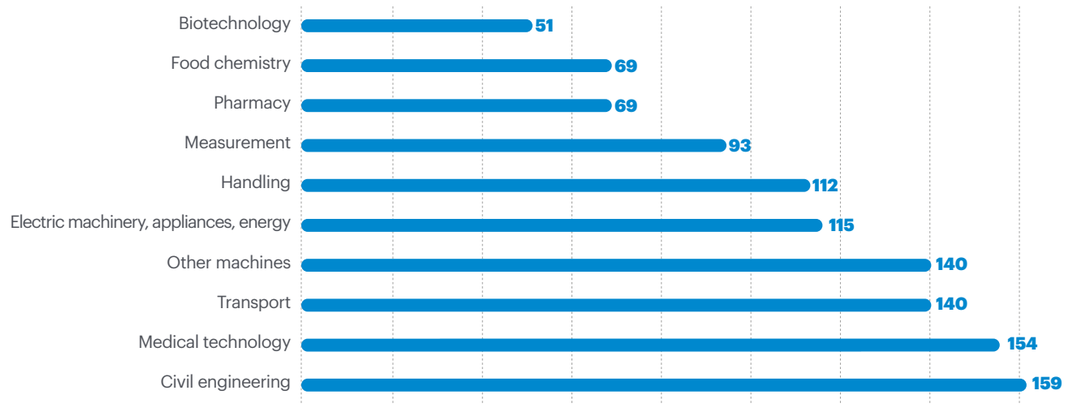
Source: CSIC annual report, 2018.

Patents

According to the Spanish Patents and Trademarks Office (OEPM) a patent is an industrial property certificate that protects procedures, products, appliances or technical devices, preventing others from copying, falsifying, or selling the product or procedure. Protection of these patents varies depending on the type of application, which can be national, European (valid in up to 40 Member States) or international (can be protected in up to 152 States through the PCT system). For example, a Spanish patent remains valid for 20 years from the application date.

The number of patents has become an indicator of the innovation level in a country. According to the World Intellectual Property Organization (WIPO), the United States, China and Japan are the countries with most applications processed through the Patent Cooperation Treaty (PCT) with 56,142, 53,345 and 49,702, respectively, in 2018. Applications from Spain during that same year amounted to 10,809, with emphasis on civil engineering, medical technology and transport.

Sectors with highest number of patent applications via PCT



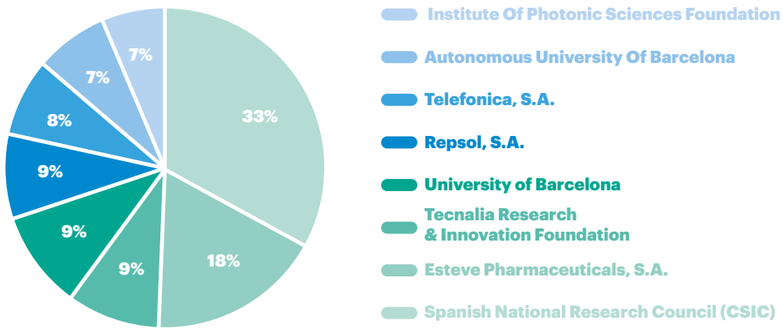
Source: World Intellectual Property Organization. 2017 data.

At the European level, Spain applied for a total of 1,776 patents from the European Patent Office (EPO)[22], 6.3% increase to the previous year, places Spain 15th in the world classification for patent applications, a considerable distance from the United States (43,612 applications), Germany (26,734 applications) or Japan (22,615 applications).

Even so, the number of applications per inhabitant puts Spain even further in the world classification. With 49.3 million inhabitants, Spain registered 36 patent applications per million inhabitants, relegating it to 27th place behind Italy (70.7 applications per million inhabitants) and Denmark (with 5.8 million inhabitants, its ratio is 411.4 applications per million inhabitants). The European paradox is therefore proven: **Spain is an excellent scientific knowledge producer, but it struggles convert this knowledge into innovation and, as a result, into wealth for the country.**

According to the latest data from 2018, eight Spanish entities accounted for 10.3% of all patents (European and via PCT) applied for through the European Patent Office:

Patents applied for from the European Patent Office in 2018

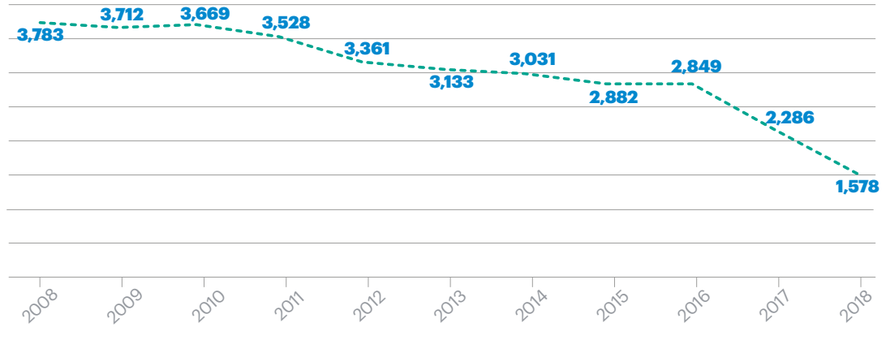


Source: European Patent Office.

By placing the spotlight on the patents applied for through the OEPM which are valid in Spain, it is seen that applications have dropped significantly over the past two years. The reason for this decrease can be attributed to the entry into force on 1 April 2017 of the new Patents Law, which includes the obligation to pass a prior examination to obtain a patent and has led to a drop in the number of applications.

[22] European Patent Office, 2017.

National patent applications to the OEPM



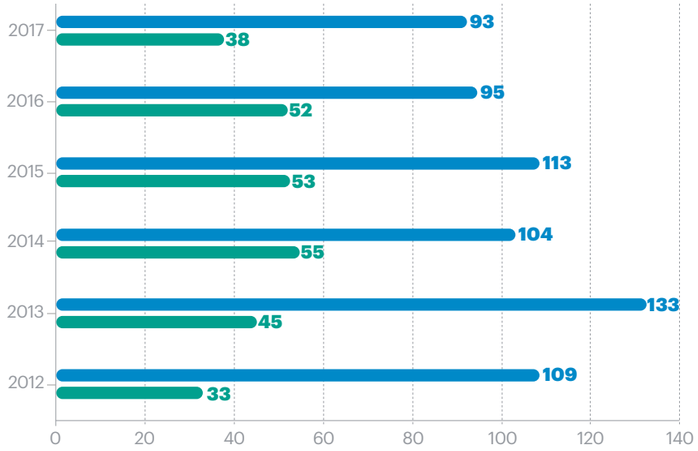
Source: European Patent Office.

Spin-off

Beyond the partnership agreements, the provision of services or the licences, tech transfer has also become apparent in so-called spin-offs: companies created to make use of products or services generated from R&D findings. **Spin-offs aim at providing users with value**, are involved in the creation of value-added jobs, and allow researchers who are unable to remain in the university to continue working on their investigation.

In 2017, Spanish universities created 93 spin-offs, which employed 160 people (an average of 1.7 people per company). Over half (56%) were from engineering and architecture, whereas 16% came from the health sector. The number of spin-offs created in 2017 was the lowest since 2012. In its report, CRUE attributes this to the situation in Spain and to the "decrease in human resources in transfer management units dealing in promoting and managing the creation of spin-offs".

Creation and evolution of university spin-offs



Fuente: CRUE, 2017

Another indicator involves the companies that increased their capital over the year (38), which dropped considerably in relation to 2016 (52 companies). Two readings can be made of this data: **funding for spin-offs must be increased and the management capacity of these companies must be improved.** The proportion of personnel in universities who work in tech transfer, barely reaches 1%. Another 2% are involved in innovation management, and the remaining 97% are research personnel.

“Generating knowledge is essential and it must be powerful. But this does not ensure that this knowledge reaches companies. Several factors must be considered to achieve this, such as time, the country’s type of business network, or the innovation policies. Tech transfer is a slow process based on trust between a university and a company.”

Pep Martorell

Associate director of BSC-CNS

Entrepreneur and researcher: a multi-disciplinary team

An entrepreneurial attitude is one of the essential ingredients behind the tech transfer success. Universities have been carrying the banner for the so-called *Third Mission*, the goal of which is to transfer knowledge to society in addition to their two prior functions: education and research.

The concept of the university’s third mission is very wide-ranging and includes many nuances. One of the most famous readings is the concept proposed by Clark (1998), who links the *Third Mission to the Entrepreneurial university* based on the technological commercialisation process of university resources. The new relationship established between the university and society has direct repercussions on the teaching programme of the former, which has spent years trying to provide its students with tools to develop an entrepreneurial attitude and adopt cross-skills such as leadership, fund raising, or team management.

“The drivers behind this entrepreneurial attitude are the changes in the market and in society. Uncertainty worldwide and, more specifically, on a socioeconomic level is more patent than it was a few years ago. An entrepreneurial attitude allows for these situations of uncertainty to be faced.”

Xavier Testar

Deputy Director of the BIE-UB and Vice Chairman of the AEEC

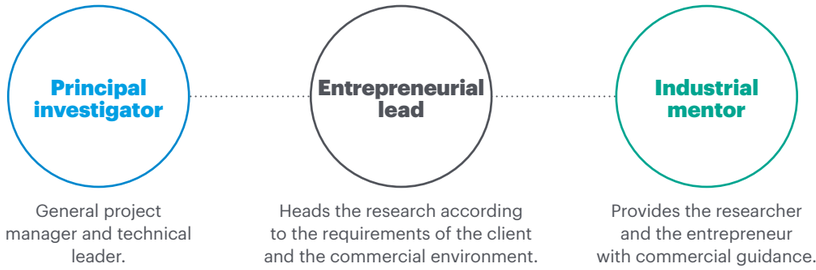
Alongside the reconfiguration of the university, entrepreneurial activity in Spain has increased significantly since the start of the financial crisis. The number of startups in the country now stands at 4,115[23]and the Entrepreneurial Activity Rate[24] is coming close to pre-crisis levels, (6.4% in 2018).

The evolution of both has expanded in initiatives such as The Collider, which connects entrepreneurs with researchers to create highly innovative startups. There are also other private and public initiatives that have also chosen to enhance entrepreneurial talent of their research teams, either through mentoring programmes or with specific courses to strengthen their business skills. Support for this type of teams, which combine scientific-technological knowledge with knowledge of the market in the same company, is also seen in the adoption of the I-CORPS method.

Lean LaunchPad method

Lean Launchpad (LLP) is a methodology created by Steve Blank, Stanford University professor and adopted by the National Science Foundation under academic supervision from UC Berkeley professor Jerome Engel. It provides researchers with methodological tools so that they can identify industrial challenges and solve them using the technologies developed in their schools.

3 profiles are highlighted:



	What characterises a researcher?	What characterises an entrepreneur?
Roles	To perform research with results that have an impact on society, to expand the frontiers of knowledge, and a systematic understanding of a field of study.	To take one's own ideas to the market, to lead a business project, to analyse the market in search for new business opportunities, to plan the strategy of a business, and to obtain funding.
Main motivation	To publish scientific articles, to be quoted in other articles, to obtain standing and recognition.	To ensure a sustainable business, with recurring revenues and a solid customer portfolio. Sale of the company.

[23] Startup Ecosystem View 2019.
[24] Global Entrepreneurship Monitor (GEM).

"Spin-offs must always go through a process of re-adaptation, because technologies don't leave the university as plug and play. All this can only be done if they know the market."

Manel Arrufat

Entrepreneurship & Innovation Manager at the Polytechnic University of Catalonia

What happens when an entrepreneur and a researcher cross paths?

Technology as added value
Hybrid teams formed by scientists and entrepreneurs apply advanced technologies to meet market needs and start structural changes of various industries.

Focus on the market
A hybrid team understands the complexity of the market. This encourages communication with various and an understanding of the customers and the demand.

Own R&D team
The researcher not only acts as source of knowledge within the team but can also unlock new market applications for a technology depending on customer requirements.

A multi-disciplinary team
Combination of both profiles in the same team offers different ways of approaching and solving a given problem, generating more effective and complete solutions.

Economic and social impact
Projects arising from research and advanced technologies that fall into the hands of entrepreneurs not only have an impact on the business network and on the economy when they successfully complete the commercialisation process, but they also play an active role in ensuring a more sustainable society.

How does this generate value for the company?

Scalability of ideas and innovative projects
With the capacity to transform industry, that would otherwise probably not have reached the market.

Risk control
Work with multi-disciplinary teams allows for the risk inherent to innovation to be mitigated, in the knowledge that the hybrid team will keep the spotlight on the market.

Access to the most advanced technologies and the best (technical and business) talent
This enables the company to adapt to the changes and gives it greater capacity to operate in a VUCA environment.

Adoption of sufficiently mature technologies to conduct pilot tests
For the company: new lines of business, scalability, competitiveness, productivity, generation of employment, etc.

Case studies

Smart Tower

Smart Tower offers a comprehensive, remote and autonomous solution for real-time information on the status of a structural asset while predictively analysing it. At present, the technology with which it operates, developed by two PhD students from the UPC and sponsored at the time by Comsa, detects structural faults in electricity pylons to an efficiency rate of 85%, although it can be applied to other types of structure. During an initial phase, the startup focused on developing the technology that had been designed by the PhD students from the UPC by validating the hypotheses and interviews with the main players in the industry. During a second phase, its goal was for the prototype to evolve to include new functions (from geolocation to vegetation or climate sensors).

Smart Tower was created during the 2018/2019 edition of The Collider. Its team, formed by Mariano Sancho (CEO), Marc Senda (COO) and researchers Lluis Gil and Marco A. Perez, is already negotiating with companies such as Endesa, Red Eléctrica and Unión Fenosa.

« »

"The Collider has had the vision to search carefully in universities, hospitals and other sectors. Saying: let's look for technologies that can be transferred to the market and that were often badly directed."

Mariano Sancho

Mariano Sancho, co-founder and CEO of Smart Tower

AllRead

AllRead is a startup that is based on computer vision technology that teaches the machine to read, and is capable of extracting alphabetic text or numbers from any image (photograph or video) and convert it into Big Data. It is 98% reliable, which is 18% higher than previous technologies. The technology on which AllRead runs is the result of collaboration between a research team from the Autonomous University of Barcelona and the Computer Vision Centre. AllRead now focuses on meeting the needs of Industry 4.0, where the volume of valuable text in operating environments is extremely high.

Created during the 2018/2019 edition of The Collider, the startup has conducted pilot tests with Port de Barcelona, although it believes its solution is constantly transforming in line with the feedback it receives from industry. The AllRead team is formed by two entrepreneurs, Miguel Silva-Constenla (CEO) and Adriaan Landman (COO), and by researchers Dimosthenis Karatzas (CTO), Marçal Rossinyol (PO) and Lluís Gomez (PM).

« »

"The startup world is not like it was ten years ago, when having an idea made you an entrepreneur. Nowadays, investors and the market are more demanding. You must know your product, your added value, your competitive difference... And technology is a very good competitive advantage."

Adriaan Landman

Co-founder and COO of AllRead

Pharmacelera

Pharmacelera is one of the first startups created by The Collider programme. The company, headed by PhD students Enric Gibert and Enric Herrero, uses artificial intelligence to design drugs and active ingredients from molecular models they themselves developed. The startup, made up of an interdisciplinary team, offers hardware and software solutions for computer-aided drug design, with products such as PharmScreen and PharmQSAR.

Since it was established in late 2016, Pharmacelera has attracted one million euros in funding (public and private), has closed deals with clients from different countries, and has signed a strategic partnership agreement with the Cambridge Crystallographic Data Centre (CCDC), as well as having patented its algorithm. The company has also started a service project with the Autonomous University of Barcelona to develop a drug for Parkinson's disease, and its goal for 2019 is to approach the major pharmaceutical companies.

"Combining the technical part with the entrepreneurial part is complex, but you soon realise that the company is much more than R&D strategy and developers."

Enric Gibert

Co-founder and CEO of Pharmacelera

RheoDx

RheoDx is developing a portable diagnostics device that improves the efficient monitoring of patients with haematological diseases. This small device immediately and inexpensively detects any abnormalities in blood cells with just one drop of blood. The technology, which was patented in 2016, was created at the Mathematics Research Centre (CRM) of the Autonomous University of Barcelona and the Faculty of Physics of the University of Barcelona.

Since its creation in The Collider in 2018, the RheoDx team has already identified six market applications for this technology, from infectious diseases such as malaria to coagulation disorders and transfusions. Oliver Balcells is piloting the startup. RheoDx plans to start marketing its portable device in 2021. In 2019, the startup received financial support from the Crowdfunding platform Capital Cell, Enisa and Statup Capital, attracting a total 600,000 euros in funding.

"I think corporations might find collaborating with The Collider startups to be interesting, as we can provide innovation not only from a technological side but also through the way we operate. They find this business culture very attractive."

Oliver Balcells

Co-founder and CEO of RheoDX

Saalg Geomechanics

Saalg Geomechanics has developed a software called Daarwin that uses geotechnical measurements and artificial intelligence to reduce the costs of public works by up to 50%. Founded by geotechnical engineers Cristian de Santos and Ignasi Aliguer, the startup is a reflection of how a research project ends up being a solution to market needs. “We work on understanding how the ground works: we have developed a software that collects all the information from the predictive design models and all the data from the sensors. Based on intelligent algorithms, we calibrate the design models during their construction phase for an understanding of how the ground will behave”, explains De Santos, CEO of Saalg Geomechanics.

Since joining The Collider in 2017, the startup has attracted the interest of Cemex Ventures, the investment arm of the construction company Cemex. Its investment in Saalg Geomechanics enabled the startup to launch the first commercial version of its software. Ferrovial, Acciona, DB and OHL are all part of the Saalg Geomechanics client portfolio.

“The Collider has helped us a great deal with our commercial drive, visibility and mentoring.”

Ignasi Aliguer

Co-founder and CTO of Saalg Geomechanics

Sectors with greatest potential for technology transfer

The contracts and agreements remaining valid in 2018 for the CSIC, the national agency that is made up of 120 research centres around Spain, are a clear example of the sectors that most benefit from the results of the country’s research: agricultural sciences (including genetic improvement projects, livestock farming, aquaculture or water in agriculture), biology and biomedicine (which is also one of the most attractive sectors for venture capital), and the area of material science and technology (development of advanced instrumentation, materials for energy, construction architecture and engineering, etc.).

The Collider´s experts has identified four sectors in which a good tech transfer strategy could become a catalyst for disruption and innovation for businesses.

Health & Wellness

Growth forecast 2022[25]
USD $10,059 trillion[26]

Mobility

Growth forecast 2030[27]
USD $1 trillion

Utilities

Growth forecast 2025[28]
USD 8,885$ billion

Industry 4.0

Growth forecast 2025[29]
USD $227,290 billion

[25] Deloitte, 2019.

[26] Note: billion = one thousand milliion
trillion = one million million

[27] KPMG, 2019.
[28] Envision intelligence, 2018.
[29] Verified Market Research, 2018.

5

International benchmarks

MIT, tradition and innovation in the United States

The Massachusetts Institute of Technology (MIT) is the second most innovative university in the world[30] after Stanford University, and eighth in the Milken Institute ranking of the best tech transfer universities in the United States. Companies such as Dropbox, Akamai, iRobot, Catalyst and BuzzFeed have their origins at the institute, which has issued over 2,000 patents over one decade.

MIT is a benchmark in tech transfer. Around fifty people work in its technology licensing office (TLO), the mission of which is:

- To identify, protect, market and license the intellectual property of MIT, helping in its transfer to society.
- To administrate and grant licences to the registered trademarks of MIT.
- To support business programmes and transfer innovation to society, from the conception of the idea to its impact.
- To create and strengthen relationships between MIT and businesses. At present, over 700 companies are in close collaboration with MIT technology licensing office. In fact, companies contribute to MIT activity by providing 20% of all research and development funds.

"The TLO has a vital role to play in moving MIT discoveries from idea to investment and impact [...] Our focus is impact, not income, and revenue derived from licensing is shared with inventors, research units, and MIT, after patent and other operational costs are recovered", explains office Director Lesley Millar-Nicholson in her annual letter[32].

Actividad de la oficina de transferencia de tecnología del MIT 2009-2018

Disclosures	Patents issued in the US	Option agreements	Licensing agreements
6,947	2,721	330	978

[30] Reuters 2018.
[31] Note: In 2018, research and development expenses at the MIT amounted to 731.51 billion dollars. Of this figure, industry provided 144.13 billion dollars (around 20%) according to MIT data on its website.
[32] MIT TLO.

International benchmarks

EEUU

Univesity of Utah
Columbia University
University of Florida
Brigham Young University
Stanford University
University of Pennsylvania
University of Washington
Massachusetts Institute of Technology
California Institute of Technology
Carnegie Mellon University

Spain

CSIC
Eurecat
BSC
BIST
Tecnalia Ventures
UAB
UAM
UCM
UPV/EHU
ICFO
UC3M
UPC
Leitat
The Collider

Israel

Weizmann Institute of Science - YEDA
Yissum (Hebrew University Technology Transfer)
SN_2E

Singapore

Agency for Science, Technology and Research (A*STAR)

Mexico

Universidad Nacional Autónoma de México (UNAM)
Instituto Tecnológico de Monterrey Campus Guadalajara

Europe

ETH Zürich (Switzerland)
IMEC (Belgium)
CEA Tech (France)
Oxford University Innovation (The United Kingdom)
TNO (Netherlands)
Ascenion (Germany)
X! Delft (Netherlands)
Innovation Exchange (Netherlands)
AIMday (Sweden)

Fuente: Nature, 2019.

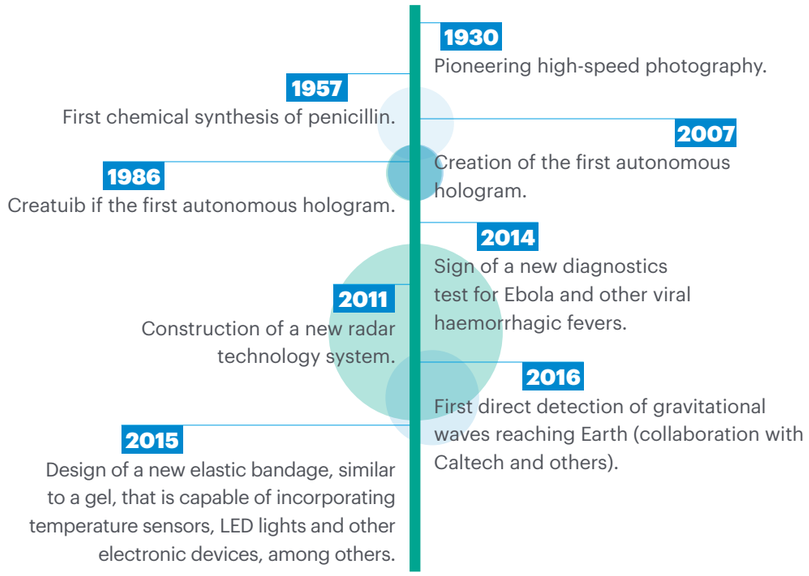
MIT support for technology transfer

Five schools (with a total of thirty departments) and dozens of centres, laboratories and programmes make up the ecosystem organised by MIT to promote research and development activities. The flexibility and simplicity of its processes, combined with the support for interdisciplinary teams of experts in their field, are part of the success formula for tech transfer at the MIT.

MIT has different programmes for developing technology that may impact the world, such as the Media Lab or the Computer Science and Artificial Intelligence Lab (CSAIL). However, aware of the difficulty involved in developing and commercialising certain technologies without the necessary funding, it launched The Engine programme in 2016.

The mission of The Engine is to close the gap between the discovery and the commercialisation of a technology. To do so, it has 200 million dollars in funding to support advanced technology projects and a network of contacts that connects the founders with other startups, companies and the Public Authorities, among other potential partners. The Engine also provides access to different facilities required by the participants in the programme. Since it was established, The Engine has funded 20 projects, according to Crunchbase.

Ninety years of research: Technological advances at the MIT



Disparity in Europe

In 2017, all EU Member States invested a total of 320 billion euros in R&D, which is 2.07% of their combined GDP. This figure, despite being similar to investment in China in 2015 (2.06% of GDP) remains far from the goal set for 2020: 3% of GDP.

The argument put forward by the European Union to increase intensity in R&D is that these efforts will stimulate its competitiveness. R&D spending by South Korea in 2015, for example, accounted for 4.22% of its GDP. That same year in Japan, investment in R&D accounted for 3.28% of its GDP.

In Europe, there is significant disparity in relation to investment in R&D. While investment in R&D remains a high priority for countries such as Sweden, Germany, Finland, Denmark and Belgium, this strategy loses force in countries such as Croatia, Bulgaria, Romania and Poland.

Within the context of this wide variety of policies and priorities, some formulas are being highlighted due to their modus operandi in the field of tech transfer. Some stand out for their trajectory, whereas others do so for their innovative approach. In any case, they are all examples to be mirrored.

Oxford University Innovation • The United Kingdom

EThis is a British technology transfer and consulting company formed to manage the results of research and development by Oxford University. It supports researchers wishing to market their industrial property through its licensing and ventures team, which not only provides advice on the subject but also establishes a network of contacts with potential partners and investors.

Oxford University Innovation also builds ties between university researchers and external clients, and opens the door to its incubator for alumni of Oxford University wishing to develop their projects. According to the latest data from 2018, Oxford University and its researchers received a financial return of 8.9 million sterling pounds. That same year, 3,881 patents and patent applications were registered for inventions originating at Oxford and 21 spin-offs were created.

CEA Tech • France

CEA Tech is the CEA's (the French Atomic Energy and Alternative Energy Commission) technology research unit. Specialising in areas such as information and communications, energy and health, the organisation has three laboratories responsible for developing technologies in the following fields: Leti, Liten and List. The main objective of CEA Tech is to make new technologies "the main driving force for growth of the industrial economy".

CEA Tech has 4,500 employees distributed around the regional centres it runs in France. The organisation works with technologies with TRL between 3 and 7 (from proof-of concept to the first prototype in an operational environment). CEA Tech runs on an annual operating budget of 650 million euros and 600 priority patent applications.

TNO • Netherlands

Founded in 1932, TNO Amsterdam is an independent research centre that employs around 2,600 people and connects people and knowledge to create innovations that foster the competitive strength of industry and society. The centre works with private companies, public bodies and other organisations on its research.

Tech transfer is one of the branches of activity of TNO, which focuses on areas such as energy, infrastructures, pharmacy, and medicine. At present, TNO's portfolio includes 17 spin-offs created between 2016 and 2019, which have generated a total of 66 new jobs.

X! Delft • Netherlands

X! Delft aims to physically connect the core of Delft Technical University (Holland) to industry and society, on campus, to create the future. It proposes collaboration between industry and the university through different programmes and services. Photonics, blockchain, artificial intelligence, the Internet of Things, or quantum physics are just some of the technologies with which X! Delft works.

The initiative by Delft Technical University holds meetings with the main players in industry to gain an understanding of their needs. X! Delft is also a meeting point for representatives of industry and startups, researchers and students. The unit also develops short-term pilot projects (between 3 months and one year) with companies in line with their strategic innovation agenda. Its facilities are home to the YES! Delft incubator and RoboHouse, where robotics projects are developed. Its corporate partners include Heineken, Aegon, Brunel and Rabobank.

Ascenion • Germany

Ascenion is a technology transfer company specialising in life science and is owned by the LifeScience Foundation. With headquarters in Munich (Germany), the company operates with different branches in Neuherberg, Berlin, Brunswick, Hamburg and Hanover.

The team at Ascenion is made up of 35 people. Many are not only experts in life science but also have years of experience in the industry, a network of contacts with the sector, and business training (MBA). The 23 institutes associated to Ascenion provide a constant flow of research results equivalent to TRL 3. The company is responsible for bringing these results to the marketplace.

How does it do that? In 2011, Ascenion created Spinnovator along with the German Ministry of Education and Research (BMBF) and several venture capital firms. The initiative involves including investors in the initial phases of the technology to provide their market vision right from the beginning. Ascenion also directs and supervises the development of the project, helping create management teams and attract funds, it provides access to a powerful network of contacts and offers technical advice on licensing and other agreements.

Ties with industry

The pan-European organisation ASTP: A World of Knowledge Transfer highlights a series of tech transfer initiatives through its relationship with industry: Innovation Exchange Amsterdam and AIMday

Innovation Exchange Amsterdam • Netherlands

Founded in 2014, the offices of Innovation Exchange Amsterdam bring together the tech transfer programmes of five Dutch universities: Amsterdam University Medical Centre, University of Amsterdam, University of Applied Sciences in Amsterdam and Vrije University Amsterdam. The entity, which employs 40 people, organises events at which researchers and entrepreneurs meet to explore ideas and find common interests. Subsequently, five of the proposals for collaboration arising during the meeting are given 5,000 euros in financial aid.

Innovation Exchange Amsterdam also offers researchers the support of a team of experts in market application, legal protection, and potential partnerships, who provide researchers with support throughout the commercialisation process.

AIMday • Sweden

AIMday is an initiative by Ångström Materials Academy, a platform belonging to Uppsala University Innovation that acts as a link between companies and researchers specialising in materials. In 2008, Ångström Materials Academy decided to organise its first Materials Day (AIMday) to explore ideas.

How does AIMday work? Ångström Materials Academy invites a series of industrial companies to explain their problems prior to AIMday. The academy then presents the information collected to researchers in different disciplines, who show their interest in specific cases. During AIMday, companies and researchers meet in small groups to discuss the problems detected and identify new opportunities for collaboration in search for a solution. The success of the event has led the AIMday concept to spread to other disciplines, such as humanities and social sciences.

Israel, an innovation hub

Israel has become a world power in terms of innovation, entering the ranking of the top ten innovation ecosystems in the world, according to the World Economic Forum. The position of Israel in terms of innovation is directly linked to the deployment of its tech transfer system, which offers significant data such as the fact that, in 2018, tech transfer offices evaluated one thousand innovations and presented more than 620 patents.

During this same period, the organisations forming part of the Israel Tech Transfer Organization (ITTN) created 74 spin-offs and signed over one thousand research and consulting agreements, according to the organisation's latest report. The pharmaceutical industry and biotechnology were the most active sectors for Israeli tech transfer offices.

There are many different models of tech transfer in Israel, all with the same mission: to put an end to the belief that research projects often fail when they try to reach the marketplace, despite their commercial potential.

Yissum

Established in 1964, Yissum is the technology transfer company of The Hebrew University of Jerusalem. Mobileye and Briefcam are just some of the startups to have received support from Yissum, which since it was established has registered over 10,000 patents, licensed more than 950 technologies, and created in excess of 150 spin-offs.

The company works with different startup acceleration platforms, such as Spark HUJI and HUGROW, and its commercial partners include Novartis, Intel, Google, Boston Scientific and Merck. The process at Yissum ranges from conception (transformation of research) to commercialisation (through licences, option agreements, collaborative and sponsored research, etc.).

AMIT

Founded in 2006 by Doctor Alfred E. Mann, AMIT is the acceleration centre of the Israel Institute of Technology (Technion). The main objective of the platform is to close the gap between applied academic research and the marketplace. With this in mind, AMIT provides practical tools and funding for the creation and development of biomedical companies.

The platform is supported by the Grassroots programme, alongside which AMIT works with doctors worldwide in the search for unmet needs and ideas that could revolutionise healthcare. Once the idea has been selected, the AMIT team creates a company and supports it through its development.

SN2E

Startup Nation 2 Enterprise (SN_2E) is a company that represents 45 academic institutions, hospitals and research centres in Israel. Led by seasoned tech entrepreneurs and business managers, SN_2E is rapidly scaling to become a marketplace for intellectual property ready for commercialisation.

The company lays claim to connecting the owners of intellectual property directly and quickly with multinational companies. In fact, its team is made up of different profiles specialising in business, sales, technology, intellectual property, marketing and innovation.

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Conclusions

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Challenges of tech transfer in Spain

The relationship between the Spanish business network and its scientific and technical system is still in its early stages. The effects of the financial recession, the public policies in support of science and tax incentives, the characteristics of Spanish business, and the country's production model have put up barriers among them on several occasions. But they are not the only ones.

The experts consulted for this report have identified a series of factors that act as a burden in the tech transfer process but that, in turn, are an opportunity with huge economic potential if tackled correctly.

Mistrust is one of the main determining factors that prevents companies and universities and research centres from strengthening ties. Both the former and the latter are building bridges and trying to define their place in the value chain, although ensuring they meet at the same junction is a question of time, willingness and information.

Meeting at this junction also involves finding common interests and a universal language to help smooth things over with regard to the implementation times and the processes of one party and the other. An **entrepreneurial attitude and the provision of business tools in universities and research centres** could help with this change. A review of the incentives received by research teaching personnel is also recommended to knock down some of the barriers on the path to the launch of an enterprising project.

Support from the Public Authorities plays a vital role in the tech transfer process. Firstly, through the funding of public universities and research centres, which are necessary resources in generating an advanced, competitive research system that can lead to wealth for society. Secondly, through tax incentives aimed at companies to encourage investment in R&D and mitigate the risks associated to investment in technology (uncertainty related to the applicability and effectiveness of technology in their business and the obtaining of long-term income and financial returns). In other words, through stable, long-term innovation and research policies in line with a national R&D strategy.

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“There is a long way to go. The mistrust between one environment (university) and another (company) is a barrier that must be broken down. But thanks to the reconciliation between the two, this is gradually becoming more natura .”

Carlos Blanco

Director of the Entrepreneurship and Innovation Service SEI-Science Pak at the UC3M

Private capital also plays a relevant role, particularly during the initial phases of research projects. Although there is already a high risk associated to investments at seed phase -and the very nature of the research projects increases this risk-, public and private vehicles are required that are willing to run this risk. Once again, a political strategy of incentives could create an environment leading to this type of initiative.

The **technological absorptive capacity of a company** is the ability of a corporation to identify, assimilate, transform and make use of valuable external knowledge within its own processes or operations to obtain a competitive advantage.

Moreover, there is a need for a **systematic transfer system** to unify the different tech transfer protocols that each institution uses. By acting under the same umbrella, a reduction in bureaucracy goes hand in hand with greater visibility and identification of the potential research projects that are likely to reach the marketplace. An increase in the number of personnel working in transfer activities is also very important, which can boost the company-university/research centre connection, identify new opportunities, and ensure the visibility of the technology portfolio.

The opportunity exists

Tech transfer in Europe and, more specifically, in Spain is an economic and social opportunity. The economic opportunity lies in the fact that the disclosure of science and technology often provides the response to challenges faced by national companies, helping boost business and the progress of the economy. The social opportunity lies in the fact that the findings by Spanish universities and research centres have a direct impact on how a society is structured, maintained and progresses through substantial improvements, such as medical discoveries or new power sources. Despite this, most countries face a major challenge: to ensure tech transfer does not become a lost opportunity.

The starting point

Tech transfer is a process that is shared among the different players forming part of the innovation ecosystem. Universities, research centres and companies play a vital role in tech transfer: the former provide the breeding ground for the scientific and technological findings, whereas companies, as the players nearest to the marketplace, help transform knowledge into an economic and social value.

The scientific context

Spain is in the first division in terms of scientific production. With regard to scientific publications, it is ranked among the top fifteen countries with the most scientific articles published. However, just like in Europe, it fulfils the European paradox: despite being a leader in scientific production, it encounters a great many difficulties when transforming this knowledge into industrial innovation.

Moreover, the Spanish scientific system has been in a relatively unsustainable situation for years now, which was made worse by the financial crisis and the significant amount of bureaucracy in place in Spain. In addition to this is the flight of talent to other countries, which remains uncapitalised and leads to the loss of quality ideas and projects.

R&D and companies

The public budget for research and development (R&D) rose for the third year running in 2017 to stand at 14.70 billion. However, the proportion of investment in this area in relation to Gross Domestic Product barely changes from one year to the next, with an increase from 1.19% in 2016 to 1.21% in 2017. This data is a far cry from the European target for Spain (2% of GDP) and many neighbouring countries.

Companies use over half the nation's spending in R&D, although the significance of this investment on GDP (0.64%) is very different to that of other countries, such as Germany (2%), Switzerland (2.4%) or the United Kingdom (1.13%). The data coincides with society's perception that "Spanish companies are investing less than they should in R&D+i".

The opportunities of technology transfer

Value generation for companies and knowledge-based business solutions.

The results of many research projects are applicable to company processes. Accessing these projects and integrating them into the company can lead to new lines of business and increased competitiveness.

Attaining strategic business objectives in terms of innovation, such as:

- Higher quality and a wider range of products (goods and services)
- Greater production or service provision capacity
- Larger market share
- Replacement of out-of-date products or processes

Overcoming the factors acting as barriers to technological innovation, such as:

- Cost: investments and budget
- Knowledge: team devoted to innovation and technological unawareness
- Market: uncertainty regarding the demand for innovation

Source of innovation and access to new technologies.

Being in contact with the research projects of university and research centres provides companies with contact with technological innovations that have not yet reached the marketplace.

Retaining talent and generating quality employment.

Scientific research talent can be found at home, but does not always stay at home. The precarious state of the country's research and development system and the lack of opportunities in the private sector is forcing many researchers to seek a new path in other countries. Strengthening tech transfer (with the associated financial return) means ensuring jobs and generating quality employment.

Creation of new high-value companies.

Tech transfer sometimes culminates with the creation of spin-offs, which are vehicles established in universities to ensure some of their projects reach the marketplace. These spin-offs can even earn a significant market share, such as Zeleros or Fractus. Other times, formulas are even being explored that combine multi-disciplinary teams (scientists and engineers collaborating with entrepreneurs) in the same startup, bringing together the best experts from each end of the same business vehicle.

Success factors for technology transfer

A real connection between universities and companies.

Spain is the birthplace of pioneering projects such as Zeleros (which is involved in the development of the Hyperloop transit system) or Fractus (which patented the first fractal antenna in the world), although a large part of these discoveries are being relegated to a drawer. Being able to overcome the gap between the discovery of these technologies and their reaching the marketplace is not only a responsibility of universities but also of companies and of the State.

The researcher - entrepreneur formula.

The combination of both profiles provides added value to tech transfer. The former, who are experts in the field in which they work, are aware of the limitations and opportunities of a certain technology. The latter place the spotlight on the market, understand the needs of companies and of the market, and quickly identify the best time to pivot depending on market requirements.

Support from intermediaries.

Although tech transfer is still in its early stages in Spain, its potential is reflected in the emergence of different intermediaries that seek to reduce the various gaps generated during the tech transfer process and that act as its catalysts.

Fostering the entrepreneurial attitude in universities.

Providing researchers with incentives to undertake their own business project is as important as promoting an entrepreneurial attitude in universities in order to narrow the gap between them and the business sector.

Policies favouring technology transfer.

The Government must also work on tax policies and instruments that facilitate and vitalise this connection, and that encourage companies to look to the pool of scientific discoveries in Spain. There is a great deal at stake: the growth and performance of a company is directly linked to its competitiveness, which in turn is linked to its capacity to respond to the changing needs of its customers and the transformation of industry.

Challenges to overcome

Overcome the mistrust between universities, research centres and companies.

Finding common interests and defining the place of each one on the value chain is key, sharing responsibility in the tech transfer process.

Improve the technological absorptive capacity of companies to acquire and integrate external knowledge.

At present, the main R&D provider of one company is, in fact, another company (primarily from the same group). There are other sources of R&D, such as universities, capable to responding to business challenges.

Establish powerful and sustainable R&D policies.

The distance between Spain and the rest of Europe in terms of investment in R&D has a direct, negative impact on the country's scientific system, and an indirect impact on the business and social network.

Create a standard technology transfer system.

There are different networks of tech transfer offices in Spain, each one associated to a centre and with its own singularities and protocols. Tech transfer processes should be standardised and systematised in order to foster and professionalise the activity. Another demand of the sector is the need to increase personnel working in tech transfer and the importance of giving greater visibility to R&D projects under development.

Tech transfer in Spain will not spring up from one day to the next. It needs time, investment and the desire for change, along with the participation and commitment of the different players in the innovation ecosystem. Like any innovation process, it is not risk-free. It does, however, have several cards stacked in its favour: world-famous success stories, excellent scientific production and a business network that, to a greater or lesser extent, is beginning to understand the value of external collaboration in its strategy to become more competitive.

There are key sectors in which tech transfer is already making the difference, such as health, transport, utilities, and industry 4.0. The growth forecasts for these four sectors -with a market value of over one billion dollars- is closely linked to the scientific and technological advances taking place in each field. Discovering the next drug leading to substantial progress in the fight against cancer, advances in energy in the transport sector, or the application of algorithmic formulas to sectors such as construction and logistics will mark a before and after in these markets. The opportunity exists: the time has come to work on taking it.

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