IMPROVING KNOWLEDGE TRANSFER AND COLLABORATION BETWEEN **SCIENCE AND BUSINESS IN SPAIN**

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List of acronyms and abbreviations

AEI - Spanish State Agency for Research (*Agencia Estatal de Investigación*)

AEIs - Innovative business clusters, commonly known as "clusters" (*agrupaciones empresariales innovadoras*) (legal term)

AGE – Spain's Central Government administration (*Administración General del Estado*)

AIReF - Spanish Independent Fiscal Accountability Authority (*Autoridad Independiente de Responsabilidad Fiscal*)

ANECA -National Agency for the Evaluation and Accreditation of Quality (*Agencia Nacional de Evaluación de la Calidad y Acreditación*)

ANEP - National Agency for Evaluation and Foresight (*Agencia Nacional de Evaluación y Prospectiva*)

APTE - Spanish Association of Science and Technology Parks (*Asociación de Parques Científicos y Tecnológicos de España*)

BERCs - Basque Excellence Research Centres

CCS - Conference of Social Councils of Spanish universities (*Conferencia de Consejos Sociales*)

CDTI - Centre for Industrial Technological Development (*Centro para el Desarrollo Tecnológico Industrial*)

CERCA – Research Centres of Catalonia (*Centres de Recerca de Catalunya*)

CICs - Cooperative Research Centres (Centros de Investigación Cooperativa)

CNEAI - National Commission in charge of the Evaluation of Research Activity (*Comisión Nacional Evaluadora de la Actividad Investigadora*)

CNIC – Spanish National Center for Cardiovascular Research (*Centro Nacional de Investigaciones Cardiovasculares*)

CNIO – Spanish National Cancer Research Center (*Centro Nacional de Investigaciones Oncológicas*)

CNMV - Spanish Securities Market Commission (*Comisión Nacional del Mercado de Valores*)

COFOG - Classification of the Functions of Government

CRG - Centre for Genomic Regulation (*Centro de Regulación Genómica*)

CRUE - Conference of Rectors of Spanish Universities (*Conferencia de Rectores de las Universidades Españolas*)

CSIC - Spanish National Research Council (*Consejo Superior de Investigaciones Científicas*)

CTs – Technology centres (*Centros tecnológicos*)

CTA - Technological Corporation of Andalusia (*Corporación Tecnológica de Andalucía*)

ECI - Economic Complexity Index

EIC – European Innovation Council

EPO - European Patent Office

ERAC - European Research and Innovation Advisory Committee

ERC - European Research Council

ETCI - Survey of Knowledge Transfer and Innovation (*Encuesta de Transferencia de Conocimiento e Innovación*)

FECYT - Spanish Foundation for Science and Technology (*Fundación Española para la Ciencia y la Tecnología*)

GEM - Global Entrepreneurship Monitor

GFC - Global financial crisis (2008)

GUF- General university funds (supporting R&D)

HE - Higher education

HEI - Higher education institution

ICTS - Unique scientific and technical infrastructures (*Infraestructuras Científicas y Técnicas Singulares*)

IGAE – Central Government General Comptroller (*Intervención General de la Administración del Estado*)

IMDEA - Madrid Institutes of Advanced Studies (Institutos Madrileño de Estudios Avanzados)

IP – Intellectual Property

IPR – Intellectual Property Right

ISCIII - Health Institute Carlos III (*Instituto de Salud Carlos III*)

ISSA – OECD International Survey of Science

I+D+i – Research, development and innovation (*Investigación, desarrollo e innovación*)

KT – Knowledge transfer

KTC – Knowledge transfer and collaboration

KTO – Knowledge transfer office

KTS - Knowledge transfer sexennium (*sexenio de transferencia*)

LSTI - Law of Science, Technology and Innovation

MAE - Monitoring, assessment and evaluation

MFP - Multi-factor productivity

MICINN - Ministry of Science and Innovation (*Ministerio de Ciencia e Innovación*)

MINCOTUR - Ministry of Industry, Trade and Tourism (*Ministerio de Industria, Comercio y Turismo*)

MINECO - Ministry of Economic Affairs and Digital Transformation (*Ministerio de Asuntos Económicos y Transformación Digital*)

MU – Ministry of Universities (*Ministerio de Universidades*)

NPO - Non-profit organisations

OECD - Organisation for Economic Co-operation and Development

OEPM - Spanish Patent and Trademark Office (*Oficina Española de Patentes y Marcas*)

OPI - Central government public research body (*Organismo Público de Investigación*)

OTRI - Research Results Transfer Office (*Oficina de Transferencia de Resultados de Investigación*)

PEICTI - State Plan for Scientific and Technical Research and Innovation 2021-23 (*Plan Estatal de Investigación Científica, Técnica y de Innovación 2021-23*)

PRB – Public research body (*Organismo Público de Investigación, OPI in Spanish*)

PRO - Public research (and development) organisation

PSR - Public system of research

RedOTRI – Network of Technology Transfer Offices (*Red de Oficinas de Transferencia de Resultados de Investigación*)

R&D - Research and experimental development

RS - Research sexennium (*sexenio de investigación*)

RTRP - Recovery, Transformation and Resilience Plan (*Plan de Recuperación, Transformación y Resiliencia*)

SECTI – Spanish Science, Technolgy and Innovation System (*Sistema Español de Ciencia, Tecnología e Innovación*)

SICTI - Science, Technology and Innovation Information System (*Sistema de Información de Ciencia, Tecnología e Innovación*)

SMEs - Small and medium-sized enterprises (*pymes* in Spanish)
STI - Science, Technology and Innovation (*CTI* in Spanish)
TTO - Technology transfer office (*OTRI* in Spanish*)*
USPTO - United States Patent and Trademark Office

Executive summary

Without exceptions, all countries around the world wish for their investment in scientific research institutions to make a more visible contribution to their own economic and societal wellbeing. While Spain is not different in this regards, notwithstanding major improvements and key areas of strength, its **science and innovation system stands out in terms of imbalances** that curtail its ability to generate and apply new knowledge to boost economic competitiveness and address pressing social challenges.

Businesses have on average limited experience of collaboration on innovation with Spain's research base. This is due to a relatively small pool of companies that engage in innovation activities rather than on their rate of collaboration, which turns out to be on a par with other countries.

Spain has built a strong **public research base** with a significant presence in the global scientific landscape for an economy of its size, but prevailing incentive mechanisms have led it to be overly focused towards academic success criteria, resulting in outputs with low connection with the market, limited impact on protectable intellectual property and low rates of research commercialisation. However, the vast majority of researchers that have participated in the dedicated OECD survey indicated they wished to increase the extent to which they work with business even if they do not see as likely the possibility of pursuing meaningful research careers within them.

Mechanisms to incite the public research base to engage with industry and society are becoming more common but are almost exclusively based on individual incentives (e.g. royalty shares from licensing contracts, pay enhancements contingent on centralised evaluation of individual merits). These help formalise and systematise engagement activities previously not accounted for and promote a culture of knowledge exchange by giving effective recognition. However, if not balanced by **incentives at the institutional level**, a system based on individual incentives risks resulting in uncoordinated efforts at suboptimal scale, accentuating the current conflicts over the sharing of the burdens and benefits of knowledge transfer. The high fragmentation of research projects in Spain is indicative of the lack of implementation of such a recommendation.

The **governance of Spain's public system of research** is to a large extent the by-product of historical factors that have resulted in a dual system with intertwined policy responsibilities for the central government and the autonomous regions. The prevalent rules of the public administration dominate the functioning of public research organisations and universities in ways that cripple their activity and renders them highly accountable on bureaucratic procedures but not on outcomes. Several of these rules, especially those regulating knowledge transfer and collaboration activities to protect the public interest, are currently being revised to improve their effectiveness. However, effective reform needs to consider more fundamental changes. Today, society has a very limited **voice** in how universities define their missions and use public resources, while the subsystem of public research organisations outside higher education exhibits some lack of explicit **purpose and strategic alignment** with government objectives and missions. The major structural differences across PROs in terms of governance arrangements illustrate the benefits of implementing more flexible models endowed with greater operational autonomy and proportional accountability tryly focused on outcomes.

The **diversity of STI policy experiences at regional level** provides invaluable lessons that can inform policy making at national level. This includes lessons from the experience of

regional innovation agencies and regionally-sponsored public research and technology centres which explicitly include knowledge transfer at the core of their missions. These benefit from greater levels of autonomy to engage with different actors and create spin-offs compared to the majority of central government PROs, while being subject to performance-based funding mechanisms that require undergoing regular processes of evaluation.

The Spanish STI system has had to deal with **rapid and hard to predict shifts from plentiful government budgetary support to extreme scarcity**, compounded by policy design and implementation measures that restrict the ability to use approved budgets. Government programmes in support of knowledge transfer and collaboration have been among the most severely impacted by budgetary cuts in the aftermath of the global financial crisis. The current EU recovery funds provide an exceptional opportunity to catch up and implement structural changes for the long term. The system should shore up to prevent another reversal in fortunes after the runout of EU funds.

The **policy mix for knowledge transfer and collaboration requires consolidation** and adjustment to respond to the situation of a wide diversity of actors and the policy objectives pursued. It should also be framed in the context of a broad ranging innovation policy, rather than as an extension of research or even R&D policy. The weaknesses of the policy mix include long processing times and other bureaucratic barriers that particularly affect SMEs; the high fragmentation of support instruments and possible overlap across national and regional levels, which can lead to confusion among potential beneficiaries if synergies are not sufficiently exploited; the limited use of institutional funds in support of consortia; and the insufficient support to the mobility of talent between public research and industry.

Acting as independent providers of technology services to companies, but outside the public sector, **technology centres** are a vital element in Spain's STI system even though their role and influence is very heterogeneous across the entire territory. Their public policy oversight and funding rests principally with the autonomous regions although some national programmes include them within their scope. Their funding model is in general overly reliant on project-based funding, which does not contribute to their consolidation as an effective bridge between research and businesses. They should be prepared to transition in their service offering to support companies with the challenges of the digital and green transformations.

The **professionalisation and coordination of knowledge intermediation services remains a key challenge**. To effectively develop their tasks, knowledge transfer professionals need to develop a wide range of competencies that range from scientific and technological knowledge, to legal, IP and commercial competencies. These profiles are currently very scarce. Knowledge transfer offices (KTOs) within universities and PROs, in particular, suffer from lack of dependable, basal financing, and staff working in them often lack the required professional experience or are hired under precarious conditions with limited training opportunities and career perspectives. In addition, knowledge intermediation actors tend to work at suboptimal scale, and are constrained to focus much of their efforts on administrative procedures associated with research project management, at the expense of efforts to foster long-standing collaborative relationships with business and their ecosystems.

Priority areas for reform

The report points to some priority areas for policy action and presents a number of detailed policy recommendations to improve science-business knowledge transfer and collaboration in Spain. These represent the basis of an implementation roadmap, focused on the following five priority areas:

1. Put in place **sound science and innovation policy foundations** that make knowledge transfer and collaboration possible and effective. This requires sustained investments

in science and innovation over time and appropriate policy and regulatory frameworks. Publicly funded research should be a prime candidate for the adoption of a protected regulatory sandbox approach that ensures proportionality in control and enforcement mechanisms. The authorities in charge of science and innovation policies should continue working to boost policy lifecycle evaluation and implementation capabilities in this complex area, putting greater emphasis in multi-level collaboration and exchange of good practices. They should also ensure that there is a broad-based innovation policy perspective supporting all major government strategies and strategic projects.

2. Re-design the **governance systems of universities and PROs** to increase their engagement with and accountability towards society, avoiding political interference in their operations through more effective operational autonomy. There should be an independent review of the PRO landscape to assess how missions and institutional arrangements currently align, and advise on options for a more efficient and effective configuration.
3. Rebalance and align **individual and institutional incentive mechanisms**, so that external knowledge transfer and collaboration activities are more attractive endeavours for all types of researchers, their teams and organisations. Spain should work towards adopting funding mechanisms at the institutional level that are partly linked to outcomes. Among those, knowledge transfer and collaboration activities and outputs should feature rather prominently, built on good and timely information about formal and informal activities. Incentive systems should be carefully monitored to detect and prevent unintended biases (e.g. gender, age or disciplinary-based).
4. Facilitate and co-ordinate the operation of diverse **knowledge intermediation agents**. There is scope for greater mutualisation of efforts of internal knowledge transfer services across different universities and PROs to better manage existing and prospective intellectual assets. There should be concerted efforts towards reinforcing and streamlining central and regional government support for knowledge intermediaries such as technology centres, science and technology parks, and clusters
5. Promote and sustain **business capacities to innovate**, to render the sector willing and ready to exchange with the PSR and other relevant actors through ever-deeper engagement mechanisms that are appropriate to their level of innovation capability. Public policies should help raise business awareness of the strategic importance of innovation.

There is ample opportunity space for Spain's innovation system to achieve a healthier degree of knowledge exchange and collaboration across sectors. While there are significant outstanding challenges, even after taking ongoing reforms under consideration, there is a unique combination of conditions that make it possible to rethink, redesign and effectively address aspects of the system that have hindered its performance thus far.

This report does not aim to provide all the answers but to serve as a helpful conduit for public debate, enabling relevant policy actors to make well-informed choices about which way to proceed and how to work together to achieve it. The recommendations listed in connection with priority themes touch upon incremental and more radical reforms, and call for greater use of co-creation mechanisms and use of evidence at all phases of the policy cycle.

The experience from several European and OECD countries shows that reforms that enhance the performance of STI systems and their economic and social impact are possible and necessary at times of change such as the current one. The mobilisation of private funds will be critical to sustain investments on R&D and innovation once the current extraordinary supply of EU funds is no longer available. This requires innovation policies across all

government to lay the ground for a post 2023 "handover" scenario. Realising the many visions of the *España 2050* strategy also requires Spain to make the best possible use of its public and publicly sponsored system of research and technology, and start doing so through an action plan or roadmap that starts today and draws on the many accomplishments achieved to date.

In order to put these reforms in motion and sustain them over time, a new type of covenant between science and society is needed in Spain today. Rather than just setting aspirational targets for investment, this should be based on a 'new deal' between actors in the science and innovation system and taxpayers and society at large, committing to place the pursuit of concrete social benefits through knowledge transfer and collaboration as counterpart for more stable and predictable support.

Improving knowledge transfer and collaboration between science and business in Spain: General assessment and recommendations

General assessment

A diagnosis of the Spanish science, technology and innovation system and the challenges for improving knowledge transfer and collaboration between science and business

This report is the main output of the project "Roadmap to foster co-operation between universities, research and business in Spain". It is based on evidence gathered since the kick-off meeting of the project in September 2020, including nearly 50 in-depth interviews with more than 90 stakeholders, experts and policy makers; the analysis of existing reports and data, experiences and practices in other countries; the results of two OECD surveys[1]; as well as comments from participants in the workshop held on 10-11 March 2021, an OECD international workshop held in September 2021 and three thematic working sessions held in October and November 2021.

This report aims to facilitate the adoption of a common language and a shared, evidence-based diagnosis of the current situation, and identifies a number of priority areas for policy reform and improvement. It documents the variety of vehicles for linking – not necessarily in a legal sense – science institutions and business. This is based on the notions of "knowledge transfer" as a mechanism that operates in multiple directions, not just from "science" to business, and "collaboration" as a deeper mechanism for joint action in the creation and use of ideas. This report uses the terms "transfer" or "transfer and collaboration" for economy of language to refer to this broader view of knowledge-based exchanges, which include mechanisms such as contracting for services and mobility of people, in the same way as the Spanish Parliament Congress of Deputies' proposition of law urging the government to develop a "Roadmap for knowledge transfer" to which this project contributes.

Despite its important achievements, the Spanish science and innovation system presents imbalances that threaten its sustainability and limit its contribution to economic and social welfare

In a relatively short period of its history, Spain went from a very disadvantaged position to being a recognised international player in the world of science and participating in numerous technological and business projects of global scope. During this convergence phase, there was little appreciation of the need for deep reforms. The **global financial crisis** abruptly interrupted this trajectory by drastically reducing the resources available for science, technology and innovation (STI) activities. The regulatory and control measures implemented during that period aimed at containing if not reducing public spending, but did not take into account the long-term effects on the STI system. The crisis revealed a series of **structural imbalances that also included the governance and funding of science and innovation.**

[1] International Survey of Science, OCDE-ISSA 2021 (http://oe.cd/issa2021hojarutaESP) and HEI Leader Survey (https://survey.oecd.org/index.php?r=survey/index&sid=678974&lang=en)

Spain embarked on a slow and progressive recovery, but so far insufficient from a global perspective where other countries have acted more decisively in strengthening their innovation systems both in terms of financial and human resources as well as in terms of policy frameworks. The country is today at a historic crossroads where structural weaknesses are coupled with the cyclical difficulties caused by the pandemic and its social and economic impacts. The COVID-19 crisis, however, also acted as a reminder to the Spanish population and political class of the importance of mobilising science and innovation to emerge from the crisis and address longer-term challenges. A number of conditions are now in place that offer new **opportunities to strengthen STI policy, implement much-needed reforms and increase investments in STI**. These include the Next Generation EU funds and the actions foreseen in the Spanish Recovery, Transformation and Resilience Plan.

Spain's STI system suffers from a number of structural imbalances. **Public administrations** play a very important role, directly financing more than 40% of R&D in Spain (i.e. above the EU average), excluding indirect tax incentives, repayable grants, and EU funds. **European funding** has played a fundamental role during the phase of domestic budgetary restrictions in which effective R&D funding fell by 30%. In Spain, the marked divergence between the budgetary announcements and the ultimate level of budget execution in this policy area has been particularly damaging as it has obscured the true degree of de-prioritisation of public investments in science and innovation for many years. Despite a recent recovery in 2019, the gap with OECD and EU levels that opened following the global financial crisis still persisted while data for 2020 remain to be confirmed.

On the other hand, the **role of business and other private actors** is still below international benchmarks, although it has increased recently in relative and absolute terms. This shortcoming is not only due to the sectoral composition of the Spanish economy and the preponderance of small and medium-sized enterprises. A wide range of data and indicators show that Spanish companies are generally not very active in innovation in general, even taking into account their profile, and in R&D and intellectual property activities in particular, leading to a deficit in the accumulation and use of intangible assets that generate sustainable competitive advantages. For example, the R&D expenditure intensity of the business sector, when adjusted for the country's economic structure, remains well below the OECD average.

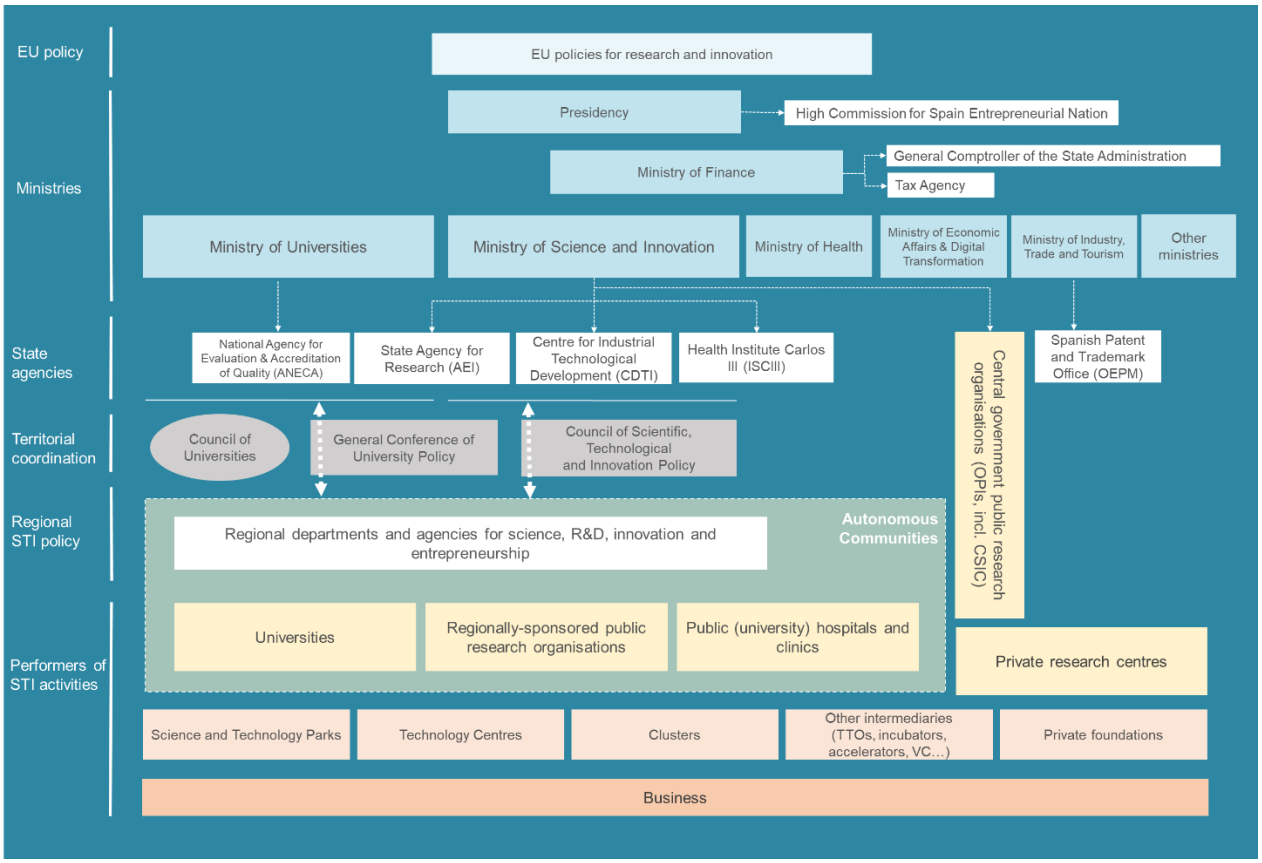
All this, combined with low levels of scientific and technical skills in the overall working age population, leads to low productivity of firms and ultimately triggers a vicious cycle in which firms competing in international markets tend to specialise in low value-added activities. Meanwhile, the rest of the sectors experience difficulties and have little incentive to adopt and promote innovation as part of their strategy.

Regional imbalances are, as in many other developed countries, a major challenge for Spain. Madrid and Catalonia account for close to 50% of all R&D expenditure, while only 5 autonomous regions out of 17 account for 77%. This territorial concentration is not only the result of historical factors, as the governance framework grants a high degree of competences to the autonomous regions in relation to the State (central government) and makes them key players in the system. The system would benefit from enhanced coordination and sharing of good practices which, although present and effective in many cases at the operational level, requires a greater degree of commitment and stability at the political level.

Public R&D and innovation support institutions are also subject to other structural and performance imbalances. The situation in terms of scientific excellence in the research base is complex, with many positive aspects and others that can be significantly improved. Although bibliometric indicators of citation impact put Spain in an acceptable position as an international player, research appears to be relatively under-specialised in the scientific fields where it is most internationally competitive. In addition, a high proportion of teaching staff in universities is not eligible for academic merit recognition, indicating that academic

excellence is very unevenly distributed. This is also evident in the **small size of projects and teams in the research base**, due to the prevailing funding and institutional promotion mechanisms that prioritise individual leadership. This is inadequate for research to successfully face the challenges of a highly competitive environment where teamwork is increasingly necessary. Several stakeholders highlighted that many researchers prefer leading very small (not to say one-person) teams rather than forming part of larger, better-equipped teams. This, combined with the business fragmentation described above, negatively impacts the capacity of actors to interact.

The policy governance of Spain's science and innovation system, 2021



Source: OECD own elaboration.

The research base in Spain is mainly dual in nature, with the co-existence of universities and public R&D centres of different types. **Universities** are the main actors in the execution of R&D and are endowed with great formal autonomy, but they depend to a large extent on the funding they receive from the autonomous regions and the regulatory framework they establish within the parameters of the Organic Law on Universities. The governance and funding mechanisms that in theory should enable universities to define and implement their strategies for achieving their multiple missions, including knowledge transfer, do not help to align resources and efforts with objectives. This makes it difficult to imitate modernising trends in other countries, such as the presence of external members in university governing councils, the strengthening of managers' executive capacities, the openness of managerial positions to external professionals, the professionalisation of management tasks, the limitation of endogamy, the connection between core funding and results, the active pursuit of private funding, and greater autonomy in faculty recruitment.

In Spain, the **Social Councils**, as the university bodies notionally in charge of catalysing the participation of society within it, play a rather singular supervisory role which is largely constrained to ratifying specific aspects related to the university's accounts as well as its external relationships, for which they have hardly any resources and decision-making capacity. Meanwhile, other countries have adopted reforms that endow universities with greater real autonomy while establishing mechanisms that allow for active participation of society in the university and for the university to be truly accountable for its use of public and private resources.

Public research (and development) organisations (PROs) are public R&D performing entities that operate as part of the public sector linked to the general state administration (central government) or the autonomous regional administrations. Their regulatory framework is highly variable given the diversity of legal regimes under which they are constituted. Central government public research bodies (OPIs in Spanish), oriented towards promoting basic research capacities, are subject to strict rules that are more typical of bureaucratic entities and that severely limit their capacity to engage in knowledge transfer and collaboration activities.

More recently, new public research organisations that enjoy greater flexibility and autonomy of action have been created, constituted as foundations and with more clearly defined institutional missions. These were mostly promoted by the governments of the autonomous regions (e.g. CERCA in Catalonia, BERCs and CICs in the Basque Country), although specialised research centres such as the CNIC or the CNIO have been created by the central government. Constituted as public foundations partially under private law, they enjoy greater flexibility and autonomy in their management of different aspects that affect their operation and knowledge transfer compared to the OPIs. This results in a very asymmetrical system.

Like many other countries, the Spanish central government public sector does not have any implementing organisations explicitly designed to provide R&D infrastructures and support services for companies. Instead, there are a number of non-profit institutions that generate knowledge of applied nature or embedded in new solutions. These benefit from multiple types of public funding, largely of a regional nature but also with programmes at national and European level, that operate in this space of intermediation between the research base and companies. **Technology centres** (TCs) in Spain are very heterogeneous and play an important role as catalysts for collaboration and economic transformation in some territories. However, with a few exceptions, their size tends to be small and their activities limited to the autonomous regions in which they are based. They are also quantitatively important for business R&D performance statistics, as they are oriented to serve the business sector, and international classification criteria aggregate most of them to the business sector. However, there is no formal process of co-ordination and prioritisation of the total public investment in TCs that would allow their alignment with national level priorities.

As is the case of universities, most **health institutions** in Spain, in particular those carrying out R&D activities, depend mainly on public funding from the autonomous regions. This sector is particularly important for innovation in health, for example to execute clinical trials and translational "bench to bedside" research. Although health institutions' participation in the research base often takes place through multiple affiliations of their staff (e.g. to hospitals and universities), their integration into the public R&D system requires more specific attention as they often have a quadruple mission: teaching, research, healthcare and economic impact.

An additional imbalance is of a **social and cultural nature**. On the one hand, Spanish society presents highly positive attitudes towards STI and have a generally positive view of its impact, as demonstrated for instance by the high acceptance of vaccination against COVID-19. The country also scored very close to the OECD average in the 2018 PISA science test.

On the other hand, there is a significant mistrust of entrepreneurship and business. The concept of innovation, even within policy making circles, is often associated with business R&D, which is problematic when it comes to implementing a horizontal approach to innovation, since innovation is not an exclusive competence of companies and R&D is neither a necessary nor a sufficient condition for innovation. Moreover, specific R&D investment objectives are distorted by adding the "i" of innovation as if it were an additional element and not an objective of R&D and other creative, technical and transformational activities.

Transfer and collaboration between science and business is one of the main weaknesses of the Spanish STI system but also one of the greatest opportunities for progress

Spain has, in relative terms, **little historical tradition of collaboration between research and business**. Analysis of available **data describing different aspects of "knowledge transfer" reveals structural problems**. On the one hand, data on the careers of PhD holders indicate that they are mainly employed in universities and hospitals, suggesting that the business sector does not represent an attractive destination for them. Companies have little involvement in the design of doctoral programmes. As in many other OECD countries, doctoral students rely on academic supervisors as exclusive mentors without fully appreciating other possibilities, particularly in the business sector.

The business sector does not figure as an active funder of R&D in universities and public administrations – a mechanism that is important for communicating needs, influencing R&D activity and establishing rights over the use of research results.

Innovation surveys at the firm-level indicate that there is a very **low rate of overall collaboration between firms and public research in Spain**, due to the fact that there is a rather small share of companies in Spain engage in innovation activities. Collaboration between the public system of research (PSR) and firms that are active in innovation is in line with the OECD average. Most firms report other priorities and see cost as the biggest reason for not innovating, even more so than lack of market demand, largely reflecting a lack of appreciation of the strategic importance of innovation. Many of the business characteristics that influence innovation, such as sectoral composition and aspects linked to size and internationalisation, are also closely linked to collaboration with public research, albeit with some significant differences between sectors.

Furthermore, **patent citation indicators** show that scientific production in Spain is not particularly technology-oriented. Scientific publications by authors in Spain have a low propensity to serve as a recognised knowledge source in registered patents, compared to citations in other scientific publications. For every 100 citations received by Spanish scientific publications in other scientific publications, there are 1.2 citations received in patents. To put this figure in context, this is below the value of 2 for Germany and below 1.5 for France, the United Kingdom, the Netherlands and Italy. The data on **co-publications between the public research and industry** reflect another cooperation mechanism that is rarely used, as business tends to favour trade secrets and other industrial property rights over publications. For example, in comparison with Germany, a few Spanish universities register significant levels of co-publications, and even the most prominent universities are well below average levels in Germany. Polytechnic universities as well as certain universities in the biotechnology and health area are the most active in this type of collaboration in Spain. **Co-ownership of patents** between the public research sector and companies is not very frequent either, but the collaboration is greater than that reflected in co-ownership since, as is the case in many other countries, academic inventions owned by companies that result from research collaborations or consultancy contracts are not directly visible in the statistics.

Comparing **indicators of the valorisation of R&D results** at the international level is complicated given the lack of standardisation. Available data indicate that the **income** received per institution for "third mission" activities is rather low in Spanish universities, while appear to exceed the European average in terms of **spin-off creation**. This combined finding suggests that the IP generated is not generally ready for commercialisation, and that there might be an excess number of spin-offs that are not commercially viable given the IP they can build upon and the level of resources made available to each of them.

The ETCI survey conducted by the Ministry of Science and Innovation in collaboration with all stakeholders provides a valuable picture on the overall public research base in Spain in 2018, including not only universities but also PROs and a significant number of technology centres. The data are indicative of the generalised problem of operations at a suboptimal scale, given the very low average values for research contracts and collaborations (less than EUR 9 000 on average for contracts and EUR 34 000 for R&D collaborations) considering the bureaucratic efforts required, as well as modest figures for IP licensing revenues totalling less than EUR 11 million. In 2018, 78 spin-offs were created, and 85% of those created in 2013 were still active.

Of the total number of priority patents filed in 2018 by research entities included in the ETCI survey, 43.5% were co-owned, and 29% of those were co-owned with companies. For many years, a series of incentives indiscriminately supporting public sector patenting have unintendedly resulted in the adoption of IP protection strategies that were principally driven by "curricular" purposes. Combined with a lack of resources for valorisation, this may have led to the **filing of patents with lower chances of commercialisation**, including many with potential but in a very embryonic state. Recent reforms have sought to avoid this problem, which helps to explain a fall in the number of patents with protection limited to the national territory.

Lack of trust between actors, due to lack of prior interaction, knowledge of respective activities and the use of different "languages" represent important barriers to transfer and collaboration. Lack of mutual recognition contributes to numerous missed opportunities that could strengthen the innovation performance of companies and increase the impacts of public research investments. The **incentives, agendas and timelines of different actors in the system are often not aligned**: researchers, curiosity-driven and incentivised by a system that primarily rewards scientific publications, tend to engage in lines of research aimed at advancing the frontier of knowledge in specific areas, often disconnected from the market in an immediate or obvious way. The ISSA 2021 survey conducted in conjunction with this study suggests that most researchers are motivated to interact with companies as a means to further their academic objectives, rather than by commercialisation opportunities as such. In contrast, most companies seem to be generally interested in the development of short-term marketable solutions, or the incremental improvement of their internal processes, while they pay less attention to the need to recruit researchers with profiles similar to those emerging from the public research base. Demand for scientific and technical services, however, varies across sectors. The fact that the ISSA2021 survey shows a high degree of interest on the part of public researchers in increasing collaboration with business is a sign for optimism as long as interests are well aligned.

Spain faces a series of shortcomings and opportunities to improve its knowledge intermediation ecosystem

The knowledge intermediation landscape in Spain is characterised by a **dual system** that combines knowledge/technology transfer offices (TTOs, OTRIs in Spanish) embedded within universities and public research organisations, with a wide range of independent intermediation service providers including technology centres, science and technology parks,

clusters, and other entities, associations, foundations and professional service providers, such as specialised consultancies and financial intermediaries.

Multiple analyses indicate that **knowledge or technology transfer offices** in universities and public research organisations generally lack the financial resources and human capital necessary to carry out all their missions successfully and sustainably over time. Their small scale and increasing bureaucratisation often leads them to see their activity dominated by the administrative management of research projects rather than transfer and collaboration activities as such, even though these are very different activities. The distinction between contracts and agreements, and their management, seems to be more due to technical-legal aspects than to substantive aspects of transfer. A better distinction should therefore be made between standard functions related to the procurement and management of project grants, on the one hand, by better communicating the purpose and use of indirect costs, and functions closer to the market for liaising with economic actors and valorisation of results, resulting in real innovation offices.

Similarly to other countries, the **professionalisation of KTO/TTO services** remains a major challenge in Spain. To successfully achieve their mission, they must count with professionals with a wide range of skills. These range from scientific and technological knowledge to understand the offer of technology and knowledge from research institutions and their potential applications in specific sectors and firms, to specialised legal, financial and commercial capacities in order to connect to potential clients and advice and provide legal guidance in processing different types of agreements. These profiles are in short supply, and the lack of resources to offer attractive contracts and career perspectives leads to a high turnover in TTO personnel that hampers the professionalisation of such intermediation services.

Increasing the level of institutional leadership support and funding for TTO activities, and recognising their mission in institutional strategies, is critical to address these challenges. Other approaches could help universities and public research organisations to equip themselves with **internal teams or support services** to respond to their knowledge transfer needs, including the adoption of mutualising measures involving more than one university for the development of combined on-campus/off-campus systems to provide more specialised services with greater value added and international scope.

International examples of **mutualising mechanisms for transfer activity** provide valuable insights. For example, in France, the *Investments for the Future Programme* (PIA) led, with the allocation of EUR 900 million, to the creation of 14 Technology Transfer Acceleration Companies (SATTs), conceived as local/regional entities at the service of universities and research centres and their relations with the private sector. The SATTs are created by one or more research establishments and their mission is to detect and evaluate the inventions that emerge from them, pursuing value creation, an economic-budgetary balance in transfer activities and the simplification of the commercialisation landscape. A previous process of university mergers had taken place in the country, which facilitated the creation of such mutualised services. Although the results of the recent evaluation point to clearly positive effects, the transferability of this model, with its high level of funding, from the French to the Spanish decentralised context could present several difficulties. An alternative would be to create this intermediate layer at sectoral rather than regional level, focusing on strategic sectors or technologies for Spain and taking advantage of existing structures such as technology platforms, technology centres or cluster organisations. This could be achieved through an expansion of the Cervera programme for technology centres, which currently provides support to implement strategic research, development and innovation programs by consortia of 3 to 5 countrywide technology centres.

Inter-institutional and inter-regional alliances among intermediaries can be critical in achieving scale and moving towards more ambitious common goals – for example, leveraging alliances between technology centres in different regions as promoted by CDTI's Cervera programme. Joint programming between the central government and the regions, as well as among regions, should be used more frequently. The examples of Tecnalia and Eurecat, which are the result of mergers of pre-existing technology centres in the Basque Country and Catalonia, respectively, illustrate the benefits of achieving greater scale.

The promotion of knowledge exchange involves the **creation of spaces and ecosystems, not necessarily of a "brick and mortar" nature, in which the different agents can get to know each other better and build trusted relationships**. These need to offer different types of support services that address the different stages of the enterprise life cycle, such as assistance with challenge definition, search for talent, market validation, piloting and scaling, in addition to enabling networking and other informal exchanges.

It is also important to consider the role of **consultancies and firms specialising in the provision of services** around IP management, contract negotiations and financial intermediation for risky projects. Informal liaison mechanisms with this sector exist in many countries. For instance, in the United Kingdom there is a working group where the tax authority and tax consultancy firms meet regularly to discuss practical problems in the implementation of R&D tax incentives. Experience in many countries indicates that the creation of a critical mass in these services is demand-driven, but as it builds up it successively acts as a pole of attraction for companies and start-ups because of the greater ease with which they can have their needs met by those expert teams. This type of consideration is equally relevant when it comes to expert capacities for externally provided to and internal services within the public administration, particularly in support and control functions that are often carried out by generalists. Many of the actors interviewed agreed this represented a barrier to bureaucratic process streamlining in science and innovation.

The analysis of STI policies for transfer and collaboration shows a complex picture in which policies co-exist at national and regional level and policy implementation is not always as planned

Competences for science and innovation policies are defined in the Spanish Constitution. They are divided between the central and regional administrations, but are subject to continuous evolution. **Strategy and planning** at central government level has progressively placed greater emphasis on the knowledge transfer and collaboration agenda in response to multiple analyses and recommendations from the European Union. Several **regulatory reforms** have taken place to facilitate KTC activities between public research and the private sector, and **multiple financial support instruments** have been created. However, there are numerous problems and challenges in relation to:

- the traditional lack of precision and horizontality of **strategies and plans**, often linked to budgetary instability and the difficulty of coordinating regional administrations with the actions of the central government administration;
- policy **implementation** processes, as highlighted by several stakeholders during interviews; and
- **monitoring and evaluation** processes to assess policy results – often limited to monitoring compliance from the perspective of processes and inputs.

The diversity of regional models to support knowledge transfer and collaboration adds complexity but provides useful lessons for the country as a whole

Despite the general trend towards a greater involvement of regional governments in science and innovation policies, there are large differences in the scale and scope of such policies driven by income inequalities across autonomous regions, by the heterogeneity of regional industrial specialization patterns, by their different institutional profiles and political aspirations, and by their different use of EU structural funds over the past decades. Policies at the central government level play an important role in these initiatives, as they set the overall legislative framework, their programmes and actions can co-finance initiatives, and through co-governance mechanisms they can influence the strategy and activity of shared institutions (e.g. consortia).

Regional governments are responsible for **helping businesses manage innovation risks** through the provision of R&D infrastructure, specialised knowledge and expertise, partnership and collaboration capabilities and business support services. They implement different mechanisms to achieve those objectives, such as the creation of technology centres.

The development of **technology centres** (TCs) represents one of the most important instruments of regional innovation policy in Spain and the main mechanism in place to support the technological development of companies. These are non-profit organisations (typically private associations or foundations) that conduct applied research and provide technological services to companies. They receive various types of public support for their work. TCs often work closely with regional universities, although in recent years they have increasingly focused on the commercialisation of their own technologies, rather than acting as intermediaries responsible for transferring scientific knowledge developed by universities to companies. Some TCs have a marked degree of sector or market specialisation, while others are oriented towards more general technology areas. Their scale and scope of activity also varies. The largest is Tecnalia in the Basque Country, which currently has more than 1 400 employees, followed by Eurecat in Catalonia, with around 600 employees. In other autonomous regions, TCs are smaller, specialised in sectors of strategic importance in their territories, and often focused on supporting SMEs. Some autonomous regions currently lack TCs, most notably Madrid. In recent years, hybrid models of innovation agencies and TCs have emerged, focused on developing links between research and business, as is the case of Andalusia's CTA. In addition to regional funding, in 2019 the central government launched the Cervera programme to foster partnerships between TCs and enhance their support to SMEs.

TCs in Spain are relatively more dependent on competitive project funding than those in other European countries, which often have a more predictable but performance-based resource base. This allows them to act more consistently with their mission as intermediaries and support organisations, as they do not need to compete for basic research projects.

Also noteworthy is the role of **science and technology parks**. Although there is great heterogeneity with respect to their size and institutional profile, they all promote local innovation ecosystems and provide support services and dedicated spaces to host innovative start-ups. These parks have established strong links with universities in their regions, and are often located within university campuses. Although they were initially set up as regional initiatives from 1980 onwards, they received considerable central government support between 2000 and 2015. Regional funding was also cut back sharply after 2015, jeopardising the survival of some parks that had not developed sustainable business models based on realistic demand forecasts. Central government support to park management entities today seems to be more focused on facilitating their management of accumulated debt, although in some cases their role as coordinators of technology platforms is also encouraged.

A current debate is whether central government should co-finance specific initiatives to support science and technology parks, especially given their capacity to act as intermediary organisations that can catalyse large-scale projects that could benefit from new funding streams such as Next Generation EU. Another issue to consider is that the support provided by parks to start-ups coexists and, to some extent, overlaps with the growing number of accelerators and incubators promoted by large companies, universities, technology centres and regional or local governments. To tackle this fragmentation and boost synergies, one of the priority areas of the recently launched entrepreneurship strategy (*Estrategia España Nación Emprendedora*) is the creation of a National Entrepreneur's Office to coordinate all existing entrepreneurship support services, in collaboration with public and private agents.

Since the mid-2000s, Catalonia, the Basque Country and Madrid have launched programmes to develop and fund **non-university public research centres**, with a greater focus on basic research than in the case of regional technology centres, but closely aligned with strategic sectors at the regional level. Catalonia was the first to adopt this approach by establishing the CERCA centres in 2005, which now comprise a total of 40 research centres in various scientific disciplines. Following Catalonia's experience, the Basque Country established its network of 9 Basic Research and Excellence Centres (BERC), focused on basic research in cross-cutting knowledge areas, and 7 Cooperative Research Centres (CIC), focused on building scientific capacities linked to the region's strategic sectors. Since 2007, the government of the Community of Madrid has invested in the creation of 7 Madrid Institutes for Advanced Studies (IMDEA). These research centres are playing a key role in terms of scientific production in their regions and contributing significantly to the attraction of international talent and European funding. Moreover, one of their common objectives is to integrate research-business cooperation as an explicit part of their missions, thus putting scientific excellence at the service of knowledge transfer. To articulate these links with industry, the centres' boards of directors include business representatives who participate in the definition of research programmes, in the evaluation of projects and even in the selection of staff. These centres have also established more streamlined procedures for the creation of spin-offs, overcoming bureaucratic barriers at the national level. For example, the regional government of Catalonia has delegated to the governing council of each CERCA the capacity to approve the creation of new spin-offs, whereas at the central government level, government approval is required for the creation of spin-offs from public research centres. These centres are set up as independent bodies outside the universities, with their own legal form (foundations in Catalonia and Madrid; associations in the Basque Country), which gives them greater flexibility in their operation compared to the centres attached to the universities and PROs. The centres are subject to performance evaluation systems that take into consideration not only research excellence but also their socio-economic impact, based to a large extent on qualitative evaluation systems that could serve as inspiration for improving the evaluation systems of universities and research centres at national level.

Other regions provide additional competitive funding to the best research groups in public universities, giving them greater financial autonomy subject to a performance evaluation system. This is the case of Galicia, which has created 8 "strategic research groups" and 7 "singular research centres". Their selection and subsequent evaluations are primarily based on criteria of research excellence, but also consider indicators of knowledge transfer and the alignment of their research agendas with the region's smart specialisation strategy.

Other instruments used at regional level include competitive grant programmes for collaborative projects, innovation vouchers, talent attraction programmes and others that aim to create networks and facilitate relations between the different agents in the system. Some of these are clearly complementary to national programmes, such as innovation vouchers, which are only offered by regional or local governments. Others, on the other hand, generate some overlap, such as the grants for collaborative projects that sometimes finance the same

type of projects as the CDTI's programmes. The unwritten rule whereby CDTI focuses on funding projects of over EUR 200 000 while regional governments focus on smaller projects is not always followed. While this is not necessarily a problem, it is worth reflecting on possible mechanisms to pool efforts and encourage multi-level cooperation through joint programming.

Central government R&D programmes include knowledge transfer and collaboration among their key objectives, but their scope has been limited and severely restricted by budgetary constraints. The policy mix for knowledge transfer requires consolidation and adaptation to the needs of a diversity of actors

The comparative analysis of knowledge transfer initiatives using the 2019 OECD-EU STIP Compass data allows analysing the 20 knowledge transfer initiatives reported by the Spanish authorities. Each of the initiatives is associated with a single instrument, pointing to a possible situation of policy fragmentation. Firms are the most prominent target group, present in 60% of the initiatives, followed by research institutions in 40% and researchers and intermediaries both in 35% of cases. Large companies seem to benefit the most from policy initiatives and programmes targeting collaborative research. On the business demand side, respondents also point out that administrative burdens prevent SMEs from making effective use of theoretically generous R&D tax incentives, which in the majority of the territory do not include additional provisions to encourage engagement with the public system of research. While financial instruments are deemed most effective, Spain is an outlier in citing guidance and regulatory instruments as significantly more prominent (63%) than direct financial support instruments (21%), owing to the adverse budgetary landscape of the last decade. Instruments to support collaborative public-private R&D, such as the CENIT projects, were abolished and have since not been replaced with fully comparable programmes. The CIEN programme, aimed at funding large private R&D projects through business-led consortia, has been smaller in scale and places lower requirements for contracting with public research entities.

The current **direct support instruments for R&D collaboration**, largely based on loans (to companies) and grants (to knowledge centres), have helped to promote linkages between actors, but have some weaknesses that should be addressed. These include the lack of attractiveness for companies, illustrated by the fact that a significant part of the budgets earmarked for support in the form of loans are not disbursed. The complexity of application procedures and the long processing times also discourage applications. With the exception of the challenges-collaboration RDI projects and the new projects in strategic areas of the AEI, the direct beneficiaries of such instruments are companies or technology centres, while universities and public research centres can only participate as subcontractors and not as equal partners. This compartmentalisation hampers the establishment of closer partnerships and the generation of long-term linkages. Moreover, beyond consortia projects of limited duration, there are no instruments to support the establishment of long-term joint research and technology centres, to which other European countries are attaching increasing importance (e.g. the CoLabs programme in Portugal or Research Campus in Germany).

The discontinuity of support instruments over time and changes of name or eligibility criteria, together with the existence of programmes with similar objectives at different levels of government (European, national, regional), are often a source of confusion for potential beneficiaries, especially SMEs. Greater communication efforts are needed to raise awareness about these programmes.

The system's actors also highlighted the lack of **support instruments for the advancement of the maturity levels** (TRLs) of the technologies developed in universities and public research centres. The launch of proof-of-concept projects by the AEI in 2021 responds to

these demands. This instrument can benefit from lessons learned from the implementation of similar programmes in other countries, as well as those implemented at regional level or driven by private foundations. These efforts should be accompanied by measures to increase the visibility of each institution's technological capabilities, so that they can be easily identified by potentially interested companies.

Policy instruments at central government level to support knowledge transfer and collaboration

General objective	Policy instruments at the central government level
Grants and loans for collaborative R&D projects	Challenges - collaboration RDI projects (AEI), since 2014 Funding for projects in strategic areas (AEI), launched in 2021 Funding for proof of concept projects (AEI), launched in 2021 Science and innovation missions' programme (CDTI), since 2020 Cervera R&D transfer projects (CDTI), since 2019 CIEN Strategic projects (CDTI), since 2014 Health technology development projects (ISCIII)
Support for the mobility and industry engagement of PhDs and post-docs	Industrial PhDs (AEI), since 2014 Industrial PhDs in health sciences and technology (ISCIII), since 2014 Torres Quevedo Grants (AEI), since 2001
Financial rewards for public researchers that engage in knowledge transfer activities	Knowledge transfer sexennium (ANECA), pilot in 2018
Support for collaborative platforms and networks	Technology and innovation platforms (AEI), since 2005 Networks for cooperative research oriented to health solutions (ISCIII), since 2013
Support for intermediaries and key infrastructures	Cervera programme for technology centres (CDTI), since 2019 Innovative business clusters programme (MINCOTUR), since 2017 Innovation Platform in Medical and Healthcare Technologies (ISCIII) Unique scientific and technical infrastructures (MICINN)
Support for the creation of science- or technology-based spin-offs	NEOTEC Programme (CDTI), since 2002 INNVIERTE Programme (CDTI), since 2012

Research staff mobility is one of the main channels for knowledge exchange and trust building between the public research sector and business. Policy instruments to promote it, in particular the Industrial PhD programme and the Torres Quevedo contracts for doctorate holders, are highly appreciated by the actors in the system. However, the industrial PhD programme is relatively small (although similar programmes exist at regional level) and resources for the Torres Quevedo contracts have decreased significantly in recent years. The evaluation of these programmes is a priority to better understand their long-term impact on researchers' careers and their links with companies, and to improve their implementation.

The **knowledge transfer and innovation sexennia** (*sexenios de transferencia de conocimiento e innovación*) were introduced on a pilot basis in 2018, replicating the model of the existing research sexennia (*sexenios de investigación*), to recognise and encourage knowledge transfer activities among teaching and research staff in universities and public research centres. The number of applications in the first call far exceeded expectations, reflecting both the interest of the scientific community in this instrument, and the fact that a broad definition of the concept of knowledge transfer was considered. The first pilot presented a number of operational problems (e.g. lack of clarity in the criteria for the evaluation of applications, long processing times) which ANECA is seeking to address as a priority in the next call, among others with the publication of specific guidelines for the evaluation of applications. This instrument, which has no equivalent at international level, can contribute to progressively promote a greater transfer culture among researchers in Spain, as the research *sexennium* did in the past. It is worth asking whether the basic concept applied to both research and knowledge transfer could be structured in a different way to have a greater incentive effect per unit of public expenditure, for example, by considering for how

long the bonus is received once past merits have been accredited (currently received until retirement), and not artificially limiting the number of six-year periods that can be achieved.

STI actors have underlined the need to raise awareness of these programmes among companies, and to consider measures to foster greater pre-contract, two-way interaction between the research and business sectors to ensure a successful transition of PhDs between academia and business. The Spanish Recovery, Transformation and Resilience Plan (RTRP) envisages the coordination of existing programmes (Cervera and NEOTEC, both managed by CDTI), with the Industrial PhD and Torres Quevedo programmes, supporting the incorporation of PhDs (or doctoral students) into companies within the framework of funded projects. Given these changes and the proliferation of talent attraction initiatives at regional level, it would be appropriate to intensify the dialogue between agents to share good practices and improving the impact of these policies.

The use of instruments for the creation of **networks and collaborative platforms**, such as technology and innovation platforms, have had a significant mobilising effect and are positively valued by their members for their capacity to generate trust and reduce transaction costs between actors, although they are heterogeneous in terms of scope and impact and could perhaps contribute more actively to defining roadmaps for sectors, technology areas and cross-cutting missions.

Central government **support to intermediary agents** (e.g. TTOs, science and technology parks, technology centres, clusters) is limited and appears significantly fragmented between the CDTI's Cervera programme for technology centres and the Ministry of Industry, Trade and Tourism's programme for innovative business clusters. In the latter case, grants are awarded to carry out innovation activities in which the participation of universities, public research centres and technology centres is not mandatory but common.

The analysis of **current direct support instruments for R&D collaboration** shows that they are mainly based on partially subsidised loans (to companies) and grants (to knowledge-generating institutions mainly in the public sector). These have promoted linkages between actors, but suffer from some weaknesses that should be addressed as a matter of priority:

- Lack of effective attractiveness to actors, due to bureaucratic and design barriers in some cases.
- Excessive segmentation of support instruments
- Limited use of institutional funds to advance consortia.
- Limited support for research mobility and to advance into higher technology readiness levels (TRLs).
- Within the research base, an excessive focus on individual versus institutional financial incentives.

New investments and knowledge transfer support programmes aim to reduce current obstacles but require greater focus and long-term commitment

Policy activity in the field of science and innovation in Spain has been particularly vigorous over the past months. A new Spanish Strategy for STI for 2021-27 was published in September 2020, followed by the release in June 2021 of the State Plan for Scientific and Technical Research and Innovation 2021-23. A national Recovery, Transformation and Resilience Plan (RTRP) was released in April 2021, which will allow channelling Next Generation EU funds into the Spanish economy and society to implement important reforms and investments in a diversity of areas between 2021 and 2023, including in the field of STI.

The support and promotion of knowledge transfer activities is a central part of these new plans and reforms. Component 17 of the RTRP includes the launch of new programmes in this field that respond to the demands of different actors in the system (e.g. proof-of-concept programme, strategic research lines, creation of technology transfer funds), as well as the strengthening and reform of existing programmes (e.g. Cervera, NEOTEC, missions programmes, etc.). It also envisages coordination between instruments, and in particular between the industrial PhD and Torres Quevedo programmes with the Cervera R&D transfer projects and the NEOTEC programme. Resources will also be invested in strengthening the capacity of TTOs, although the plan does not elaborate on the instruments to be used.

These reforms and investments are an important step in the right direction, although they entail two possible risks. On the one hand, the multiplication of programmes in this policy area increases the complexity of the portfolio of available instruments (already complex given the existence of programmes at European, national and regional level), which could lead to confusion among potential beneficiaries and an increasing burden for the agencies in charge of their implementation, leaving them with little margin to devote to ex-ante and ex-post evaluation exercises. Increasing the capacities and efficiency in programme management is essential to avoid delays in the processing of applications. On the other hand, the ambitious reforms and investments envisaged in the RTRP, which will be financed by the Next Generation EU funds for the period 2021-23, already represent, by 2021, an increase of 60% of the budget of the Ministry of Science and Innovation compared to 2020. However, the impact of these policies will only materialise in the medium to long term provided that investments do not drop significantly after the end of the EU support programme. A top priority is therefore to ensure the sustainability of public investments in R&D and innovation in the long term – in line with the Science and Innovation Pact. This is the only way to avoid delayed but equally devastating effects of the crisis on STI, as was the case with the brain drain after the 2008 crisis from which the country has not yet recovered. To ensure the sustainability of R&D and innovation investments, the private sector must be mobilised to contribute to the financing of these activities.

The current regulatory framework is complex and poses excessive rigidities on knowledge transfer, sometimes based on unsubstantiated assumptions

The current regulatory framework relevant to knowledge transfer comprises legal instruments that are specific to STI and others that affect public administrations more broadly. Regional administrations also have specific legal frameworks for their territories. In Spain, legal instruments are expected to specify in detail a vast number of situations and interactions, while country-wide and regional legal frameworks coexist and must incorporate EU directives. Compared to many neighbouring countries, even those of comparable size and level of decentralisation such as Germany, the Spanish legal framework for STI (which is only partially developed) is very complex, with excessive rigidities and *ex ante* controls that hamper knowledge transfer. To address this situation, the government has initiated a process of substantial modification of the 2011 Law of STI including the integration of elements scattered in other laws, in particular the 2011 Sustainable Economy Law and the 2015 Patent Law.

Among the main generic regulatory barriers to collaboration, it is worth highlighting the articles of Law 40/2015 on the Legal Regime of the Public Sector relating to the establishment of **collaboration agreements with public entities**, which particularly affect PRBs (OPIs in Spanish). As mentioned by interviewees, the establishment of such agreements can easily entail between 4 and 6 months of paperwork between the time negotiations are finalised and contracts are signed, which strongly discourages collaboration. The Royal Law Decree 36/2020 on urgent measures to modernise the public administration

and implement the Recovery, Transformation and Resilience Plan (RTRP) introduces changes to accelerate those procedures.

The 2003 Law on Subsidies establishes a series of **administrative requirements** for the management of publicly funded collaborative research, which drain important human and economic resources. This has also contributed to the bureaucratisation of public research centres, forced to devote a significant part of their efforts to research project management to the detriment of promoting knowledge transfer. The Royal Law Decree 36/2020 establishes some modifications that streamline procedures for grants financed with European funds.

The lack of specific regulations on the **allocation of ownership and revenues of intellectual property rights** developed in the context of public-private research activities – which are set at the institutional level – increases transaction costs, creates uncertainties and ultimately discourages collaboration. In addition to standardising processes to reduce transaction costs, the legal framework needs to allow for greater sharing of the benefits of the exploitation of research results.

In the field of researcher mobility, the 2011 Law on STI stipulates that researchers who would like to work in private companies need to request a **temporary non-extendable leave of absence** of up to 5 years. The rigidity of this regime, which limits the long-term participation of researchers in technology-based companies, may contribute to the perception of mobility as irreversible and risky. Moreover, mobility experiences are not sufficiently valued in the ANECA accreditation system.

The **conditions for researchers to participate in the creation of spin-offs** based on the exploitation of research carried out in universities or research centres is another aspect of relevance. The 2011 Law of STI establishes exceptions to the restrictions imposed by the 1984 Law on Incompatibilities of Staff in the Service of Public Administrations, which made it impossible for public researchers to participate in companies that exploit the knowledge derived from their research. However, the STI law establishes some requirements that continue to be limiting, such as the necessary participation of the university or centre of origin in the company's shareholding, and the requirement of a part-time, fixed-term employment contract to regulate the researcher's link to the company. In addition to these legal restrictions, it is worth noting that some support programmes for the recruitment of research personnel, such as the Ramón y Cajal or Juan de la Cierva programmes, do not allow the participation of awarded researchers in companies, with no exceptions for spin-off activities.

Addressing these formal restrictions requires achieving a consensus on the extent to which regulatory conditions that apply to government ministries and agencies are at all relevant for research personnel working in entities controlled by the public administration but whose mission is not the function of administration, but the generation of scientific and technological knowledge and its transfer to society. It is essential to adapt the current legislative framework to serve the general public interest, making processes more flexible and eliminating excessive rigidities that lead to "irregular" situations (i.e. not within the framework of the law), in the words of many interviewees, that involve administrative risk-taking on the part of managers and researchers. These also absorb too many resources from the administration itself, which could be allocated to planning and integrating evidence into decision-making and implementation processes, and from the system's actors, who would have greater capacity to devote themselves to their science, innovation and transfer functions.

It should also be noted that legal definitions and formal registers of different types of actors serve important administrative purposes, but do not necessarily reflect a changing and complex reality, and often lead to excessive compartmentalisation of the scope of programmes. They should therefore be used with caution and be easily adaptable.

The ongoing legislative reform agenda puts knowledge transfer as one of the main policy priorities

The proposed amendments to Law 14/2011 on Science, Technology and Innovation have two main objectives: to reconcile the provisions of the 2011 Law of STI and the 2011 Sustainable Economy Law and to address several of the system's regulatory shortcomings. Its objectives are structured along three main axes: 1) Improving the governance and coordination of the Spanish STI system; 2) Improving careers in the public research system; and 3) Promoting the transfer of research results to society. The latter is the most relevant to the objectives of this report. Measures envisaged in this area aim to address current obstacles to KTC while protecting the public interest. The regulatory changes under consideration would help to:

- Clarify the parameters under which organisations and researchers should determine the sharing of rights over the commercial use of intellectual property as well as outcomes of collaborative activities between the public system of research and private entities, so that the arrangements are fair and induce all parties to exert appropriate efforts.
- Create more room for manoeuvre for the different types of institutions in the public research base in relation to their knowledge transfer and collaboration activities:
    - Define clear exceptions to the still complex regime of incompatibilities in the public sector;
    - Adapt the regulation of research staff mobility in order to minimise the professional risks associated with undertaking and starting a new career in other institutions;
    - Define the transferability of IP rights and streamline some mechanisms;
    - Facilitate the creation of start-up companies derived from public research findings; the potential exploitation of IP rights through business structures, a measure that could transform the way TTOs operate;
- Reward knowledge transfer activities carried out by research staff, so that they receive the same treatment as research activities in promotion and internal resource allocation processes. A minimum standard is established that entitles researchers to receive part of the income obtained from their activities.

The wider margin granted to institutions would be a positive development in line with the recommendations of this report. The minimum entitlement to economic benefits by researchers is broadly in line with practices in other countries. It is also supported by evidence that shows that researchers' commercialisation activities are positively encouraged by small increases in the share of income they receive from the exploitation of their research. A key question is whether setting a minimum could effectively lead PROs that currently offer better conditions to their researchers to worsen them, as this would have negative effects on knowledge transfer. The proposal should also recognise the role of teams and not just individuals, as research and innovation are effectively "team sports". It is also important to clarify the role of R&D personnel who do not formally qualify as "researchers" or equivalent, and whether IP legislation will also be amended.

The draft proposal for a new Law of the University System also contains various elements related to university-business cooperation and knowledge transfer. It envisions changes in the governance structure of universities, including a new system for the nomination of members of Social Councils, and proposes to introduce a new financing system combining baseline funding with a performance-based component.

The remaining consultation period should be used effectively to consider a broader range of options to make the Social Councils more effective in their defined role, prevent their politicisation and ensure that teams have some degree of continuity in order to preserve know how and strategic direction.

The proposed introduction of a performance-based component to the financing of universities is well aligned with the recommendations of this report. Efforts will need to be devoted to defining the size and operation of the performance-based component, as well as testing it, requiring close collaboration with regional administrations and universities themselves.

Recommendations

The diagnostic analysis presented in this report points to some priority areas for policy action to improve science-business knowledge transfer and collaboration in Spain. These represent the basis of a potential action roadmap, focused on the following key priorities:

1. Put in place **sound science and innovation policy foundations** that make knowledge transfer and collaboration possible and effective. This requires sustained investments in science and innovation over time and appropriate policy and regulatory frameworks. Publicly funded research should be a prime candidate for the adoption of a protected regulatory sandbox approach that ensures proportionality in control and enforcement mechanisms. The authorities in charge of science and innovation policies should continue working to boost policy lifecycle evaluation and implementation capabilities in this complex area, putting greater emphasis in multi-level collaboration and exchange of good practices. They should also ensure that there is a broad-based innovation policy perspective supporting all major government strategies and strategic projects.
2. Re-design the **governance systems of universities and PROs** to increase their engagement with and accountability towards society, avoiding political interference in their operations through more effective operational autonomy. There should be an independent review of the PRO landscape to assess how missions and institutional arrangements currently align, and advise on options for a more efficient and effective configuration.
3. Rebalance and align **individual and institutional incentive mechanisms**, so that external knowledge transfer and collaboration activities are more attractive endeavours for all types of researchers, their teams and organisations. Spain should work towards adopting funding mechanisms at the institutional level that are partly linked to outcomes. Among those, knowledge transfer and collaboration activities and outputs should feature rather prominently, built on good and timely information about formal and informal activities. Incentive systems should be carefully monitored to detect and prevent unintended biases (e.g. gender, age or disciplinary-based).
4. Facilitate and co-ordinate the operation of diverse **knowledge intermediation agents**. There is scope for greater mutualisation of efforts of internal knowledge transfer services across different universities and PROs to better manage existing and prospective intellectual assets. There should be concerted efforts towards reinforcing and streamlining central and regional government support for knowledge intermediaries such as technology centres, science and technology parks, and clusters
5. Promote and sustain **business capacities to innovate**, to render the sector willing and ready to exchange with the PSR and other relevant actors through ever-deeper engagement mechanisms that are appropriate to their level of innovation capability.

Public policies should help raise business awareness of the strategic importance of innovation.

1. Systemic foundations and enabling conditions for science and innovation

The science-business interface is one of the most critical and fragile points of an innovation system. It is also the most difficult to act upon, given its complexity in terms of the diversity of responsibilities, actors and linkage mechanisms. If the framework conditions under which the Spanish STI system operates do not meet a series of basic requirements and actors are not able to fulfil their specific functions, KTC risks being seen as an accessory element. As the Spanish STI strategy recognises, a reform agenda for public research-business linkages should be accompanied by efforts to strengthen the overall system.

For knowledge transfer policies to have positive effects in the long term and at scale, it is essential to ensure political commitment to maintain and stabilise resources for STI over time (not only for R&D investments), and to engage in efforts to spread a culture of innovation across all layers of society. As the innovation imperative that Spain faces today widens the scope of innovation policies, it requires co-ordination and new institutional arrangements that extend beyond the confines of the Science and Innovation Ministry (and Universities by the same token) to a "whole-of-government" approach to innovation policy. This implies establishing stable platforms for co-ordinating actions, a focus on policies with a medium and long-term perspective, and the commitment of policy makers at the highest level. It also requires coherence and complementarity between local, regional and state levels.

The accumulated policy experience in the field knowledge transfer and collaboration, both at the central government and regional levels, offers invaluable opportunities for policy learning. Further efforts should be made to institutionalise such processes of best practice exchange and policy learning, as is currently the ambition of RED IDI (a multi-level strategic coordination network to support research and innovation policy in Spain), which can still do much in terms of adopting genuine policy co-creation approaches.

As in all areas of public policy, the monitoring and evaluation of public policies for knowledge transfer and collaboration is essential to ensure effective management of public resources, improve the instruments used and maximise their impact. However, Spain has little tradition of evaluation compared to other OECD countries. Efforts are progressively being made in the right direction, including the evaluations of the Independent Authority for Fiscal Responsibility (AIReF), created in 2014, although to date these have only addressed a couple of programmes in the field of R&D and innovation.

The evaluation of knowledge transfer policies is particularly complex, given that their effects materialise in the medium to long term and are not easily attributable. The different elements that constitute the Spain's growing Information System on STI (SICTI in Spanish) are key resources for this purpose at national level, requiring further investment, development, inter-connection and dissemination efforts. The diversity of experiences in the field of evaluation at both regional and international level provides an important impetus and basis from which to learn and support policy decision making in a more effective fashion.

Recommendations

This report presents a series of recommendations aimed at improving the governance of science and innovation policies.

In terms of strategy and planning:

- Set a realistic vision of the role that science, technology and innovation should play in Spain in the medium to long term (horizon 2030, España 2050), and develop a

detailed Plan that has the broad support of all actors of the STI system, as well as civil society.

- Articulate a sustainable, multi-partisan pact on science and innovation. This requires securing long-term agreement across the political spectrum on a stable public funding model for science and innovation, with an equal commitment by researchers and research institutions to work to deliver concrete benefits to society. Such a commitment can underpin a new social consensus on innovation that is more robust to variations in the budget cycle. In particular, it is important to ensure that funding for R&D and innovation remains stable once European recovery funds have run out. This is a prerequisite to avoid a reversal as damaging as that caused by the global financial crisis and its aftermath, which is still impairing the Spanish STI system. In this respect, a roadmap with various measures and steps to be taken to ensure a smooth transition to the post-Next Generation EU period should be developed. The mobilisation of private funds is necessary to ensure such sustainability.
- Ensure greater openness to external independent influences in the way the system is assessed, strategies defined, public organisations governed, opportunities for improvement identified and the system evaluated.

In terms of policy implementation:

- Advance with the planned reforms of the STI Law, and review the provisions of the current legislation that act as barriers to collaboration and knowledge transfer, with the aim of making processes more flexible and eliminating excessive rigidities, especially with regard to the establishment of collaboration agreements with public entities, the management of collaborative research financed with public funds, and the mobility of research personnel. To this end, an independent assessment of the efficiency and cost-benefit of administrative procedures affecting the public research system is recommended.
- Reduce the need to regulate every aspect of the system by adopting measures that allow a progressive transition from the current legalistic approach to a framework governed by a set of general principles, codes of conduct, guidelines and good practices. These should be reviewable and help to effectively respond to the needs of the system's actors in the field of collaboration and knowledge transfer.

In terms of policy evaluation:

- Strengthen the capacities of the administration to systematically collect high quality data (both quantitative and qualitative), store it, analyse it and make it easily accessible to both the research community and the public. The value of such information and intelligence systems depends on their sustainability over time, and it is therefore necessary to ensure their long-term funding.
- Strengthen coordination between collectors and processors of science and innovation data, and improve alignment between the indicators used and the purposes pursued.
- Evaluate the policy mix for knowledge transfer to identify specific areas for improvement and maximise their impact. This exercise should also aim to identify potential synergies between programmes, as has been the case in the context of the RTRP, where coordination between the NEOTEC grants and the Cervera programme with the Industrial PhD and Torres Quevedo programmes is promoted.
- Make more systematic use of qualitative impact cases, illustrating all types of results, especially in relation to indicators that are difficult to quantify.

- Progressively institutionalise the culture of public policy evaluation. This includes the establishment of more transparent mechanisms for the assessment of different policy options *ex ante* and for conducting *ex post* impact assessments.

2. Effective governance of universities and PROs: missions, autonomy and accountability to serve society

The governance of universities and PROs represents another priority area for reform, complementary to actions to improve the governance of public science and innovation policies.

Knowledge transfer and collaboration between university and business in particular have been hindered by the prevailing governance arrangements of universities. Society has little ability to influence how universities make use of public resources while the university system is overly exposed to politicisation. Despite their formal autonomy, universities are severely restricted in their ability to attract external talent to management and academic positions. Spain, which has a dual PSR system that combines HEIs and PROs, needs to reconsider the optimal configuration of such an ecosystem in terms of specialisation and allocation of resources. The system of PROs (excluding university centres) must re-identify its distinct rationale and specialisation strategy, including serving economic, social and environmental missions through specialised scientific and technological capacities, services, infrastructures and expertise of value to the public and private sectors. Appropriate organisation and governance mechanisms need to be in place for them to accomplish these tasks.

Recommendations

- Increase results-oriented accountability to match existing high levels of autonomy in parts of the system, particularly within the university system, while allowing for institutional reforms that enable universities and different types of PROs to enjoy similar levels of effective autonomy under governance and funding arrangements that are consistent with their stated missions.
- Emulate recent reforms in several European countries with a move towards increasing levels of institutional university autonomy, especially linked to human resources, coupled with arms-length steering mechanisms and greater accountability, possibly through the establishment of performance-based contracts between regional governments and universities. From a transfer perspective, moving in this direction would require:
    - either completely transforming the current governance system to give an effective voice to external stakeholders in setting university strategy,
    - or effectively strengthening the role and capacities of the Social Councils. This would imply ensuring that the Social Councils have sufficient resources and autonomy to efficiently fulfil their functions; increasing the number of representatives that can participate in the governing council (currently limited to three); and providing greater clarity on the eligibility criteria and level of engagement of their members.
- Commission an independent review of the PRO system, analysing their alignment with the government's STI strategy and the needs of the Spanish STI system. The review's recommendations should spell out options for organising public research and innovation facilitation infrastructures and the significant human and material resources in synergy with the university system. This would help solving the problems posed by the existing regulatory asymmetries between different types of PROs and examine the appropriate mix of public support for technology centres.

- Provide sufficient flexibility to implement experimental governance approaches at regional and/or institutional level. This "test and learn" approach would benefit the whole system in the longer term, as it would allow testing a diversity of approaches and generate evidence regarding their impacts. Regional governments have a critical role to play in exploiting these opportunities but the overarching country-wide framework needs to support them.

These reforms require concerted action between the central government (in charge of reforms in the Law of Universities and accreditation policies), regional governments (in charge of university policy implementation and funding) and universities themselves (with their own statutes and practices).

In the current international and domestic landscape, there is an urgent need to reconsider the governance arrangements for institutions that serve the social purpose of universities and public research centres, something that should in itself be a subject of democratic debate at the different levels of government in Spain. The experience of reforms in European countries illustrate how deep reforms can be implemented with full respect of democratic and public service values. These reforms have in most cases not happened overnight, and have required considerable leadership on the part of elected officials at responsible levels of government as well as additional resources to support the transition process. The ongoing reform of the Organic Law of the University System and the available EU funds represent a unique opportunity for Spain.

3. Aligning individual and institutional incentives to decisively and effectively promote transfer and collaboration

The Spanish authorities have made the provision of individual incentives a major focus of their KTC policy strategy. This includes the adoption of rules that entitle public researchers to benefit from the economic outcome generated by their research, the authorisation of certain transfer and collaboration activities, the adoption of private law-based intermediation vehicles, as well as the introduction of a salary bonus system managed at the national level to reward such activities (knowledge transfer sexennium, KTS). These reforms are extremely important as they directly address underlying problems that have discouraged transfer activities by researchers in the past.

However, the reforms do not appear to extend to many PROs the flexibility already granted to universities for setting up contracts with firms and appear to be widening the engagement gap since the implementation of the KTS, at least in its pilot, has been very different. Furthermore, a possible unintended effect of individual incentives such as the KTS is that they result in uncoordinated efforts, developed at sub-optimal scale and without the necessary support by the institutions in which researchers work. Such direction would accentuate the current conflicts over the sharing of the burdens and benefits of knowledge transfer. In line with the recommendations already made in 2014 by the ERAC expert panel, a priority for reforms is to consider the introduction of institutional funding mechanisms. These should be partly linked to the achievement of results that are consistent with the missions and strategic objectives of such institutions. Institutions could use the leeway provided by additional KT-based funding streams to strengthen their transfer capacities, as well as to reward researchers and other staff internally who contribute to transfer results, not only in terms of salaries, but also providing them with better support services, or with the possibility to hire personnel and purchase equipment.

While the availability of a broader set of knowledge transfer indicators such as those developed by the Ministry of Science and Innovation can greatly facilitate this vision, it is also important to introduce complementary qualitative evaluation components to avoid

falling into reductionist approaches that distort incentives towards what can be measured quantitatively. This could also encourage experimentation in the generation of evidence to support evaluation processes. The experiences documented in research and technology centres in Catalonia and the Basque Country provide relevant examples within Spain.

Recommendations

- Establish incentive mechanisms at institutional level, whereby the basal funding of universities and PROs would be partially linked to the achievement of results in the field of collaboration and knowledge transfer (in addition to results in the field of research and teaching). These results would be evaluated on the basis of previously established quantitative and qualitative indicators, which would illustrate the degree to which the actions and results obtained are in line with the strategies, missions and objectives established by common agreement between the institutions and the regional administrations. Likewise, the institutions should have the autonomy to decide their implementation plan for these strategies.
- Ensure that researchers get a fair share of the commercial outcomes of their research.
- Increase the awareness and recognition of knowledge transfer merits so that they are equivalent to merits for research excellence, not only in terms of remuneration, but also in selection and promotion processes for university professors and researchers. They should also be considered for the selection of projects funded by national and regional science and innovation programmes that have knowledge transfer as one of their objectives.
- Make strategic and operational choices concerning the knowledge transfer sexennium (KTS), which has a significant culture change potential, to maximise its value for money and avoid creating an excessively complex system of individual incentives. In particular, it is important to:
    - Decide whether it is principally intended to work as a financial incentive, engaging the various bodies responsible for their funding, an accreditation and recognition career incentive, or a mix of the two.
    - Build consensus on the intended scope of the KTS and consistently improve the assessment process, e.g. by issuing clearer guidance and increasing the diversity of evaluation panels, for instance by including business sector representatives (and not only academics) so that more impactful activities are given the appropriate recognition.
    - Avoid possible overlaps between instruments and ensure it effectively acts as an incentive mechanism. One option could be to grant salary bonuses for shorter periods of time but allowing rewards for new merits to be claimed more frequently.
    - Monitor and correct the possible undesired effects of the KTS by institutional, professional, age and gender groups, to prevent these incentives from aggravating existing disparities in the Spanish public R&D workforce, characterised by a significant degree of precarity among the younger generations of researchers that coexists with a very protective system for those with permanent positions.

4. Activation and coordination of public and private intermediation agents, promoting their professionalisation and action on an optimal scale and close to the market.

One of the essential functions in an innovation system is to identify promising ideas and procure resources to develop them into possible solutions to address needs, as well as to identify which needs require the creation of new knowledge. In complex and specialised systems, with highly decentralised information about ideas and needs, intermediation agents play a key identification, connection and selection function.

Recommendations

Recommendations that specifically concern TTOs are the following:

- Create conditions that allow increasing the level of institutional support and resources allocated to TTO activities. This would enable them to go beyond the administrative activities linked to the management of contracts and calls for proposals, to focus on transfer activities and become real innovation offices. Increasing the internal institutional support to TTOs requires ensuring that their mission and strategic objectives are an integral part of institutional strategies, they receive stable funding to pursue their activities, and have the support and recognition of the management of universities and PROs. An option to increase the allocation of resources to TTOs could be the establishment, by the central government, of a competitive funding line to support the implementation of strategic plans proposed by TTOs for a period of 3-5 years. Positive evaluation of the impact of such plans based on TTO model KPIs would allow them to apply to the next round of funding.
- Provide tailored and regular training to all professionals working in TTOs. This should be targeted to both new entrants and more experienced professionals, in order to support their professional development and career progress (both vertically and horizontally). Training should be provided in several modules by practitioners and experts in different domains (e.g. commercial, legal, IP management, etc.) and be specifically tailored to the needs of TTOs, as is the case of courses provided by RedTransfer or ASTP. The establishment of an official accreditation programme for technology transfer experts could also be considered. The ASTP accreditation system could serve as an inspiration for the development of a national system, coordinated at the central government level but involving several actors, including RedOTRI, RedTransfer, regional actors, technology centres, research groups and the most advanced TTOs. Compared with having multiple training programmes of heterogeneous quality, this would avoid duplications and enable reaching economies of scale. Incentives could also be offered to Spanish TTO professionals who become accredited through the ASTP system. The establishment of mentorship programmes or secondments, where a member of one organisation spends time in another, could complement training programmes.
- Enable and promote the attraction and retention of a diversity of profiles for TTO positions, including candidates with market experience coming from the business sector. Consider increasing the sectoral specialisation of the professionals working in TTOs, so that their advice and services can be more targeted and ensure a better match between research supply and industry demand.
- Increase the visibility of the activities carried out by TTOs, both within the research and business world, through various dissemination measures adapted to different target audiences.

Recommendations aimed at improving the overall intermediary ecosystem (including TTOs and the wide range of independent intermediation actors) are the following:

- Develop a comprehensive map of the intermediation ecosystem across the territory, including both public and private institutions. This map, which should be interactive, easily accessible and contain detailed information of the catalogue of services provided by each actor, would be particularly valuable for firms (and particularly for SMEs), sometimes overwhelmed and confused by the multiplicity of actors in the intermediary ecosystem. Such a map could also be used to identify possible gaps, synergies and overlaps in the provision of services by different publicly supported entities.
- Encourage mutualisation efforts of intermediation services at regional and/or sectoral level, with the aim of reaching an optimal scale to offer more specialised services (e.g. legal and IP management advice) and higher impact. Inter-institutional and inter-regional alliances should be explored as a first step to address the current atomisation of intermediation services.

5. Development of innovation capacities and interaction with the public research base on the part of companies

One of the greatest challenges for the Spanish productive system is to increase the innovation capacities of companies in order to develop activities with greater value added. The OECD definition of innovation in the context of companies includes the provision of new or improved products to users and the implementation of new and improved processes. The capabilities within the firm define the type of innovations that they can undertake and their degree of ambition. Innovation is not among the priorities of most Spanish companies and this hampers their capacity to absorb and apply external knowledge to new uses. This is not a good ground for knowledge transfer.

For companies in many other countries, tax incentives are an important incentive for R&D that allows the systematisation of innovation activities. The simplification of the R&D tax incentives system for firms could make them more accessible to all potential beneficiaries, in particular SMEs. As the recent AIREF assessment indicates, their implementation should be reviewed. The adoption of additional elements to encourage the engagement of the research base in industrial R&D could also be considered if the availability of funds allows for it, as is already the case in the Basque Country's tax system.

Innovations can be implemented by existing firms or by new entrants. Spain's recent entrepreneurship strategy (*Estrategia España Nación Emprendedora*) illustrates the intention of the government of identifying reforms that could improve the innovative capacity of enterprises through entrepreneurship. It includes numerous references to innovation as well as to the role of "transfer". The strategy highlights the role of Enisa, a state-owned company of the Ministry of Industry, Trade and Tourism, which has increasingly positioned itself as a national benchmark in the promotion of innovative entrepreneurship through risk financing via participative loans. The strategy proposes streamlining the processing of these loans and ensuring the availability of budget throughout the year. Other relevant examples of Enisa's actions include joint actions with different actors in which interested companies receive training on entrepreneurship to consolidate their projects and strategic plans.

With regard to CDTI, the recent Recovery, Transformation and Resilience Plan (RTRP) reinforces the actions of INNVIERTE (a co-investment initiative aimed at technology companies in early stages of development), and complements them with the creation of a transfer fund for technology companies in the start-up phase, especially spin-offs. The NEOTEC programme, which supports the creation and consolidation of technology-based

firms, will also be reinforced and the recruitment of doctors by those firms will be incentivised.

Given the range of instruments implemented at different levels, it is worth exploring the possibilities for promoting and coordinating the supply of services to companies, especially SMEs, to facilitate a more simplified path and in which innovation activities in general and transfer in particular can be proposed to companies on the basis of an initial analysis at the right time. Entrepreneurship, innovation, digitalisation and internationalisation, are all highly overlapping fields of policy action that would be better addressed in a coordinated manner to allow for an optimal use of the wide but heterogeneous existing offer.

Ongoing campaigns to promote entrepreneurship and digitisation can make innovation in a broad sense a major focus of these campaigns. Public administrations could also use their incentive instruments to ensure that the research system contributes to improving the capabilities of enterprises to adopt new technologies, in particular but not exclusively information technologies, in a way that is appropriate to their capabilities and needs. Universities can also play an important role in providing training activities that are critical for the development of new knowledge-based start-ups, including through the development of entrepreneurial skills among students and academic staff.

Especially in the field of research-based start-ups, there is an urgent need to adopt mechanisms to facilitate the transition of these start-ups from a phase in which their funding comes from investors (which are scarce in most sectors) to one in which customers take on this responsibility. This includes greater support for proofs of concept and for innovative public procurement.

As indicated in the *Estrategia España Nación Emprendedora*, instruments geared towards the public procurement of innovation solutions (including pre-commercal procurement of R&D services) can be used to promote collaboration between research and technology centres and innovative companies to develop new technologies not yet present in the market. It should be considered whether and how to optimise the demand by universities and research centres for specialised goods and services with high technological content that may be provided by Spanish companies. This could contribute to the strengthening of an “industry for science” with international projection.

Recommendations

In relation to the design and implementation of business support programmes, instruments to support KTC need to be adapted to innovation needs that diverge significantly across firms. These instruments support different channels of interaction, the relevance and appropriateness of which largely depends on firms’ internal R&D and innovation capabilities and their technological maturity. Recommendations in this regard include the following:

- Improve the dissemination of broad-based programmes among potential beneficiaries, with special emphasis on SMEs, but also considering their capacity to attract companies not currently established in Spain. Simplifying application processes and speeding up their processing, with the aim of reducing the time between application and resolution.
- Consider introducing initiatives at the bottom of the "innovation ladder" by having business and engineering schools, in collaboration with Chambers of Commerce, provide support to SMEs to identify the role that innovation could play in their business plans.
- Help companies (especially SMEs) access existing innovation and entrepreneurship support mechanisms, through the creation of a digital one-stop-shop with up-to-date

information on support instruments (at national, regional and European levels) that may be of their interest. This platform could also facilitate the identification and contact with intermediary agents located in geographical proximity or specialised in their areas of activity. The PI+D+I Network (Red PIDI), an information and advice service for firms interested in R&D and innovation public support programmes, coordinated by the CDTI, contributes to these efforts and could benefit from wider dissemination among companies. Websites set up at regional level or by technology centres also contribute to facilitating SME's access to information.

- Address barriers that currently prevent a wider use of R&D tax incentives by companies, and consider including additional tax deductions for collaborative R&D activities, as is currently the case in the Basque Country.
- Explore the potential of implementing a national innovation challenges programme, building on the best practices implemented by some regional governments and in other countries, particularly during the COVID-19 crisis. Such challenges can be a driver for the creation of knowledge-based start-ups, and can also be a valuable mechanism to promote knowledge transfer and collaboration.
- Progressively increase the use of innovative public procurement, building capacities within the administration to effectively implement such programmes.
- Encourage researchers' mobility and long-term university-business links, for instance by: introducing entrepreneurship education courses at all levels of university education (from undergraduate to doctoral level) and in all academic disciplines (including the "basic" sciences); involving industry professionals in teaching and mentoring activities (as originally pursued with the creation of the figure of Adjunct Professor); increasing the opportunities for students to do internships or research stays in companies during their studies, e.g. to develop their Master's theses or in the framework of dual education programmes.

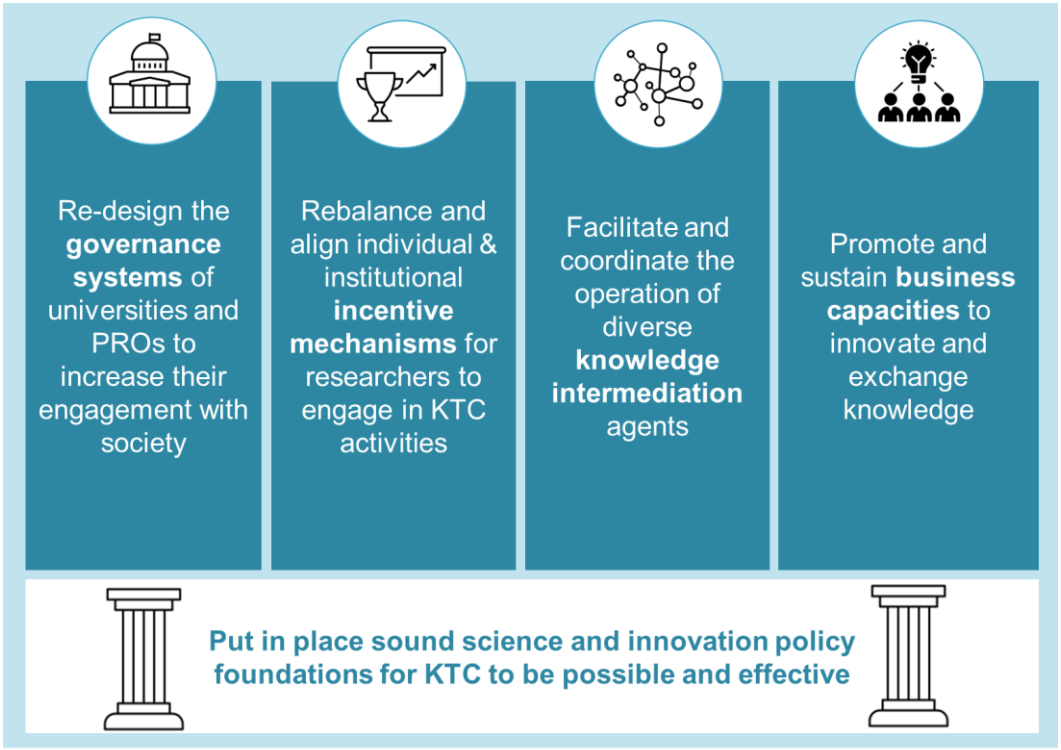
On business innovation support infrastructures:

- Examine the potential of open innovation platforms to accelerate the matching and interaction between different actors, while avoiding a supply-side perspective and the excessive proliferation of non-interoperable and hardly sustainable platforms over time.
- Invest in demonstration facilities open to businesses, following other international examples such as the *Mittelstand 4.0* Competence Centres in Germany. These infrastructures, staffed by highly qualified experts, would allow companies to test new technologies in real-world environments.
- Support the establishment of mixed public-private centres for collaboration and co-creation, with an indefinite vocation, in line with other international examples (e.g. Catapults in the UK, CoLabs in Portugal, Research Campus in Germany). These initiatives should not necessarily involve public investment in newly created centres, but rather the use and upgrade of existing infrastructures, covering also the staff and running costs with the contributions of private funding.
- Leverage existing technology platforms to encourage companies, in collaboration with other actors, to jointly develop technology roadmaps for existing and emerging sectors that can inform future science and innovation support planning.

A call for action

This diagnostic and assessment report concludes with an emphasis on the many opportunities available to Spain's innovation system to achieve a healthier degree of knowledge exchange and collaboration across sectors. While there are significant outstanding challenges, there is a unique combination of conditions that make it possible to rethink, redesign and effectively address aspects of the system that have hindered its performance thus far.

Overview of priority themes for reform to enhance public research-business collaboration



Note: PSR stands for public system of research.
Source: OECD own elaboration

This report does not aim to provide all the answers but to serve as a helpful conduit for public debate, enabling relevant policy actors to make well-informed choices about which way to proceed. The recommendations that have been listed in connection with priority themes touch upon incremental and more radical reforms, and call for greater use of co-creation mechanisms and use of evidence at all phases of the policy cycle.

The experience from several European and OECD countries shows that reforms that enhance the performance of STI systems and their economic and social impact are possible and necessary at times of change. Realising the visions of the *España 2050* strategy requires Spain to make the best possible use of its public and publicly sponsored system of research and technology, and start doing it so through an action plan or roadmap that starts today and draws on the many accomplishments achieved to date.

Improving knowledge transfer and collaboration between science and business in Spain

1. Introduction

Without exceptions, all countries around the world wish for their investment in scientific research institutions to make a more direct and visible contribution to their own economic and societal wellbeing. While retrospective evidence about the global impact of scientific research on prosperity is abundant enough to make a strong general case for investing in science, the channels through which these impacts ultimately materialise are complex and present several challenges to policy makers. Outcomes of scientific research can be highly uncertain, take several years to materialise and the distribution of benefits and costs may be ultimately highly skewed to the point that it may be at times criticised as unfair, especially by those least favoured. So, while it is broadly acknowledged that the global scientific enterprise is founded on the basis of mutual reciprocity among nations around the generation and sharing of global knowledge commons, policy makers continue to strive for a greater degree of "appropriation" of the outputs of scientific research investments for the benefit of their societies. This appropriation can in turn contribute to the overall sustainability of the domestic scientific enterprise and its contribution to the global public good. This question broadens the focus beyond a policy for science towards a wider innovation-system perspective that valorises the role of science and its institutions within it.

Over time, societies have built complex systems to generate new ideas and transform them into new realities, from the goods and services that households can use in their daily lives to the instruments and practices that can be applied in factories or hospitals, for current and future generations. Innovation systems, like "managed" natural ecosystems, are under constant evolution, see different types of actors specialise in multiple tasks and behaviours, all under the watch of governments that intervene in the ecosystem with a toolbox of innovation policy instruments. Endowed with significant public support, scientific institutions have evolved over time to play a central role in the generation of new knowledge and proved particularly effective at that. But in the context of decentralised modern market economies, an innovation system requires the private initiative of businesses, in particular where the logic of the market prevails, e.g. where government does not assume the provision of certain goods and services for the public, being it often it is necessary for both to combine their initiative alongside other members of society. The effective engagement between businesses and the institutions and actors of science is therefore instrumental for the concrete economic and social realisation of impacts that have a foundation in science and its institutions.

It is therefore not surprising that governments in most developed countries, which make sizeable public investments in science, concur in identifying the level of such engagement and varlorisation as insufficient, making it an explicit priority area for the further improvement of their innovation systems. On request from countries, the focus on engagement between public research and business is a recurrent and prominent feature of OECD Innovation Policy Reviews. Most countries believe they could do better on this front, but remain challenged by its complexity in terms of types of actors involved, the breadth of relationships, and the many trade-offs and synergies that need to be considered.

While Spain is no exception to this rule, a large and rapidly growing body of domestic and international reports have coincided in highlighting a number of specific structural weaknesses and imbalances in its innovation system that point to a level of engagement and cooperation between science and business well below its true potential. This situation limits the extent to which the knowledge generated in universities and in public research organisations can contribute to the generation of new economic opportunities and improvements in societal wellbeing. Indeed, on several metrics, Spain lags its peers in terms of innovation and productivity performance. For instance, although Spain ranks among the world's largest contributors to scientific publication output, in broader measures of innovation performance it stands behind many of its closest neighbours, as reflected in indicators such as patenting, innovation rates and persistent low productivity (OECD, 2017[1]). In light of this, several internal and international observers have argued that an increase in the extent and quality of inter-sectoral collaboration and other forms of engagement could and should play a major role in helping reduce this innovation gap. This has therefore become a recurrent feature of EU and OCDE policy recommendations to Spain.[2]

1.1. Rationale for this study and report

The extensive and growing literature around the situation in Spain may suggest that it has been over-diagnosed and that the barriers to knowledge transfer and collaboration between science and business are already sufficiently well understood, potentially calling into question the need for yet another study like this one. Furthermore, the most recent wave of EU policy recommendations[3] and policy strategies in Spain are not short of allusions to the engagement and knowledge transfer challenge, with both ample statements of intent and concrete proposals on this subject becoming particularly abundant over the last decade. This therefore begs the question about the extent to which policy strategies, regulatory intentions, plans and programme announcements have been actually implemented as envisaged and whether they are on course to meet expectations. In a rapidly changing world, benchmarks and expectations are also set to change, hence solutions that might have proved successful in the past may fail to provide a guide to future action.

[2] One early example is the OECD evaluation of Public-Private-Partnership in research in Spain (OECD, 2005). The evaluation recommended a shift from a project-based to programme approach and greater focus on grants versus loans. The review led to decision at the highest level of Government to launch the CENIT framework. CENIT contributed to increasing the role of the Private Sector in funding PPPs but did not succeed in becoming a stable framework for long-term public private co-operation in large-size projects as the programme was discontinued after the global financial crisis for budgetary reasons, while similar programmes that followed since did not attain a comparable scale.

[3] Under the European Semester framework, the European Council regularly reported on Spain's productivity gap and linked it to low levels of cooperation between the public research at large - and the universities very specifically - and the wider economy. Since 2014, the European Council repeatedly recommended Spain to address this issue in order to increase the flow and the impact of knowledge transfer, increase the quality and labour market relevance of higher education and foster research and innovation overall, as stated in the following Council's Country Specific Recommendations (CSR) to Spain: "Increase the labour-market relevance of vocational education and training and of higher education, in particular by enhancing the cooperation with employers" (CSR 2014); "Take further measures to improve the labour market relevance of tertiary education, including by incentivising cooperation between universities, firms and research institutions" (CSR 2016); "Increase labour market relevance of tertiary education" in order to increase public-private cooperation and the mobility of researchers between the public and private sector (CSR 2017); "Increase cooperation between education and businesses with a view to mitigating existing skills mismatches" (CSR 2018); "Increase cooperation between education and businesses with a view to improving the provision of labour market relevant skills and qualifications, in particular for information and communication technologies" (CSR 2019).

This point lies at the heart of the project's aims. The European Union engaged the OECD via its Structural Reform Support Programme to assist the European Commission and Spain's Ministries of Science and Innovation and Universities in reaching a shared and evidence-based understanding of the current state of science – business engagement, identifying key obstacles to effective co-operation and priorities for policy reform, and developing a policy implementation roadmap with concrete, evidence-based and actionable policy measures to enhance collaborative research and innovation, tailored to the Spanish context.[4]

Counter to the over-diagnosis concerns, it is apparent that there are several evidence gaps into the state of science-business engagement in Spain and its ultimate causes and implications. These gaps have profound implications for the practice of strategy definition and policy implementation in a changing world. Through this study, the OECD brings in its own statistical and data analysis expertise to provide an additional international benchmarking perspective to domestic efforts.

A second consideration is that, while Spain is not short of indicators and other forms of evidence, new frameworks may be needed to assess the situation. In this regard, the possibility to compare with other countries is bound to reveal not only better practices that result in greater system effectiveness and efficiency, but also point to better ways to formulate strategic and practical choices to science and innovation policy makers. Furthermore, a study of this kind is also oriented towards enabling the science and innovation policy community in Spain to engage with the broader policy community with a stake on innovation policy, along the lines of the OECD proposed "whole-of-government" approach to innovation policy (OECD, 2010[2]; OECD, 2015[3]). Innovation is an imperative to the whole of government and not only dedicated ministries with the subject on its title. International evaluation can become a powerful driver for policy change, because it provides policy makers with justified and legitimated models of action, based on a systemic view which incorporates the perceptions and needs of all stakeholders involved, including the private sector (Filiatreau, 2007[4]).

This project comes at a time of rapid transformations in the middle of a major pandemic with its associated health and socioeconomic crises. Such crisis presents itself examples where barriers to engagement and collaboration have been overcome following the identification of clear and shared priorities. The EU's Next Generation recovery instrument, devised to help repair the immediate economic and social damage brought about by the coronavirus pandemic and support the green and digital transformation of the EU, represents a major influx of financial resources for Spain (EUR72 billion[5]), offering the potential to unlock a number of investments that strengthen the capabilities and resilience of its innovation system. Such an opportunity after a decade of limited public resources for science and innovation implies a major responsibility to ensure an informed and efficient use of resources so that the initiatives it contributes to articulate are truly sustainable and resilient to future shocks, while supporting the necessary medium-to-long term transformations that have been part of policy agendas for quite some time now.

Connected to the above, this project is also set within a context of several government strategic announcements that are fundamental pillars for policies on science-business engagement. Reforms of the Law of Science, Technology and Innovation and more recently the Law of Universities are in development in parallel, while the proposal of a new Law of Start-Ups has knowledge transfer and collaboration as a key objective. The government has promoted the initiative of a Pact for Science which, while it has secured a rather broad-based

[4] See "Roadmap to foster co-operation between universities, research and business in Spain".

[5] One billion in English, and throughout this report = 1 000 millions.

stakeholder support, it is as of this date still short of securing multi-partisan support across the political spectrum. On February 4th 2021, the Spanish Parliament (Deputies Chamber) approved, with no votes against, a non-binding law exhorting the government to develop a "Roadmap for knowledge transfer" in Spain[6], thus giving a broad based endorsement to the task that the OECD and the European Commission are assisting the government with.

Overall, this study's intention is to instil a more strategic, systematic and effective use of evidence across all phases in the policy cycle connecting strategy, planning and implementation of measures that directly or indirectly impact on the engagement between science and business. For strategies in this domain to be successful, they need to bring an appropriate mix of calculation, opportunism, vision and experimentation.

1.2. About the report's scope and method

The project has broadly confirmed that language defines how the engagement challenge is perceived, communicated, formalised and acted upon by policy makers and stakeholders. This is also reflected in the scope of this project and the terminology used throughout. A major difficulty faced is the widespread use of terms in the Spanish context to refer both to generic and formal categories subject to specific legislative treatment. A case in point among many others is the term "public research organisation", abbreviated as PRO, which should not be confused with Spain's "Organismos Públicos de Investigación (OPI)[7]" depending on the translation, which denotes an important specific type of central government PRO subject to a very unique set of rules compared to other PROs in Spain and abroad, but common to other parts of the public administration. As a result, this report encourages readers to exert particular care in distinguishing allusions to such specific Spanish legal entities, and the broad concepts and categories that are explicitly defined in this document or in other complementary OECD and external literature. As the report will show, this Spanish idiosyncrasy, coupled with the tendency to make ample use of formal registers, has deeper practical implications for the way in which external recommendations are interpreted, the build-up of silos around formal legal categories, how policies are implemented, and the overall state of science-business engagement.

The **concept of science-business engagement** (vinculación) used in this introduction is intentionally broad but needs to be somewhat operationalised to describe the scope of this project and report. Rather succinctly, these are key framing points worth retaining throughout the entire report.

- **Business** refers to entities defining an institutional sector of the economy geared for the provision of goods and services under the logic of the market, charging economically meaningful prices for them. They include established businesses and newly created entities, including those that may not be distinguishable from the individuals (entrepreneurs) who found them before they even have a legal entity. Businesses are not necessarily private entities, since they may also be ultimately controlled by government institutions (public enterprises).
- **Science and research institutions** are defined on the basis of their engagement in R&D and related scientific activities. The OECD, through its Frascati Manual, provides a globally accepted definition of *Research and Experimental Development*, which is complemented by the definitions in the Oslo Manual on innovation. The latter frames R&D as a potential innovation activity but equally highlights that not

[6] Find the press release here

[7] Literally *Public Research Organism* but translated throughout the report as (Central government) Public Research Body (PRB).

all R&D activities result in innovations nor all innovations have a direct basis on R&D (OECD, 2015[5]; OECD/Eurostat, 2018[6]). Both "R" and "D" are knowledge generating activities, and effectively distinguishable from each other by their purpose. Research pursues understanding (basic or applied) of phenomena advancing the state of science, while (experimental) "Development" aims towards the development of products and process that represent advances in the state of the art of technology.[8] The scientific research enterprise is subject to norms that favour the flow of knowledge among peers. Under a logic of producing knowledge public goods, the public sector currently plays a major but not exclusive role in it is funding and implementation.

- **Public and the public sector**. In established and internationally accepted classification systems, the term *public* is used to characterise institutions under the control of government across its differences branches and levels, which conform the public sector. Control is a complex notion that cannot just be characterised in relation to reliance on funds originating from the public sector.[9] It is necessary for an organisation to be considered public that the government has effective mechanisms of control over management and key decisions. This applies for instance to foundations under the control of governments. Despite this specific definition of "public" as applicable to institutions, it is particularly important that references to "public interest" or "public service" should not necessarily be identified with the narrow responsibility or interest of organisations in the public sector. For example, the decision on how best to manage intellectual property generated within the public sector on the basis of public interest should not be necessarily based on revenue maximisation for the public sector organisation. Private organisations driven by the public interest can be recognised as such, e.g. through charitable status or other forms such as social enterprises. For instance, in some countries public interest organisations like the majority of their universities are set up as private organisations independent from the formal control (not regulation) of their national or regional governments and rely significantly on public sources of funding.

- **Knowledge transfer and collaboration**. As the report will show, there is a plethora of mechanisms that enable or embody the flow of knowledge between science and business, from informal exchanges and people moving across jobs to formal contractual agreements between institutions. These flows are bi-directional even though the language often used tends to reductionist, implying a unidirectional transfer of knowledge from the science base to business, as if knowledge, even of scientific and technical nature, only resided in one sector. **We use in this report the terms knowledge transfer (and collaboration), knowledge exchange and engagement rather interchangeably** to refer to purposeful and planned interactions and knowledge flows, reflecting the importance of systematic approaches to these exchanges. Not all such interactions necessarily represent collaborations, a concept that requires a deeper form of engagement on a parity basis in which parties share

[8] In the Spanish context, it is very common to refer to the combined notion I+D+i as encompassing R&D and innovation efforts. This reflects in part EU terminology in the context of State Aid frameworks and other approaches (sometimes R&I is used instead). However, this combination may sometimes generate confusion at different levels. It may imply that R&D and innovation are entirely separate entities and may result in silo approaches to policy. It may also muddle the monitoring of policy targets such as those applicable to R&D if additional innovation investments are included.

[9] For example, an SME that relies on government institutions as main or sole customers is not automatically characterised as part of the public sector.

costs, risks and the proceeds of collaboration, so on many instances we refer to **Knowledge Transfer and Collaboration (KTC)**.

Ultimately, **the project's scope is defined by the interaction space between business and science and R&D institutions, either formally in the public sector or heavily reliant on its support and regulation**. This emphasis on the public science and research base stems from the policy interests outlined in this introduction, namely how to generate social and economic impacts from public investments in creating new knowledge.

The research base directly can influencs the entrepreneurial ecosystem through the establishment of spin-offs and formal technology transfer activities to industrial partners. This is the rather restrictive model of KTC that most people have in mind, often considering as well the inter- or tans-sectoral mobility of researchers. However, it is very important to appreciate the impact of the research base on business and entrepreneurial ecosystems through the role of students, graduates and research support staff, as well as through networks of scientists, enterpreneurs, and even government officials who can spot opportunities for engagement.

This interaction space between publich research and busines involves other public and private actors, providing different types of knowledge intermediation services and infrastructures as well as partnering in multiple fashions in the further development and diffusion of innovations. For instance, interactions between the public research base and other public institutions also entail private-public partnerships, such as those that arise in the context of applied research oriented towards the delivery of new public services in health with the engagement of private business actors.

Options for role specialisation at institutional and individual level offers plenty of opportunities for different engagement ecosystems to flourish, particularly in a quasi-federal country like Spain where policy responsibilities are shared between the national and regional governments.

This report builds on desk research, the analysis of existing indicators, regulatory and policy documents, and insights obtained from nearly 50 in-depth interviews with representatives of some of the main stakeholders in the Spanish science and innovation system, conducted between November 2020 and May 2021. Interviewees included more than 90 representatives from business, universities, public R&D centres, technology and innovation support organisations, intermediary organisations (incl. technology transfer offices, science and technology parks, clusters and incubators), professional bodies and trade unions, national and regional government agencies, as well as individuals with recognised expertise from academia and think tanks.

The report also incorporates lessons from relevant European and international experiences and policy practices, as well as evidence from two surveys conducted by the OECD, targeted at university senior management (HEI Leadership Survey)[10] and the broad scientific and research community in Spain (OECD International Survey of Science, ISSA)[11].

1.3. Structure of this report

The remainder of this report, whose main assessment and recommendations are condensed in a standalone extended summary, is organised as follows:

[10] https://heinnovate.eu/en

[11] http://oe.cd/issa2021hojarutaESP

- Section 2 provides an overview of Spain's science and innovation system from an international perspective. It describes the system's performance and its governance structure.
- Section 3 assesses the current state of science-business knowledge transfer and collaboration, based on the analysis of quantitative indicators, existing literature as well as insights gathered through stakeholder interviews.
- Section 4 analyses the role of the central government in promoting science-business engagement by examining both the governance system, the regulatory framework and policy instruments implemented at the central government level to promote science-business knowledge transfer and collaboration.
- Section 5 explores the diversity of regional STI policy models that is rather unique to the Spanish context and the instruments used to promote science-industry knowledge transfer and collaboration.
- Section 6 draws on the analysis and interview material to assess ongoing policy reforms in the field of knowledge transfer and collaboration and identifies a number of priority areas for further policy action.

2. Spain's science and innovation system from an international perspective

2.1. The economic context

As noted in the latest OECD Economic Survey of Spain (OECD, 2021[7]), until the onset of the COVID-19 pandemic, Spain had been experiencing a robust job-rich recovery, moving progressively towards a more balanced economy with a healthier financial sector and reduced reliance on the construction sector as a driver of growth. The impact of the pandemic crisis has (at least until this point) been more severe than in other European countries, due in part to the sectoral composition of the economy, with a high share of services and tourism-related activities in employment and value-added. Contact restrictions, the lagging use of digital technologies and a high share of small firms and temporary employment contributed to making Spain more vulnerable to the shock. The high share of small firms and temporary employment also made Spain more vulnerable to the shock. Swift and extensive income and liquidity support measures mitigated the economic and social impact of the pandemic. The short-time work schemes and the support to the self-employed limited the impact on unemployment, while public loan guarantees helped prevent a disruption to the supply of credit in contrast to the 2008 global financial crisis (GFC).

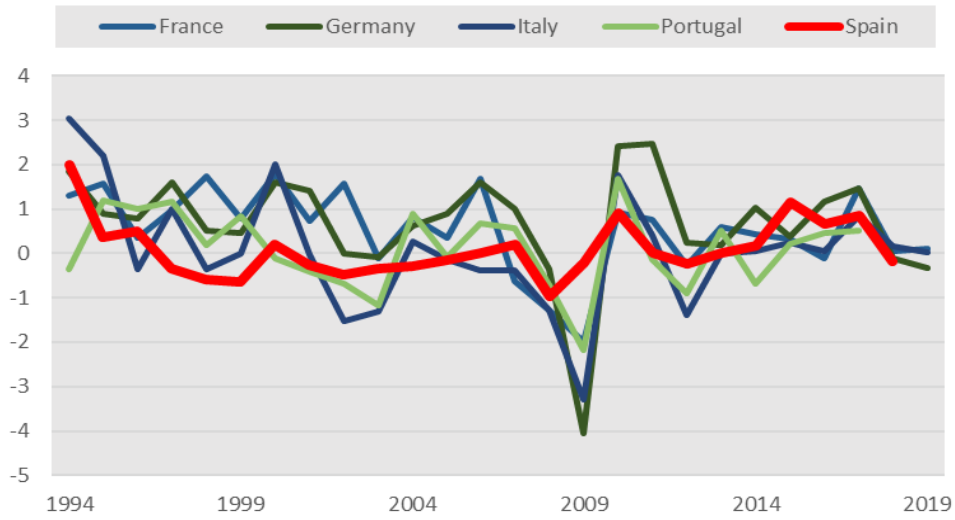
After the steep decline in 2020, GDP growth is projected to be strong in 2021-22 (OECD, 2021[8]). The high vaccination uptake and the lifting of most restrictions have led to a broad-based recovery, with service activity improving since April 2021. Labour market recovery has gained momentum, with social security affiliations exceeding pre-crisis levels in September 2021. Domestic demand is expected to be the main driver of growth as higher confidence, improving labour market conditions, and the Next Generation EU funds boost private consumption and investment. Spain's national Recovery, Transformation and Resilience Plan outlines the envisaged use of EUR 72 billion (5.8% of GDP) of these funds over the next three years (Government of Spain, 2020[9]). The plan has a strong focus on digital and green investment objectives, which should be achieved through ambitious structural reforms to boost productivity, create jobs and improve environmental outcomes. The path towards future fiscal stability relies on long-term productive investments today and learning the lessons from the 2008 GFC, which resulted in a decline in the quality of public spending mix, with public investment as a share of GDP among the lowest in the OECD in 2019, a reflection of the relative ease in cutting investment compared to current spending when facing short-term budgetary pressures. For example, government R&D funding decreased from 0.64% of GDP in 2009 to 0.47% in 2018, severely destabilising Spain's science and innovation system.

Despite being on a steady recovery path from the deep scars left by the 2008 GFC, Spain faced the COVID-19 outbreak without having fully overcome several of the imbalances that unfolded during that crisis (OECD, 2020[10]). A number of structural reforms and favourable global economic conditions helped the Spanish economy recover, but employment rates remained below their pre-crisis levels. GDP growth remained below pre-GFC rates in Spain, in common to many other OECD countries. The slowdown in GDP growth over the period 2010-2017 was driven by the lower contribution of labour input (OECD, 2019[11]).

Labour productivity levels and growth remain weak in Spain. From 2014 to 2018, annualised growth in GDP per hour worked was 0.4%, half the rate of 0.9% in the EU28 and OECD areas. Over the past two decades, Spain recorded one of the lowest (and often negative) rates of multi-factor productivity (MFP) growth among OECD countries (Figure 1). Although MFP growth improved in recent years, outpacing pre-crisis rates, it remains sluggish. There has been a persistently large productivity gap between the best performing global firms and

Spanish firms (OECD, 2018[12]). Spain's poor productivity performance has been linked to the misallocation of capital to low productivity firms and an investment gap in knowledge-based capital (OECD, 2020[10]).

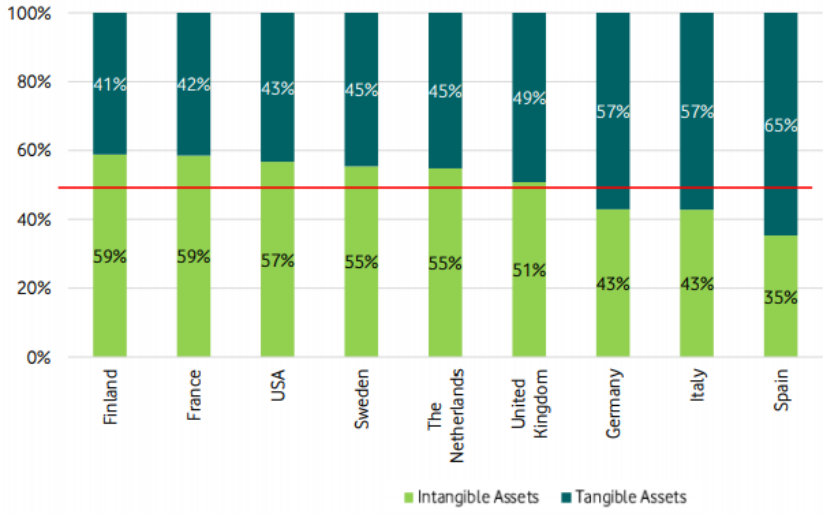
Figure 1. Multi-factor productivity annual growth rates, selected countries, 1994-2019



Source: OECD Productivity Database, February 2021, https://data.oecd.org/lprdty/multifactor-productivity.htm.

Spain has seen net job destruction in industries with above average labour productivity levels over the past decade (OECD, 2019[11]). The economic activities with largest net job creation in absolute terms in Spain between 2010 and 2017 were accommodation and food services, computer and information services, and other personal services. Among these, only computer services have above average productivity and labour compensation per worker. Despite an outstanding convergence process during the last two decades, the profile of private investment in Spain is still more geared towards tangible capital investments than other major economies (Figure 2).

Figure 2. Intangible investment over total investment in the private sector, 2015



Source: Fundación Cotec-Ivie, Fundación BBVA-Ivie (2019) and INTAN-Invest (Corrado et al., 2016[13]). Accessed from https://www.bde.es/f/webbde/INF/MenuHorizontal/SobreElBanco/Conferencias/2019/Sesion_1_Pons.pdf

Spain's business sector is dominated by SMEs. In December 2017, 99.7% of all non-financial corporations in Spain were SMEs, employing 63.8% of the business labour force. Of these, micro-enterprises dominated with a share of 89.8% of all enterprises. Yet small is not synonym with entrepreneurialism and a dynamic business sector. The OECD DynEmp project shows that young firms and new entrants contribute positively to employment creation, however with a lower rate in Spain than among other countries (OECD, 2020[10]).

According to the OECD Entrepreneurship Financing Database, venture capital (made up of the sum of early stage and later stage venture capital- VC) has been experiencing a robust increase in recent years, in particular from 2019 to 2020 when VC funds went from USD 655 to 918 million. Dealroom.co estimate that investment grew even faster in the first half of 2021 and that the combined value of the Spanish startup ecosystem has reached EUR 46 billion, up from EUR 10 billion in 2015. VC funding is however below its potential, since it lies below the EU average at just EUR77, while sources of funding from outside Spain and the EU are relatively underutilised.

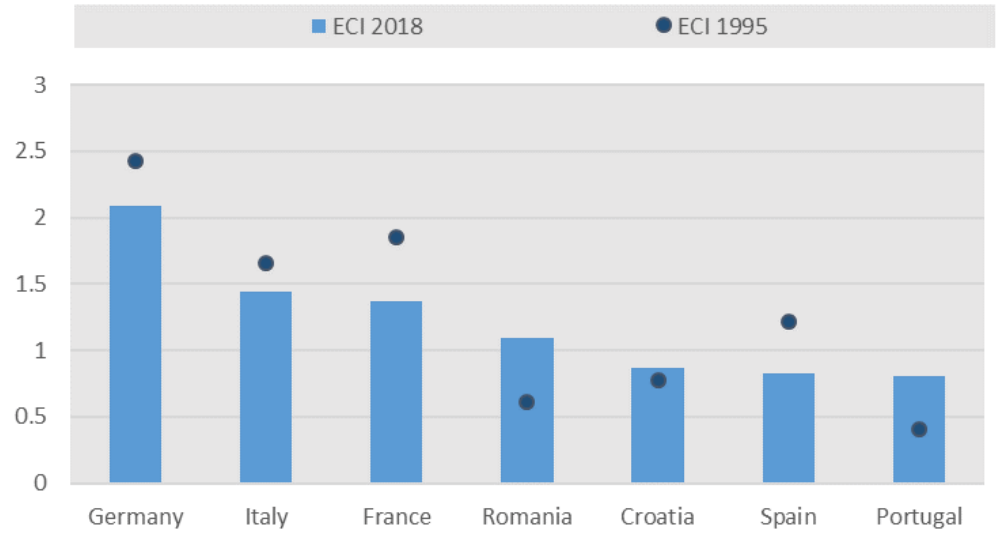
Let us turn our attention to Spain's current economic strengths and weaknesses in an internationally competitive environment by looking at its exports. Based on its export product profile, Spain ranks as the world's 32nd most complex economy in the Economic Complexity Index (ECI). This measure is indicative of the degree of sophistication of an economy's tradeable sector and can be related to the extent of know-how of an economy.

Figure 3 shows that over the past two decades Spain's exports have become less complex, in common to other major European economies which in contrast displayed higher initial levels of complexity. In the meantime, other less developed European economies have developed more complex export portfolios, some surpassing Spain it in recent years, as is the case of Romania and Croatia. The distribution of Spain's exports by type of product in 2018 reveals the importance of tourism and transport exports within services. In addition to its specialisation in a number of traditional industries such as agro-food, footwear and ceramics, Spain does count with significant exports in products associated to knowledge intensive industries, including the automotive, pharma and aerospace industries.

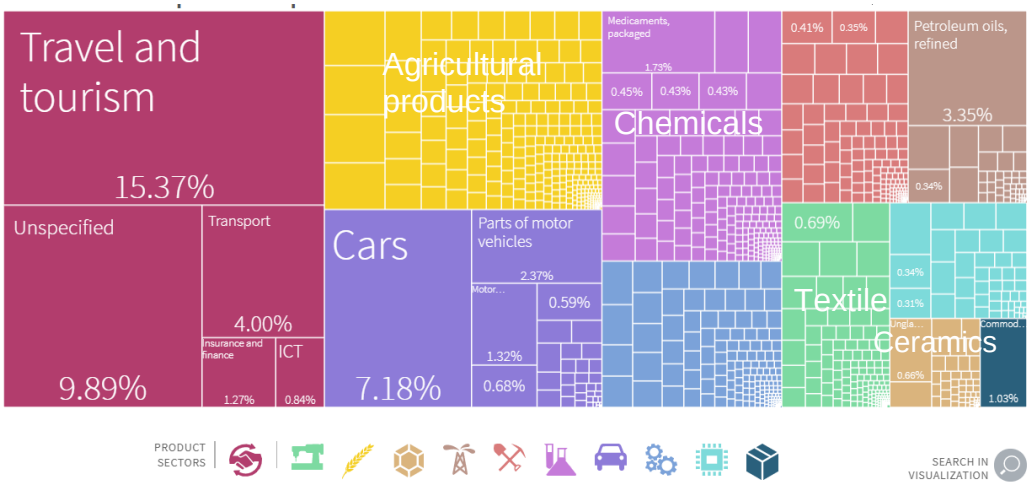
The geographical distribution of these activities is unevenly distributed in Spain's territory. A recent study by the European Commission provides further insight on economic complexity at the level of Spanish provinces (Pérez-Balsalobre, Llano-Verduras and Díaz-Lanchas, 2019[14]). In addition to those hosting some of Spain's major cities (Madrid, Barcelona, Valencia, Zaragoza and Vizcaya), those of Alava, Gipuzkoa, Guadalajara and Pontevedra also appear among Spain's top tier of provinces by complexity.

Figure 3. Economic complexity of Spain's exports

Economic complexity index (ECI)



Distribution of exports



Note: The *Economic complexity index* expresses the diversity and sophistication of the productive capabilities embedded in the exports of goods of each country, based on UN COMTRADE data for goods and IMF data for services. The economic complexity of a country is calculated based on the diversity of exports a country produces and their ubiquity, or the number of the countries able to produce them (and those countries' complexity).
Source: Atlas of Economic Complexity, Complexity Rankings, https://atlas.cid.harvard.edu/

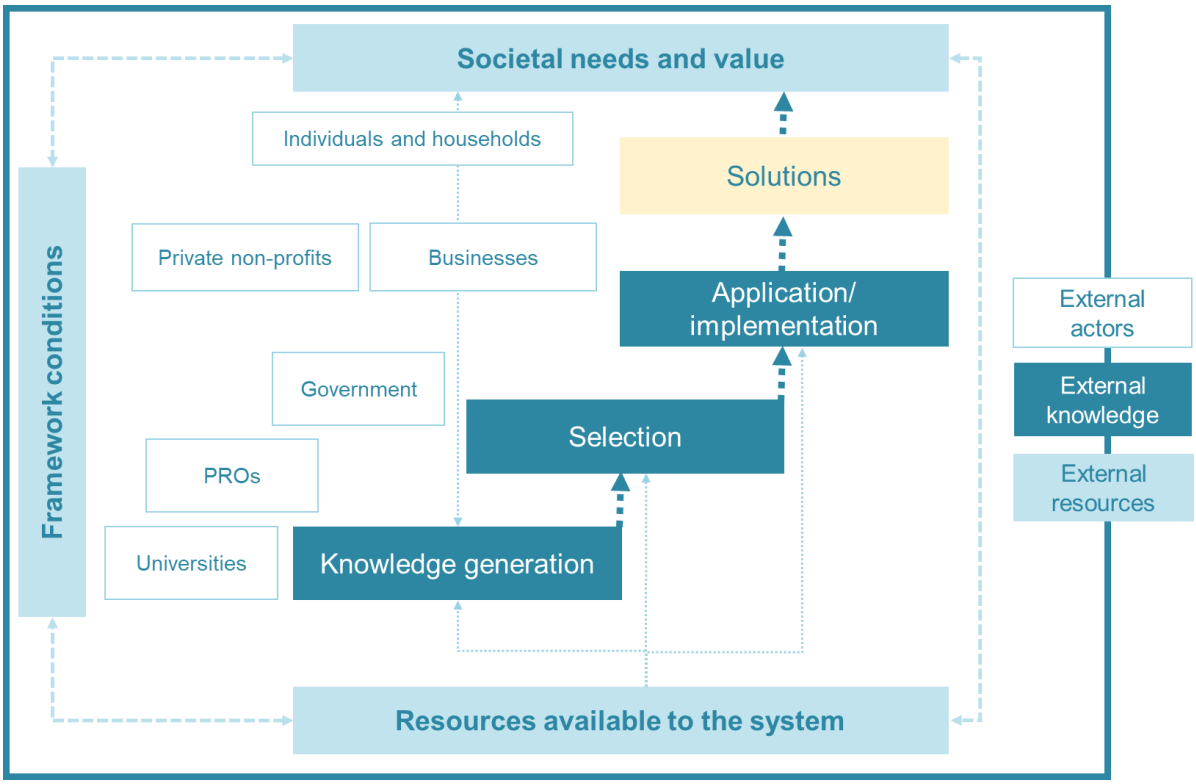
2.2. Features and performance of Spain's innovation system

2.2.1. Features and actors of an innovation system

There are multiple definitions of an innovation system (OECD, 1997[15]). The concept rests on the premise that understanding the functional linkages among the actors involved in innovation is key to improving innovation performance. Innovation and technical progress are the result of a complex set of relationships among actors producing, distributing and applying various kinds of knowledge. The innovative performance of a country depends to a large extent on how these actors relate to each other as elements of a collective system of knowledge creation and use as well as the technologies they use.

Figure 4 presents a stylised representation of an innovation system, highlighting its main functions and actors. A well-functioning system has knowledge generating and application/implementation capacities, joined by selection functions that prioritise the use of resources for the development of ideas so that they can be brought to users in the form of practical solutions that address societal needs and generate value. In a self-sustaining system, the resolution of such needs and the generation of value provides resources with which the system can evolve and transform itself to address new opportunities and challenges, for example, navigate the transition to a greener economy. An innovation system is not a closed one, actors move across different systems, knowledge flows in and out of it, as well as resources. Within a system, different types of actors specialise on a portfolio of functions out of design or as result of previous conditions, but these roles can be subject to change as new institutions can emerge while others can in principle disappear if their purpose has already been served or can be best served by others. The diagram helps depict the positioning of different actors in Spain's system as well as considering on what dimensions the system might appear to be underperforming relative to its potential.

Figure 4. A stylised model of an innovation system



Source: OECD own elaboration

Key features of Spain's innovation system

The principle of specialisation leads to universities and PROs being associated with the generation of new knowledge, while businesses tend to be associated with application, with governments being assigned a mix of resourcing, framework setting and public service delivery functions. This section outlines some key features of the main different types of actors in Spain's innovation system, with Box 1 focusing on the mapping of the Spanish R&D performing actors in the R&D statistics that are frequently used to characterise this important dimension of the innovation system.

Businesses. The core features of Spain's business sector have been described in the previous sub-section, including its economic structure and important role of micro-enterprises and SMEs, with the implications that carries for achieving scale and raising productivity. Businesses engage in virtually all the functions found in an innovation system. Companies in all industries, not only those dedicated to financial intermediation, play a very important role in the process of project selection by raising and directing financial resources towards the development and implementation of ideas to pursue market opportunities. Several companies engage themselves in the generation of state-of-the-art knowledge and applications, but as in many other countries but perhaps in a more pronounced fashion in Spain, businesses in most industries are "letting" the public sector take responsibility for much of the leading edge knowledge generation responsibility, focusing instead in later stages of the technology and commercial readiness spectrum.

The business sector includes membership organisations, sometimes legally set up as foundations, which defend the interest of the business community and provide additional services to it. They also include the Spanish Confederation of Business Associations (CEOE in Spanish) and the Spanish Chamber of Commerce, which include innovation-focused subgroups. Other associations and fora, such as the *Foro Empresas Innovadoras*, have the promotion of innovation among their members and in the broader system as key part of their remit. Associations with a thematic industry focus and businesses among their principal members (e.g. AMETIC, AseBio, FEIQUE, FIAB) are in several instances inclusive of other types of actors, which makes them also major conduits for cross-sectoral knowledge exchanges and science-business engagement.

Private non-profit organisations operate in the private sphere to play a number of important roles in the innovation system pursuing a mix of private and public interests, such as the promotion of a culture of innovation and influence policy. For instance, Cotec foundation seeks to highlight the role of innovation in society and counts with the King of Spain as Honorary president, with its annual reports on the state of innovation in Spain a mainstay of the debate. NPOs raise funds from individuals and business for philanthropic purposes where science and innovation are either a goal or a step towards another major goal. While in the case of Spain they are not particularly active as R&D performers as such, several foundations with strong links to companies are extremely influential in promoting R&D careers and the scientific system in general (for example, March, La Caixa, Botín-Universia (Banco Santander), Rafel del Pino, Ramón Areces, Barrié, and Amancio Ortega to cite some of the best known) (Rey-García and Álvarez-González, 2015[16]).

Government sector. In line with several other OECD advanced economies, the general government sector[12] in Spain in all levels of government (central, state, local and social security funds) accounted for somewhat more than 20% of the Spanish economy's total wage bill, while it represented more than 15% of the total employees in the economy, slightly above Italy and Portugal. The general government sector in Spain has considerable responsibilities for developing and implementing new solutions for societal needs in the domain of collective and other public services such as health, education and defence, thus also raising the importance of its adoption of innovative processes and engaging other actors to support that objective. Subsection 2.3 below discusses in more detail the role of government institutions

[12] The term Government as used here and in international classification guidelines is typically translated into Spanish as "Administraciones Públicas" although this sector sometimes encompasses more than public administration functions, e.g. defence, while the Spanish term "Gobierno" refers to the executive branch of the Government sector. To avoid confusion, this report's English version refers to the Government sector as an institutional sector in the STI system to avoid confusion with the executive branch.

in the innovation system. Section 4 of this report deals in more detail with public policies for knowledge transfer and collaboration.

Universities comprise their departments and institutes of public universities, as well as those of private universities. The mission of universities is a complex one, as it combines teaching and research as defining features, in addition to what is commonly and loosely defined as their third mission, as a catch all for non-core forms of economic and societal engagement. In Spain, the Conference of Rectors of Spanish Universities (CRUE) represents an ensemble of 50 public and 26 private universities. Some of these universities also belong to other associations that represent and coordinate the universities of particular regions.

Public research (and development) organisations (PROs) have no commonly defined global definition but two key defining features help identify them, namely the requirements to be 1) engaged in research and development (R&D), or closely related scientific, technical and innovation activities, either as a primary purpose or secondary activity; 2) being formally part of the public (government-controlled) sector, or have some other strong ties with the public sector, particularly in terms of financing dependence (OECD/Eurostat, 2018[6]). In Spain, it is possible to identify the following:

- **Central government's public research organisations**, directly overseen by the central government administration under different regimes. There are at present 5 PROs with the category of Public Research Bodies (PRBs, OPIs in Spanish) that are governed by the 2011 STI Law[13]. These include the Spanish National Research Council (CSIC in Spanish), the State Agency for the performance of scientific R&D and Spain's largest PRO. CSIC is principally an R&D performing and coordinating body, comprising 120 specialised and transdisciplinary centres, and almost 50% being joint centers with universities and other institutions. The Carlos III Health Institute (ISCIII) is also included in this category, as a performing and funding research institution specialised in health. In addition, the central government sector includes a number of more recently created specialised PROs, such as CNIC and CNIO, legally constituted as public foundations under the Ministry of Science and Innovation and benefiting from greater operational flexibility.
- **Research organisations and centres under the responsibility of the autonomous regions** with a primary focus on research activity. Examples include BERC and CICs (Basque Country), CERCA (Catalonia) and IMDEA (Madrid). This type of PROs has been the subject of considerable organisational innovation in recent years, with different institutional set ups equipped with greater degree of flexibility than the majority of central government PROs.

Technology Centres (CTs) and **Technological Innovation Support Centres** (CAITs), connected to the central or regional administrations, are principally oriented towards business in their R&D and broader STI activities. Their precise orientation and institutional set up varies across Spanish regions. In many cases, these are formally outside the public sector, fully set up as private organisations, often as foundations. As a result, they are in most cases not PROs in the strict definition of the term even if their reliance on public funding can be significant in some cases. Tecnalia, originating in the Basque country, is Spain's largest Technology Centre, which as a result of its business serving orientation is classified as part

[13] The full list of OPIs is as follows: Spanish National Research Council (CSIC), the National Centre for Energy, Environment & Technological Research (CIEMAT), the National Institute for Aerospace Technology (INTA), the National Health Institute Carlos III (ISCIII), which is also a financing agency, and the Astrophysics Institute of Canarias (IAC). In early 2021, CSIC absorbed three pre-existing OPIs, namely the Spanish Institute of Oceanography (IEO), the National Institute of Agrarian and Agro-Food Technology (INIA), and the Spanish Geological and Mining Institute (IGME).

of the business sector. Eurecat in Catalonia is another example. FEDIT is the national association of regional technology centers to which most of them are associated with.

Public hospitals and clinics also represent an important category of PROs in Spain, combining health as primary mission with educational, research and knowledge transfer/engagement objectives and operations. These are also under the responsibility of regional governments. ISCIII funds and coordinates the networked public research consortium of biomedical research (CIBER).

Public system of research and innovation, abbreviated as PSR, is used to denote the broad range of public service institutions with research and innovation responsibilities, comprising not only public universities and government controlled institutes, centres and medical clinics, but also private universities and R&D, innovation and technology institutes subject to a significant degree of governmental influence, budgetary or regulatory, with regards to their status and knowledge generating activities[14]. This "system", in addition to the actors that can be considered part of it, can also include the governmental actors, institutions and norms that help govern it.

Individuals and households, although rarely in charge of systematic knowledge generation activities such as R&D, serve several vital functions in an innovation system, not only as users of the goods and services provided by firms, often demanding and experimenting with new solutions public authorities and universities, but also as providers of human and financial resources. Workers in the innovation system organise themselves in **trade unions** with different forms of professional body or political orientation (the major horizontal trade unions are typically structured or federated by industry/sector), and in the form of **professional associations**, such as scientific societies (COSCE, AEAC), student bodies and the association of technology transfer professionals (RedTransfer).

Box 1. R&D performing actors in Spain's R&D sectoral statistics

Common international classifications such as those that guide the production and dissemination of R&D statistics help facilitate comparisons on the basis of established and widely accepted taxonomies. R&D performers within any given country are classified in the OECD *Frascati Manual* into four main groups, taking into account as main differentiating attributes whether they i) provide higher education services, ii) are controlled by government and iii) operate in the marketplace on a for-profit-like basis. However, in order to fully understand what specifically falls under each of the four main groups which are inspired by the overarching IMF-OECD-UN *System of National Accounts*, each country presents idiosyncratic figures that are not only subject to change, but also need to be outlined, making it helpful to relate specific national legal forms to the way in which these are accounted for in the statistics and broader policy discussions. For instance, the legal form of a *foundation* in Spain and its different regions can apply to entities that might be classified into any of the sectors below:

Higher education

Universities are the main actors in Spain's Higher education (HE) sector. They comprise the departments and institutes of public universities, as well as private universities with demonstrated R&D capacity. There are 83 listed universities in Spain in 2019/20, 50 of

[14] A map of institutions that are part of the Spanish system of research and innovation is available at https://www.ciencia.gob.es/site-web/Estrategias-y-Planes/Sistema-de-Informacion-sobre-Ciencia--Tecnologia-e-Innovacion--SICTI-/Datos-globales-del-sistema/Red-Espanola-de-Centros-de-I-D-I--RECIDI-.html.

which are public, which account for most of the sector's R&D. Underneath, a total of nearly 2200 units described as internal or affiliated centres (such as faculties, schools, departments), research institutes, doctorate schools, hospitals, foundations and others are registered as university degree providers.

In Spain's decentralised political system and subsidised tuition fees, Spanish public universities depend on the autonomous regions (*Comunidades Autónomas*) as main providers of institutional financing. General university funds (GUF) cover the large part of the academic and support HE workforce, providing an implicit support to their R&D activity. In Spain's R&D statistics, the R&D part of GUF is calculated by the universities themselves and reported to the National Statistical Institute (INE), while previously it was estimated as the difference between total expenditure and other identifiable funding sources of HE funding. The R&D activities of several university hospitals are reported under this sector.

Government

This sector comprises agencies in the central, regional and local government sector. The central government comprises a number of formally-defined Public Research Bodies (OPIs) as well as other specialised research bodies. A number of research centres under the responsibility of the regional governments are also major actors in the R&D performing landscape, often operating under relatively more flexible legal forms such as foundations. In Spain's R&D statistics, OPIs, other PROs outside the HE sector and technology centres administered by government and the majority of hospitals have been classified in the government sector because they are government institutions controlled and funded by government at its different territorial levels.

Businesses

This sector covers all companies charging economic significantly prices for their good and services, both public and private, regardless of their main economic activity. It also includes commercial enterprises, enterprises in which the government has shareholdings and co-operative research and technology organisations set up as companies. R&D, technology and innovation support centres in Spain follow a large diversity of models, in line with the diversity in regional contexts and regional strategies that may provide a significant funding component but without the ability to control their overall activity. For instance, *Tecnalia*, initiated in the Basque Country, and the *Corporación Tecnológica de Andalucía (CTA),* are formally set up as private foundations, a status that allows for them to be classified as part of the business sector as they are deemed to serve primarily business interests. It is important to recall this point when considering estimates of Business Enterprise R&D, which include this type of organisations in line with recommended international guidance.

Private non-profit institutions

This sector comprises non-profit institutions that are independent from government and whose purpose is not to serve the R&D and technology needs of companies, as otherwise they are classified as part of the business sector. In terms of R&D performance, this sector is relatively small but several Spanish private foundations make substantive contributions to the country's R&D effort as funders.

Boundary cases: hospitals and clinics

The majority of hospitals in Spain are public and formally dependent on public authorities and for the purpose of R&D statistical reporting, they are included in the

Government sector. Like universities, public hospitals also rely principally on regional governments for the best part of institutional financing and are subject to rules at that level of government. However, as noted, several university hospitals are included in the higher education sector. Private for profit hospitals are included in the business sector.

Source: OECD, based on multiple sources, such as Sistema Integrado de Información Universitaria (SIIU). SG Universidades, https://www.educacionyfp.gob.es/servicios-al-ciudadano/estadisticas.html, and OECD R&D statistics Sources and Methods, https://rdmetadata.oecd.org/

Linkages and intermediation

The specialisation patterns outlined in complex systems can only work if there is an appropriate linkage and engagement network. As this report will later discuss, it is particularly important to consider the role of knowledge intermediaries that represent some form of "infrastructure". Technology centres, clusters, incubators, science and technology parks, and specialised providers of professional services around law, finance and IPR, all represent examples of organisations that, under different settings and legal arrangements, help connect different actors and functions in the innovation system. The health of such a system will often depend on whether it generates enough demand to support a critical mass of such intermediaries that can operate without entirely relying on governmental support. Also within organisations without such specific remit, small teams and individuals will be relied upon to adopt intermediary roles that help connect supply and demand for different types of knowledge and coordinate decisions around them. The role of these intermediaries in Spain will be analysed in sections 3 and 6 of this report.

The rest of the world

Spain's STI system is highly internationalised and open to exchanges with the rest of the world. Actors outside Spain play an important part in the national innovation system. Membership of the European Union shapes the regulatory framework, particularly in domains under EU level responsibility. As indicated by R&D and other statistics, the European Union has become a major contributor to R&D activity in Spain, acting for several years to counteract a rapidly declining domestic funding, with institutions based in Spain increasingly relying on EU funds. In Spain, the share of EU funding for R&D and innovation conducted by universities, PROs and even business is above what other indicators might lead to expect. The allocation of EU funding, oriented towards collaborations, excellence criteria or regional development has favoured some Spain-based institutions more than others. For instance, European Research Council funding has been highly concentrated in more prestigious research institutions which are also endowed with greater flexiblity to attract talent from abroad and engage in collaborations. Overall, participation in international programmes (e.g. CERN, ESA) and EU funding for individuals and R&D and innovation projects are major factors shaping university and PRO activity as well as opportunities for engagement with businesses.

Multinationals also play an important part in Spain's innovation system. Over one-quarter (27% in 2014) of economic activity (GDP) in Spain depends on foreign markets, around the same as in the United Kingdom and Italy. Spain's inward investment (equivalent to 43% of GDP in 2015) was slightly larger than outward investment (39% of GDP in 2015). Foreign controlled affiliates are also responsible for a considerable share of business R&D expenditure (nearly 40% of BERD in 2015) (OECD, 2017[17]). Under a broader notion of international orientation that captures the impact on national income of exports and sales through foreign affiliates, Spain's international orientation was equivalent to 28% of GDP in

2014 (OECD, 2017[18]). Close to 40% of the external R&D purchases by Spanish firms are directed to units based abroad, of which three quarters correspond to affiliated companies.

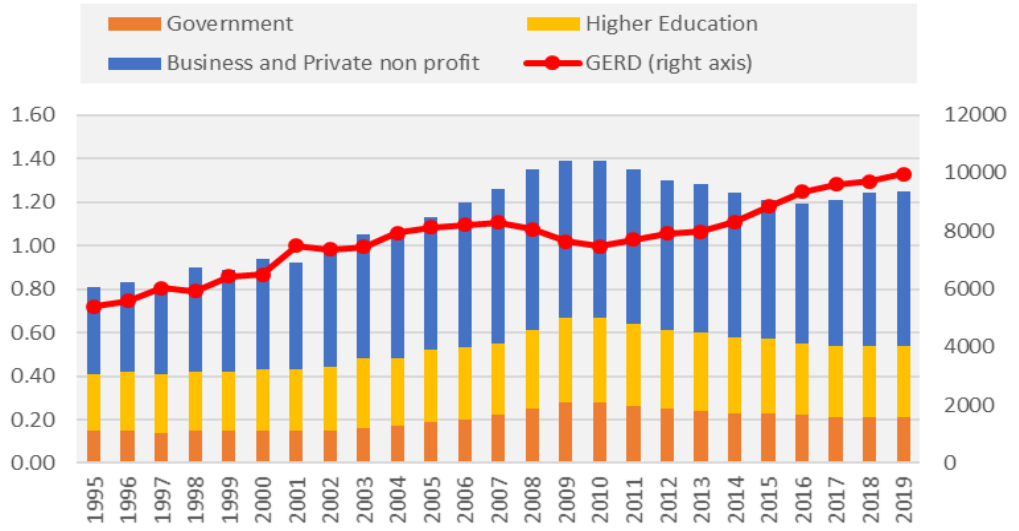
In the innovation system, outward internationalisation understood as the opening of branches abroad is not the sole prerogative of corporations but examples are rare in the case of Spain. Despite strong cultural and linguistic links with several countries, Spanish universities are relative latecomers to the opening of campuses abroad, with only private business schools having apparently taken such initiative thus far. With respect to private technology centres serving the collective business community, the OECD study team has only become aware of a single entity pursuing an internationalisation strategy.

2.2.2. R&D trends and structure: irregular and unbalanced

The level of R&D expenditure in Spain in 2019 stood at 1.25% of GDP, below the OECD and EU average (Figure 5). While this represented a noticeable increase with respect to 20 years before, when R&D intensity stood at only 0.8% of GDP, over that period several other countries have been orienting their economy much faster towards higher levels of investment in R&D. For example, within the EU, Portugal more than doubled its R&D intensity from 0.7% in 1999 to 1.4% in 2019, while Germany went from 2.3% to 3.2%, while Israel and Korea became the world's most R&D intensive economies.

Figure 5. R&D expenditure trends in Spain

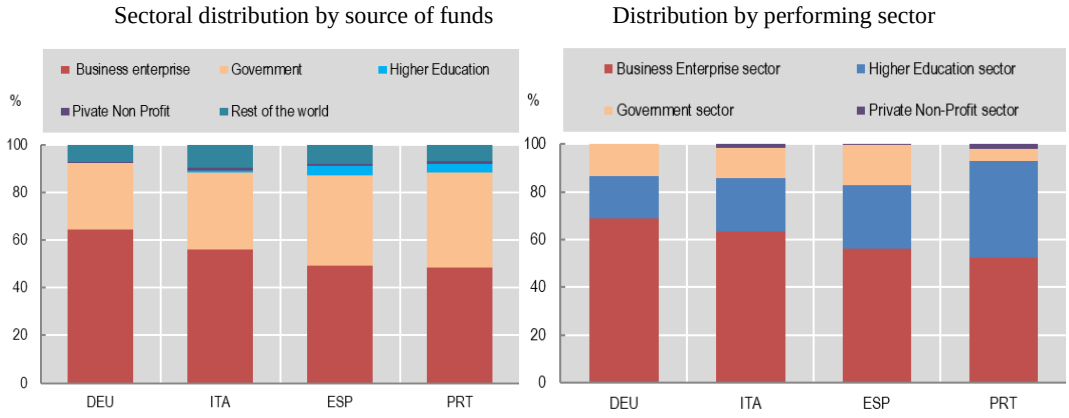
R&D intensity by sector and total Gross domestic expenditure on R&D



Note: R&D intensity as percentage of R&D, and total GERD expressed in million EUR.
Source: INE R&D Statistics. February 2021,
www.ine.es/jaxi/Datos.htm?path=/t14/p057/a2019/l0/&file=01002.px#!tabs-tabla

Compared to other countries with higher overall levels of R&D expenditure, businesses have a relative smaller role (see Box 1 for an explanation of sectoral boundaries in the case of Spain for R&D statistics) in terms of R&D performance and funding (Figure 6). In 2019, the domestic business sector was directly responsible for funding almost 50% of R&D expenditure in Spain, a slight net increase from the mid-1990s when it stood at 45%, but an even more significant increase from the trough in 2010 when it only stood at 42%. This erratic behaviour stands in contrast with more sustained increase in Portugal and Italy.

Figure 6. Structure of R&D expenditure in Spain by source of funds and performing sector, 2019

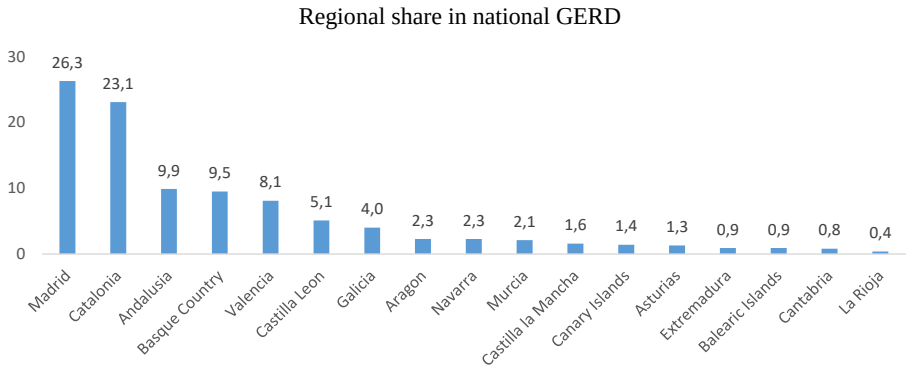


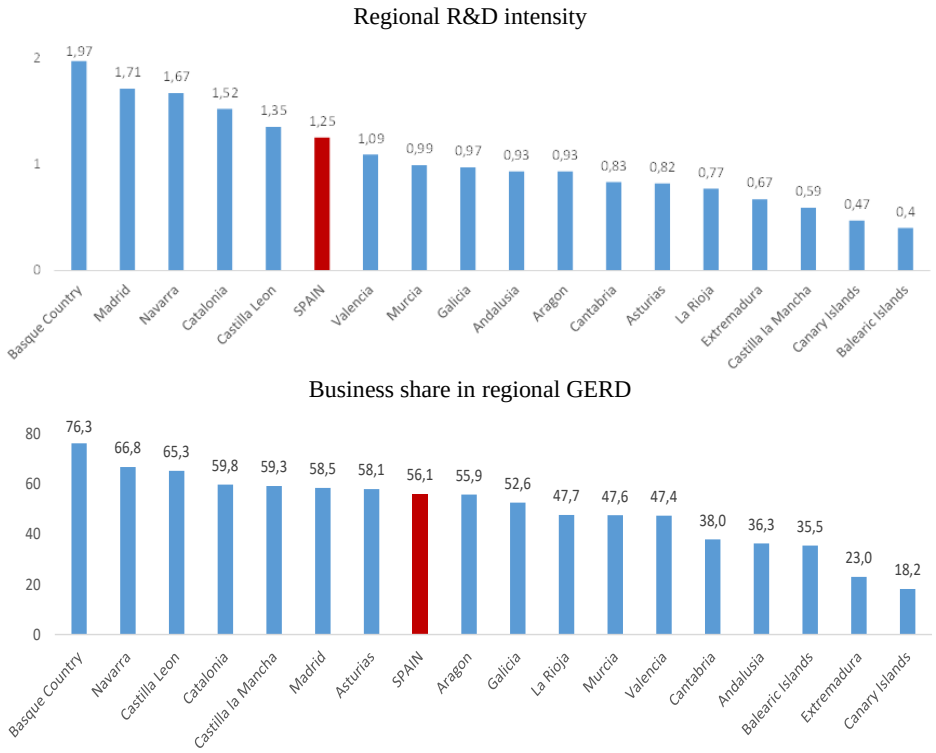
Source: OECD R&D Statistics. July 2021, http://oe.cd/rds

In recent years, the business sector has become the main R&D performing sector in Spain, but the speed at which this has happened has lagged that of the best performing ones. The business sector has been the main driver of R&D growth across the OECD area after the GFC shock, increasing the overall share of experimental development in total R&D since most experimental development is concentrated in the business sector. Spain's business sector reports very little basic research. International sources of funding play a noticeable role, but these appear to be principally driven by EU funds and relatively less so than by businesses based abroad.

There are significant disparities in the R&D orientation of Spanish regions. Like in other European countries, there is a large regional concentration of R&D expenditure. In particular, as shown in Figure 7, Madrid and Catalonia account for close to 50% of all R&D expenditure in Spain, while just 5 regions out of 17 make up for 77%. With regard to the R&D intensity indicator, a large heterogeneity can be observed, ranging from almost 2% in the Basque Country to under 0.5% in the Balearic and Canary Islands. There are also marked differences in the contribution of business to R&D efforts in regions, as the business orientation is particularly marked in the Basque Country, followed by Navarra and Castilla-León.

Figure 7. The regional R&D landscape in 2019 – concentration and heterogeneity





Source: INE R&D Statistics 2019, Results by autonomous regions.
https://ine.es/jaxi/Tabla.htm?path=/t14/p057/a2017/l0/&file=02006.px&L=0

2.2.3. Science and the public system of research: strengths and room for improvement

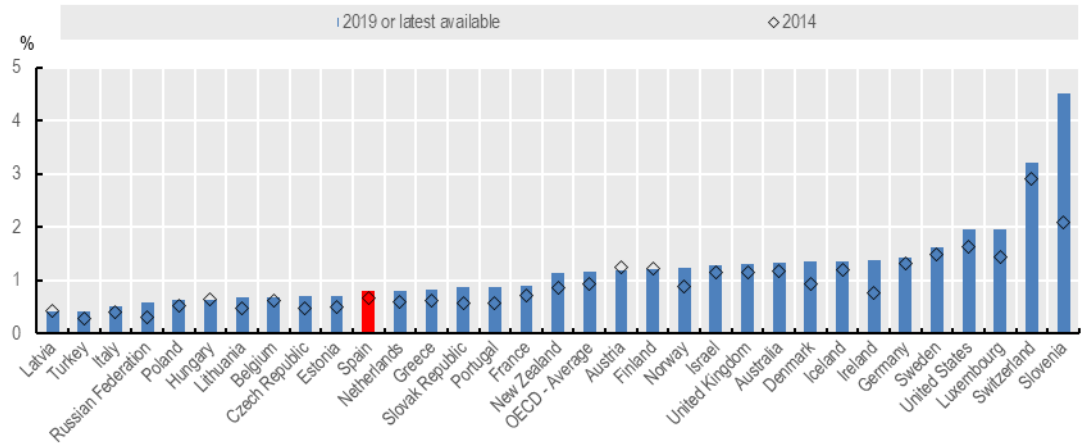
Advanced qualifications

Spain's science system evolved in recent decades from a lagging position in the early 1980s to become a sophisticated and mature system as evidenced by its scientific publication footprint and areas of excellence. The expansion of Spain's university system at all levels contributed to lifting tertiary graduation figures and eventually resulted in fast growing numbers of new doctorate students and graduates. Student enrolment in doctorate or equivalent programmes has exploded since 2013, from 25 000 to nearly 75 000 individuals, surpassing France but still at a distance from Germany with 200 000 and the United Kingdom with over 110 000. Compared to these countries, Spain's doctorate enrolment profile is highly oriented towards Medicine, the Social Sciences and the Humanities, as only 31% of enrolment is in the fields of Natural Sciences and Mathematics, ICT and Engineering (NSE). At a doctorate level, this is a relatively low share of enrolment in NSE subjects compared to its European peers. The number of new doctorate graduates in Spain went from 1.6 per 1000 population aged 25-64 in 2010 to 3.66 per 1000 in 2017, but this rapid surge appears to be principally explained by a policy reform in 2016 requiring long registered doctoral students to submit their theses and complete their degrees. If one discounts the several thousands of students that were prompted by this measure and takes the steady state path of graduations as reference, Spain is close to 2 graduates per 1000 people in the indicated age group, effectively moving in line with the EU average.

This growth in the number of doctoral students and graduates is still to be noticed in the overall working age population, as the share of doctorate holders is below the OECD average (Figure 8). An intervening factor is the mobility of highly qualified individuals to other countries in search for better conditions to pursue their careers. Labour force statistics

struggle with current sample sizes and methods to provide a precise estimate that help describe their carriers and background, but it is possible to note from the data submitted to the OECD as part of its 2017 Careers of Doctorate Holders exercise, that Higher education and Health services are the main activity of employment for doctorate holders, indicating low absorptive capacity within manufacturing and other business services.

Figure 8. Doctorate-level attainment in the working age population, 2019



Note: 25-64 years, 2014 and 2019 or latest year available. It includes Short-cycle tertiary education (L5) for Switzerland 2014-2019. 2019 data for Russian Federation correspond to 2018 value.
Source: OECD (2020), "Education at a glance: Educational attainment and labour-force status", OECD Education Statistics (database), https://doi.org/10.1787/889e8641-en (accessed on 22 September 2020).

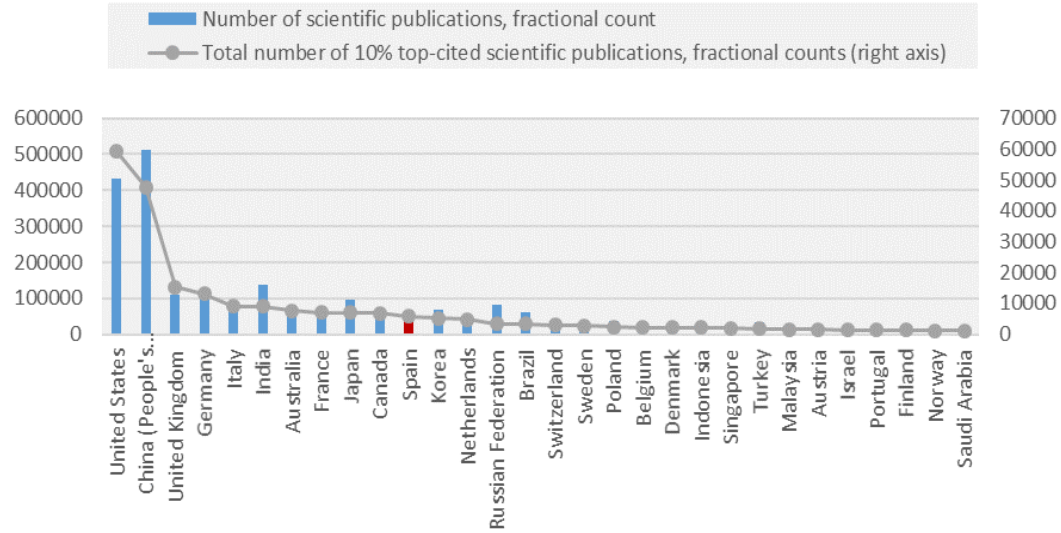
Spain does not appear to be an attractive destination for internationally mobile researchers. Relatively few doctorate holders resident in Spain have been born abroad. In 2016, about 10% were in that category, compared to 33% in Belgium, 30% in the United States, 22% in the United Kingdom and 17% in Germany. The fraction of international students among PhD students has oscillated between 15 and 18%, a level higher than Italy, possibly reflecting the appeal of Spanish as instructional language to Latin-American students, but well below that of France and the Netherlands at close to 40%.

Scientific production

Despite its many limitations (OECD and SCImago Research Group (CSIC), 2016[19]), indicators of scientific publication output provide an accessible measure of scientific performance at the level of STI systems. In the latest OECD bibliometric statistics based on Scopus indexed data, Spain was the world's 11th largest producer of highly-cited scientific publications in 2018 (Figure 9), notwithstanding the protracted negative impact of the crisis on public R&D funding[15].

[15] Following the crisis, annual government budgets for R&D in Spain, combining central and regional governments, dropped by over 30% compared to OECD and EU aggregate governmental R&D budgets. As of 2019, this gap still persisted despite moderate budget increases in the latest years.

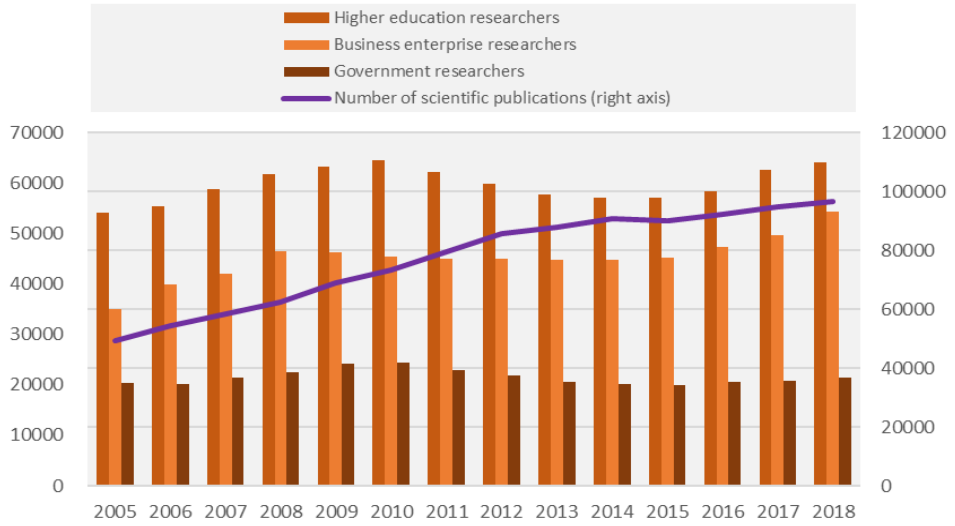
Figure 9. Economies with most 10% top-cited publications vs total number of publications, 2018



Source: OECD Bibliometric indicators. Accessed from OECD STI.Scoreboard. February 2021. http://www.oecd.org/sti/scoreboard.htm

The financial crisis of 2008 led among other things to Spain transitioning from being a magnet for publishing scientists coming from abroad to becoming a net donor. In 2018, it is estimated that close to 760 authors previously based in Spain reported being affiliated to an institution abroad. The shortage of domestic funds also enticed Spanish researchers to become increasingly active and effective in applying for EU funds. The number of scientific publications continued to increase although at a lower rate since 2012, revealing a significant degree of inertia and stronger incentives to publish for promotions, recruitment and salary complements, in addition to the increasing dependence of Spanish researchers on international sources of funding and networks.

Figure 10. Scientific publications and researchers in Spain, 2005-18

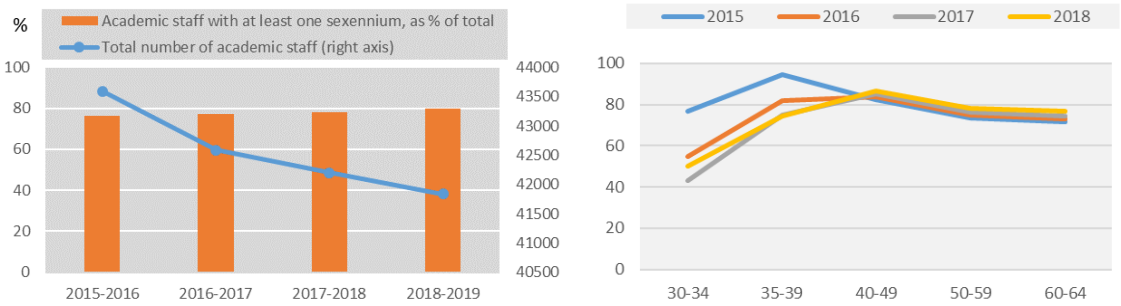


Note: Fractionalised counts of scientific publications and Full time equivalents for researchers.
Source: OECD Main Science and Technology Indicators and OECD Bibliometric Indicators, accessed from OECD STI.Scoreboard. February 2021.

Spain's scientific performance is, in terms of quality as proxied by normalised citations, broadly comparable with the entire world's scientific production, as close to 10% of documents published by scientific authors based in Spain fare among the 10% most cited documents within their field. Evidence from the research "sexennium" incentive system that accredits some form of research accomplishment in the previous six years indicates that one in five academic staff do not demonstrate having attained such standard of research merit (Figure 11). There are major differences by area, from 90% of staff attaining at least one merit in the Natural sciences, to only over 70% in the areas of Social Sciences and in Engineering and Architecture. Attainment is higher for mid-career academics, which appears to be explained by relatively lower research expectations among older generations during their early careers as well as difficulties for the younger cohorts to attain the standard as the start of the formal academic career gets increasingly delayed and they are less likely to have a "permanent" status that makes them eligible to apply for it (Ordovás et al., 2021[20]).

Figure 11. Attainment of research merits among academic teaching staff

Percentage of academic teaching staff with at least one "research *sexennium"*, by year and age group (right figure)

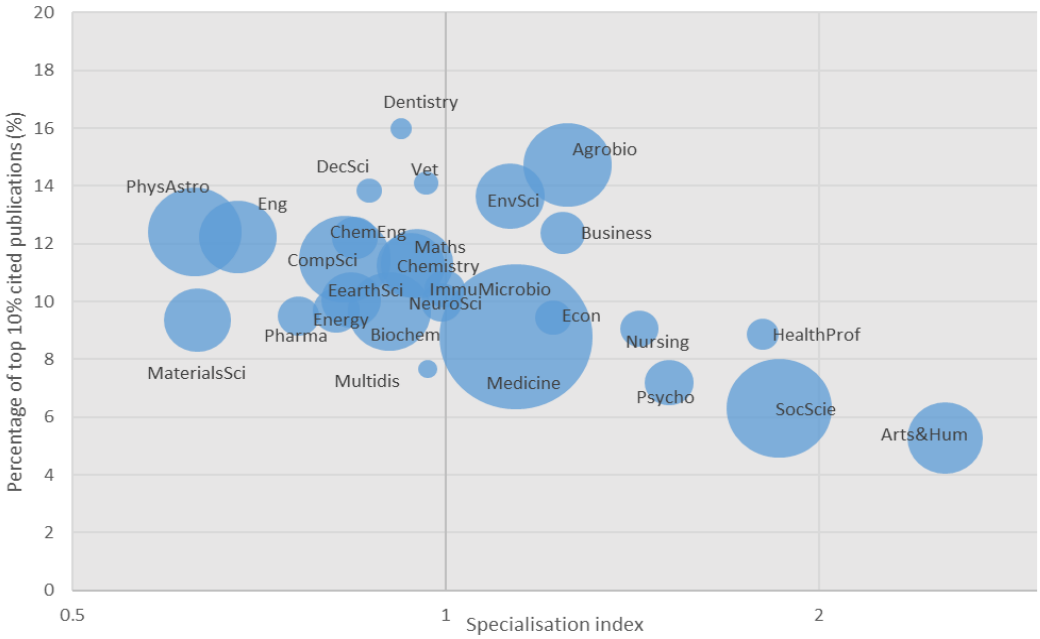


Source: OECD Analysis of data from Sistema Integrado de Información Universitaria (SIIU). Ministerio de Universidades. Indicadores de personal docente e investigador (PDI): Sexenios del cuerpo docente universitario. Accessed from http://estadisticas.mecd.gob.es/EducaDynPx/educabase/index.htm?type=pcaxis&path=/Universitaria/Personal/EPU19/Sexenios&file=pcaxis&l=s0

All this indicates that there is still considerable room for improvement for the system on a pure "scientific excellence" basis. This report highlights that measures conducive to greater scientific excellence should not be necessarily at odds with the policy objective of realising greater direct economic and social impacts from scientific research. This is already appreciable in Spain's patterns of specialisation and excellence by research domains. The degree of specialisation in scientific production appears to be negatively correlated with its degree of citation-implied excellence, as shown in Figure 12. Exceptions can be found in areas such as agricultural and biological science, environmental science and business where specialisation is high and scientific excellence is well above the world's average. Spain attains high rates of scientific excellence in physics, engineering, chemical engineering, computer science, maths and chemistry, but specialisation in those fields is relatively small. In medicine, social sciences, arts and humanities the opposite is the case.

Figure 12. Patterns of scientific excellence and specialisation in Spain, 2018

Top cited publications, specialisation index and publication volumes of Spain-affiliated scientific authors, by field



Note: Bubble sizes represent the volume of scientific production. The reference benchmarks for specialisation and top cited publications (world levels) are 1 and 10% respectively. Specialisation is presented on a log scale and is defined as the ratio of Spain's share of scientific output for a given field, relative to the world's share for that field. A value greater than 1 implies a higher degree of specialisation for Spain in that field, compared to the global norm.
Source: OECD Bibliometric indicators. http://dotstat.oecd.org/Index.aspx?DataSetCode=BIBLIO#

2.2.4. The innovation gap

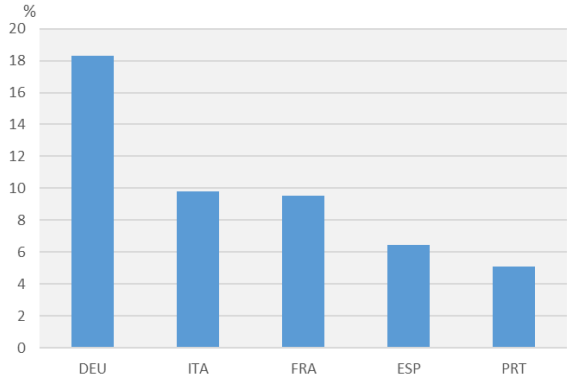
Spain's innovation gap has been documented along a wide number of indicators, including business R&D funding and performance levels, patenting and reported innovation activity. What follows is a brief overview of the main patterns.

Business engagement in R&D

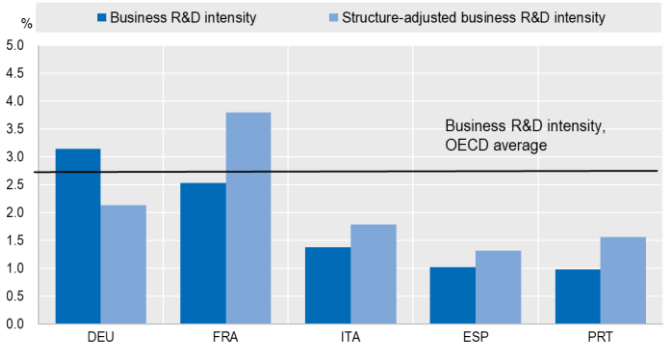
As noted at the outset of this document, investing in R&D is neither a necessary nor sufficient condition for innovation to occur. However, the behaviour of business R&D in Spain is quite illustrative of some of the challenges experienced by the STI system. It has been argued that Spain's economic structure is partly responsible for the limited engagement of business in R&D. Indeed, Spain's share of gross value accounted for by industries that are globally characterised by high or medium-high levels of R&D intensity is rather small (left image of Figure 13).

Figure 13. Industry structure and business R&D intensity, 2017

Industry GVA in R&D intensive industries



Business R&D intensity and adjusted for industrial structure



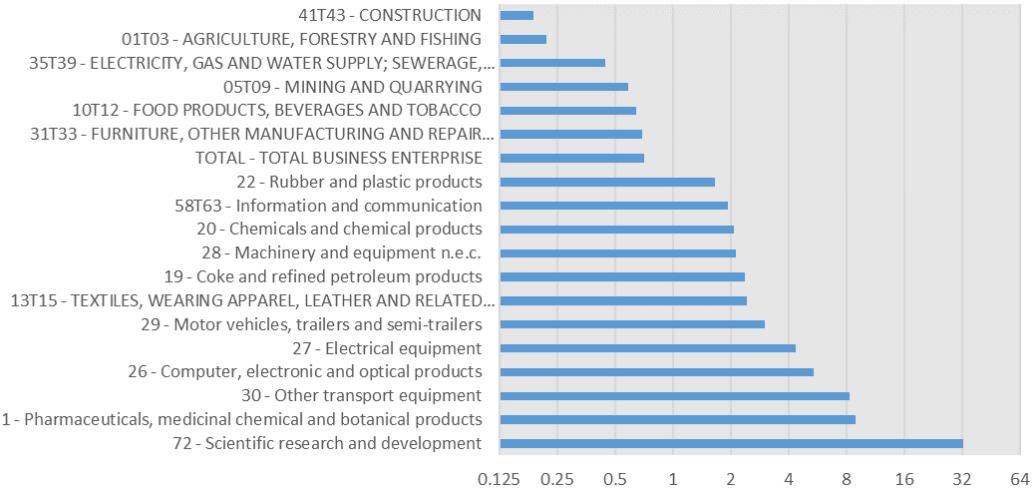
Note: Share of industry GVA in High- and Medium-high R&D intensive activities, as % of total GVA. R&D intensity as % of industry GVA.
Source: OECD calculations based on the ANBERD Database, http://oe.cd/anberd, the Structural Analysis (STAN) Database, http://oe.cd/stan, Main Science and Technology Indicators Database, http://oe.cd/msti, and Research and Development Statistics Database, http://oe.cd/rds, November 2019

This diminishes the potential capacity to undertake R&D within industry as well as the economy's ability to make full use of outcomes of research activity within the public system of research. However, this is not the entire story, as accounting for its industrial structure does not imply a major convergence to OECD average business R&D intensity levels. As the chart in the right of Figure 13 shows, weighting the R&D intensity of different industries in Spain (see Figure 14) by the overall industrial structure of the OECD only results in a small increase, implying that R&D intensity within Spanish industries is substantially below the OECD average.

In most recent years, Spain's business sector was able the regain the lost ground since the 2008 GFC and investment growth has been encouraging. However, in the global landscape Spain has been lagging behind some of the closest comparators, as Spain's level of R&D expenditure in the business sector failed to grow as fast as in Italy and Portugal after the crisis (Figure 15). What is concerning about this process is the possibility that Spanish firms miss out on the possibilities of positioning themselves in high value added components of the global value chains, losing competitiveness.

Figure 14. R&D intensity in Spanish business sectors, 2016

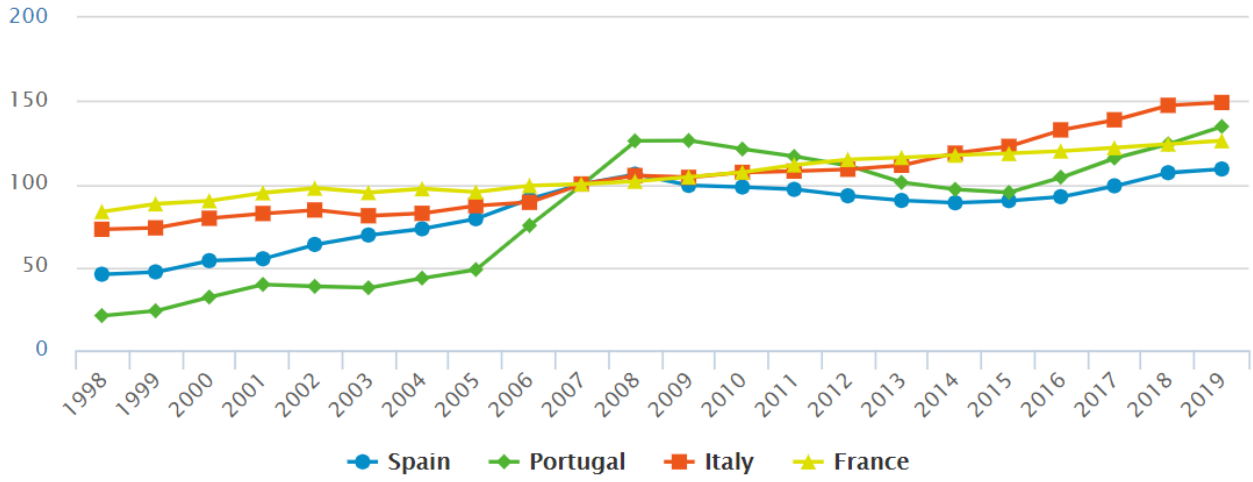
R&D expenditure as a percentage of industry gross value added, for top intensity industries and broad industry groups



Note: R&D expenditure has been allocated by industry on the basis of the main activity of the R&D performer, rather than on the basis of main activity of the user of the R&D. This may tend to overstate the R&D intensity of ISIC72, Scientific research and development.
Source: OECD, Anberd database, based on INE data, http://oe.cd/anberd

Figure 15. Business R&D expenditure trends in Spain and neighbouring countries

Constant USD PPP, index 2007=100



Source: OECD Main Science and Technology Indicators, http://oe.cd/msti

Patenting

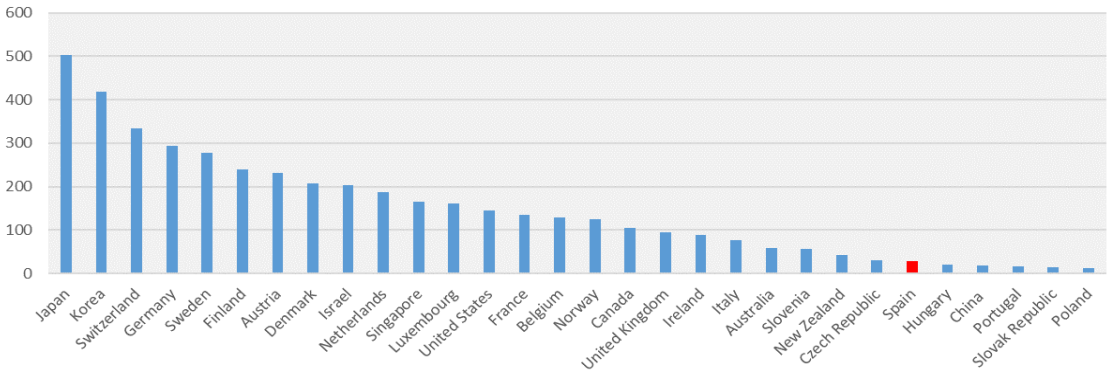
Spain's broad structural and R&D weaknesses find themselves reflected in patent statistics, as these show the extent to which R&D and innovation activities result in patentable inventions. With 1.343 patent families[16], Spain was the 19th country in total number of

[16] A patent family is the ensemble of patent applications covering the same or similar technical content that are filed by the same applicant in different jurisdictions. Patent families a defined on a common set of patent offices

families amongst the top economies in 2016. In total or per capita terms, Spain's patenting performance is also below what would be expected from its scientific output indicators (Figure 16).

Figure 16. Patenting intensity, top 25 economies, 2016

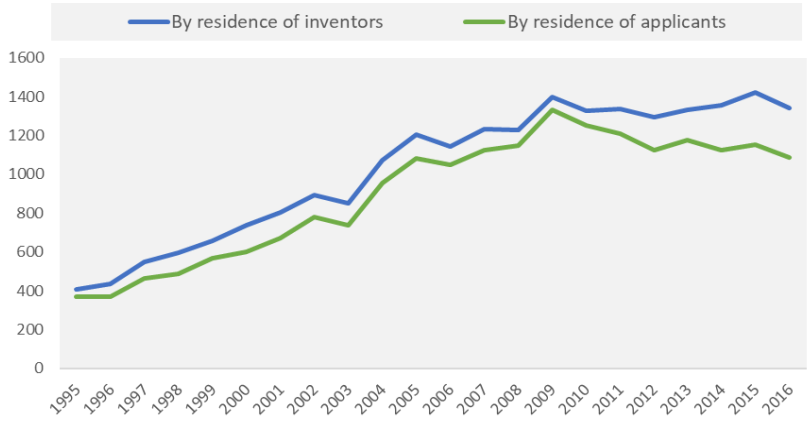
Number of IP5 patent families per million population, reported on an inventor and priority year basis



Source: OECD IP Statistics. February 2021.

The number of patent families by priority year originated in Spain went down sharply after the 2008 financial crisis (Figure 17). The downturn was more accentuated when patent families are counted by country of residence of applicants compared to the country of residence of inventors, which reflects the fact that public and private sector inventors located in Spain contribute more to patents owned by entities located abroad than the opposite. This applies in particular in the case of foreign controlled multinationals and other entities involved in consortia involving Spain-based inventors.

Figure 17. Patenting trends in Spain, IP5 patents

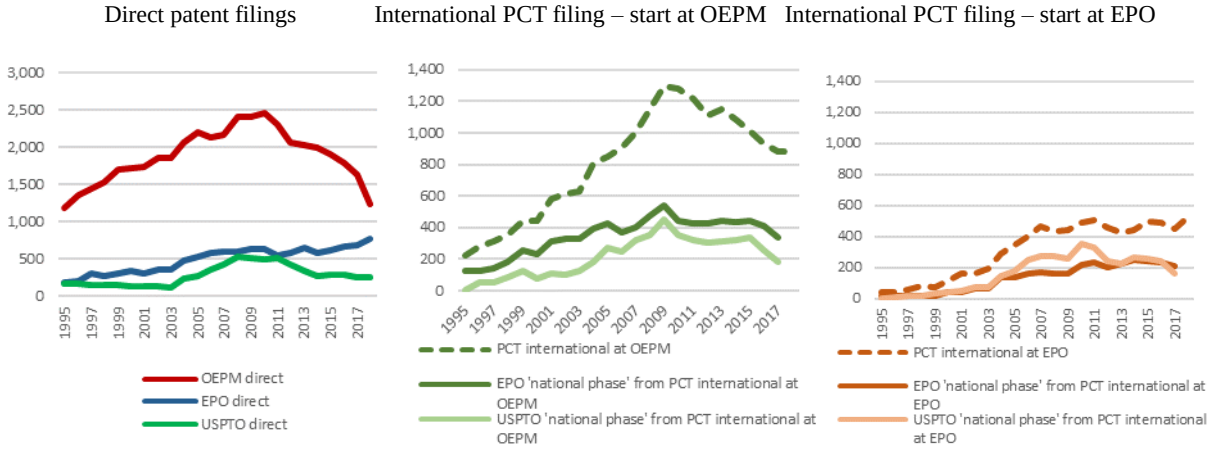


Source: OECD Patent Statistics, Accessed February 2021.

are preferred for international comparisons to patent-based indicators relying on filings to single national offices because the latter suffer from the home advantage bias and the influence of the geographical location of the applicant (OECD 2009, https://www.oecd.org/sti/inno/oecdpatentstatisticsmanual.htm). The IP5 patent families refer to patents that have been filed in *at least two* IP offices worldwide, one of which among the Five IP offices (namely the European Patent Office, the Japan Patent Office, the Korean Intellectual Property Office, the US Patent and Trademark Office and the State Intellectual Property Office of the People Republic of China).

Patent families classified by the country of residence of inventors or applicants that include national and foreign patent filings indicate the extent to which a country invents and protects its inventions internationally. Figure 18 shows the main filing routes chosen by Spanish applicants, which are explained in Box 2. Filings at the Spanish Patent and Trademark Office (OEPM) can be presented in Spanish and therefore represent the preferred option for first filing by small and medium-sized companies and individual inventors. OEPM direct patent filings by Spanish applicants dropped significantly following the 2008 financial crisis, going back to mid-1990s levels. This stands in contrast with sustained increases of presumably higher quality direct patent applications at EPO. Direct filings at USPTO remain low, following a peak at the end of the 2000s.

Figure 18. Main patent filing routes by Spanish applicants, priority year 1995-2017



Source: Martinez (2021) based on PATSTAT October 2020.

Up until 2017, the legal framework for patenting in Spain was the Spanish Law 11/1986 of Patents and Utility Models, which mirrored the European Patent Convention[17] in many respects, but had one important difference: the lack of substantive examination at OEPM. Until 2001 patent applications were granted at OEPM subject to an examination of formal requirements only. After 2001, the possibility of granting national patents subject to substantive examination of patentability requirements (rather than only formal requirements) was introduced, for those interested applicants paying an additional fee. Another change was introduced in 2001 with an exemption for all Spanish public universities from paying fees at OEPM.[18] This exemption also covered searching fees for PCT international filings when OEPM acted as receiving office. These conditions arguably encouraged excess, low quality patenting, in the case of public universities partly oriented exempted from paying patenting fees towards boosting researchers' CVs.[19]

[17] Spain signed the EPC in 1986.

[18] Portugal also had a 100 percent patent fee exemption for universities.

[19] The National Evaluation Commission of Research Activity (CNAI) created in 1989 to reward scientific contributions of Spanish researchers, added a new field in 2010 to evaluate researchers' individual contributions to 'technology transfer and innovation' (*campo cero*). Eligible items included patents and other forms of protection of industrial or intellectual property *in exploitation* (demonstrated by a change of ownership or licensing agreement). For patents not showing evidence of use, patents granted by OEPM with substantive examination were valued more than other OEPM grants and international patent filings were valued more than

Box 2. Filing routes used by Spain-based applicants

Multiple routes are used by Spanish applicants to build international patent families. Taking into account the costs associated with each, the preferred route can convey information about the expected value of inventions and their potential for commercialisation worldwide. There are two generic possibilities to seek patent protection in a given jurisdiction, either by **directly filing a patent application in the corresponding patent office** or by using the international **Patent Cooperation Treaty** (PCT) procedure, also known as the PCT route. The PCT allows applicants to fix a priority date for the protection of an invention, and gain time to decide where to file a direct application among all the patent offices worldwide of PCT signatory states. The applicant gains time by using the PCT route because the alternative involves direct filings at each single patent office, and (s)he only has 12 months after the priority filing to decide whether and where to file for international extensions. The PCT route adds 18 additional months, giving applicants 30 months to file directly (national phases) in the jurisdictions of her choice. Since seeking protection in many patent offices can be rather expensive, the PCT route provides additional time for instance to PROs with potentially valuable IP to identify relevant commercial partners with whom to share the costs.

In Europe, applicants seeking protection in several European countries can also benefit from a two-step procedure. Instead of filing directly at several European patent offices, they can opt for a single direct filing at the **European Patent Office** (EPO). This EPO filing can be their priority filing, or an international extension of a previous priority filing in another office 12 months earlier, or the entry into the PCT national phase at EPO (30 months after having filed a PCT international application at any patent office recognized as PCT receiving office). The European Patent Convention (EPC) provides advantages for applicants for the examination and granting phase, as it allows patent applicants to file a single patent application at EPO that, if eventually granted, could be later directly validated in any of the EPC member states without further examination. A number of stakeholders interviewed in this project pointed at the potential benefits of the future **European unitary patent**, which once granted would provide automatic protection in all EU members. This is still in the implementation phase after the 2012 agreement, which Spain, Italy and Croatia did not sign. Italy decided to join the EUP in 2015.

Source: OECD, based on Martinez, C. (2021), Patenting trends and routes, *CSIC-IPP Working Paper*, forthcoming.

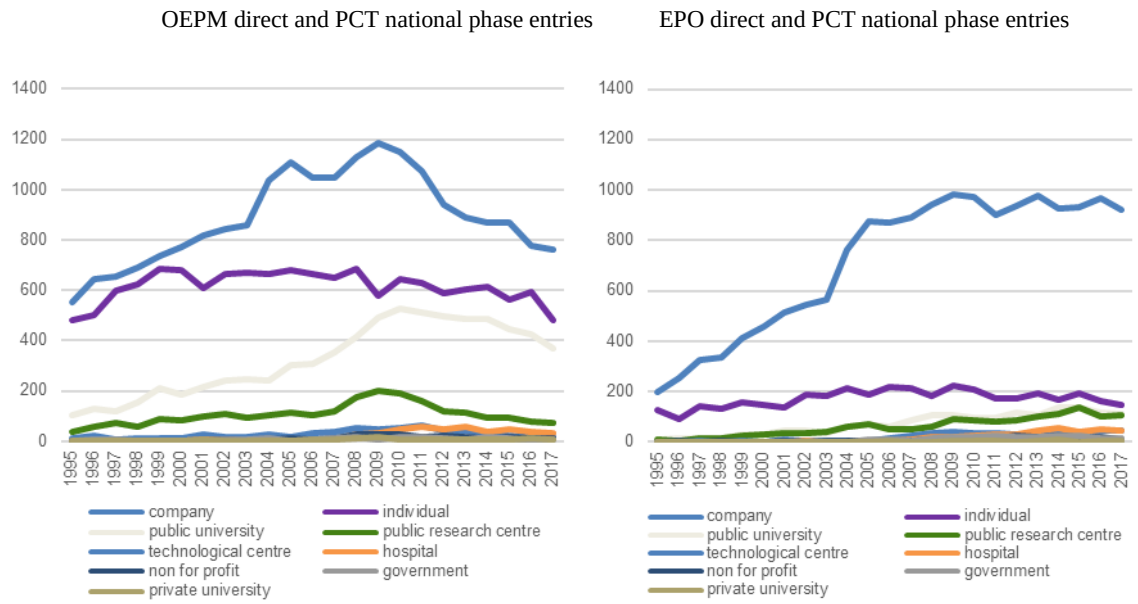
This "open doors" situation changed with the 2015 Spanish patent law, which entered into force in April 2017 introducing very substantial changes in the system. Since then, all Spanish patent filings have to go through substantive examination. Furthermore, public universities are no longer fully exempted from paying patent fees at OEPM. They can be reimbursed for the cost of OEPM fees if they can provide evidence of patent exploitation or commercialisation not later than four years. In contrast, PROs have not benefited from free subsidies or reimbursements before or after the reform.

domestic filings. CNEAI rules explicitly said that 'the international extension of the patent (national, European, international) would be taken into account, with more value given to broader scope of the protection'.

Figure 19 shows the evolution in number of patent filings at OEPM and EPO, between priority years 1995 and 2017. The largest share of filings has always corresponded to companies, followed by individual applicants, public universities and public research centers. Similar to R&D, the 2008 financial crisis had a deeper impact on the number of patents filed by companies earlier than for the patents filed by other types of applicants, and more so for OEPM filings than at EPO. Patent filings at EPO appear to be less sensitive to the economic cycle. Public universities reached a peak of more than 500 OEPM filings in priority year 2010, but by 2017 the figure had gone down to around 370. The difference may be attributed to a stricter screening process by technology transfer offices (TTOs, OTRI in Spanish), as well as a decrease in the number of patentable inventions from research results (invention disclosures), which according to the RedOTRI annual survey declined from 1,326 in 2012 to 1,097 in 2017 (RedOTRI, 2017[21]).

It is not yet possible to assess the full impact of the patent law that entered into force in April 2017. Most observers coincide in agreeing that it contributed to strengthening the screening process at OEPM and within public universities.

Figure 19. Patent filings of Spanish applicants by sector, priority years 1995-2017



Source: Martinez (2021) based on PATSTAT, October 2020.

Further insights about the appropriation strategies of Spanish firms can also be obtained from innovation survey statistics. These show that in 2016 only 10% of large Spanish companies applied for patent protection, the same figure as Portugal, but less than half for France and Italy. R&D firms present a low rate of patenting at 12% (OECD, 2019[22]).

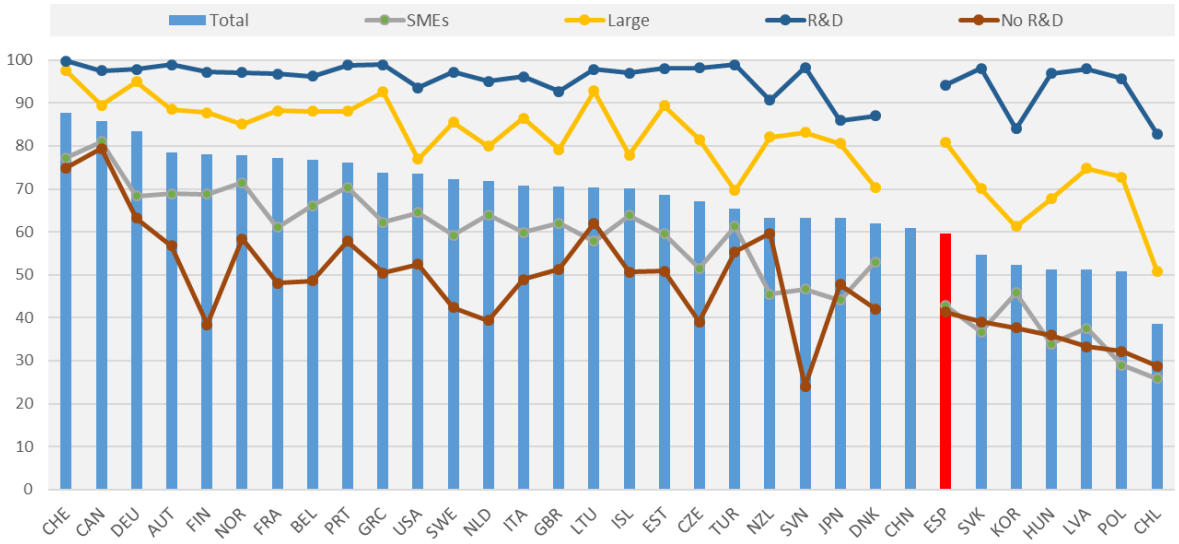
Innovation in firms

Business innovation statistics help illustrate how countries differ in the extent to which their companies bring new products to the market or adopt brand new processes, as opposed to just capturing R&D investments or patenting activity. Spain's performance on this indicator, based on the survey-based self-assessment of companies, is not among the leading countries (Figure 20). The statistics on counts of firms or employment in firms that innovate are most useful for their insights about differences across different types of companies. In that regard, it is possible to note that international differences in reported innovation across countries are

very similar across companies that undertake R&D, but differences are very marked among those who do not, where Spain's results are rather poor at only 40% of employment of non R&D performers found in firms that innovate. The gap is rather obvious when looking at firms of different sizes, as not only employment in innovative SMEs is low by international standards, but also among large firms, many of which do not carry out R&D.

Figure 20. Employment in innovative firms, 2016

As a percentage of total employment in the relevant category



Source: OECD Business Innovation Statistics 2020. Accessed February 2021.

The problem is not just that R&D is low and infrequently engaged in, a problem that instruments such as R&D tax incentives can help address, but also that innovation is rather infrequent in Spanish companies that do not carry out R&D. The fact that reported innovation "touches" a rather small share of the Spanish business workforce calls for a coherent, whole of government approach to business innovation promotion. The international gap is too large to be solely attributed to measurement issues.[20]

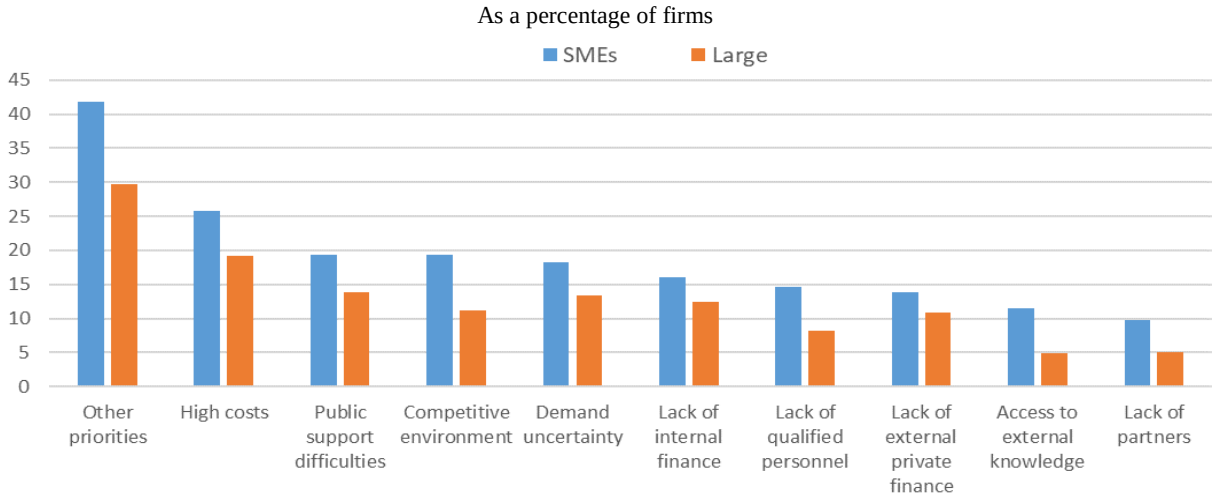
Support dependency is another potential issue at play. In Spain, nearly 50% of companies engaged in R&D for innovation in 2016 received some form of public support, a figure among the highest in the OECD area, compared to just over 10% of companies who are innovation-active but do not carry out R&D, which is among the lowest (OECD, 2021[23]).

Spanish businesses tend to cite other priorities as the main factor preventing or restricting participation in innovation activities (Figure 21), signalling limited appreciation of an overriding imperative to innovate. Business size appears to be a determining factor of barriers faced, particularly when it comes to innovation as a low priority, an important feature given

[20] Indeed, it is important to account for the possibility that companies that respond to Spain's combined R&D and innovation survey interpret the definition of innovation as implying an innovation that is the necessary result of R&D activity they do not have. Such framing effects have been demonstrated in other countries and have over the years been corrected as R&D and innovation questions have been split across different survey instruments with different purposes. Therein lies an important communication implication for Spanish policy makers, in that if they wish to promote innovation regardless of its knowledge basis and compare themselves better to their peers, they should consider investing in a separate survey that conveys a view of innovation that is comparable to that of its peers.

the relatively high importance of SMEs in Spain's economic structure. This innovation performance may be connected to traditional emphasis on strategies to compete on cost and an industrial structure geared towards more traditional sectors.

Figure 21. Factors preventing or limiting engagement in innovation activities in Spanish firms, 2018



Source: INE. Business innovation survey 2018 statistics. Accessed from https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736176755&menu=resultados&idp=1254735576669

2.2.5. Strengths and weaknesses in Spain's culture of science and innovation

Spain's business innovation indicators might be potentially suggestive of an innovation culture deficit that may have deeper societal factors. However, the actual evidence on this point is rather mixed.

The studies by the Spanish Foundation for Science and Technology (FECYT) on the social perception of science and technology and by the Cotec Foundation on the social perception of innovation in Spain provide two helpful portraits of how Spanish society assesses the role of STI and STI institutions and what factors underpin it. FECYT reports have identified a favourable attitude in the Spanish population towards the scientific and technological enterprise, its impact on wellbeing, and the reputation of science professionals (FECYT, 2020[24]). The 2019 Cotec survey with Sigma Dos, based on close to 2400 phone interviews, shows that 3 out of 4 Spanish citizens have an overall positive view of innovation, but this figure has been subject to a rapid deterioration in recent years from particularly high levels, from 89% in 2017, to 80% in 2018 and 73% in 2019 (Cotec, 2020[25]).

More recent evidence collected after the onset of the COVID-19 crisis portrays a number of rapidly changing views about the culture of science, technology and innovation in Spain, which can be also contrasted with other indications on the system's response to the crisis (Box 3). On the positive side, high levels of trust on vaccines reported in surveys appear to be confirmed in vaccination rates among eligible age groups thus far. However, the 2020 FECYT survey indicates a decline in the proportion of respondents who consider that the beneficial effects of S&T outweigh their negative effects (FECYT, 2020[24]).

Box 3. A science and innovation system rapidly mobilised in response to the COVID-19 crisis

It is difficult to develop a picture of Spain's science and innovation system's resilience throughout 2020 based on indicators as there is a significant lag in the generation of official statistics. A number of complementary indicators provide some glimpse of the experience in 2020.

Notwithstanding the difficulties caused by the pandemic, especially during the lockdown phase in Spring 2020, two encouraging signs can be found in Spain's contribution to scientific publications related to COVID-19 in the biomedical area and the rapid growth in domestic patent applications to the OEPM, for the first time since the introduction of the 2015 Patent Law, reversing a previous declining trend which reflected in part a shift away from lower quality patents.

As reported by the OEPM, applications for patents grew 9.2% with respect to 2019 for patents and 24.9% for utility models. The growth is remarkable, and in the case of patents reverts a long decreasing trend. As regards applicants, CSIC was, for another year, the largest patent applicant, followed by the household appliances manufacturing company CECOTEC in the second position and the Polytechnic University of Madrid in third place (OEPM, 2020[26]). While further results are awaited, it is expected that PROs and public-private consortia have played an important part in this development.

OECD analysis of PubMed indexed publications and works on COVID also shows Spain making a substantive contribution as the sixth largest producer of COVID-19 related publications in the biomedical space and third economy with the highest number of drug studies registered the NIH's ClinicalTrials.gov (data for January-November 2020) (OECD, 2021[27]).

On a more qualitative basis, several interviews carried out in this project have coincided in pointing out that the COVID-19 crisis helped justify the adoption of special measures contributing to the reduction of crippling bureaucracy and focused minds and hearts into shared objectives, breaking silos for greater collaboration across different institutions and actors in the system with limited resources.

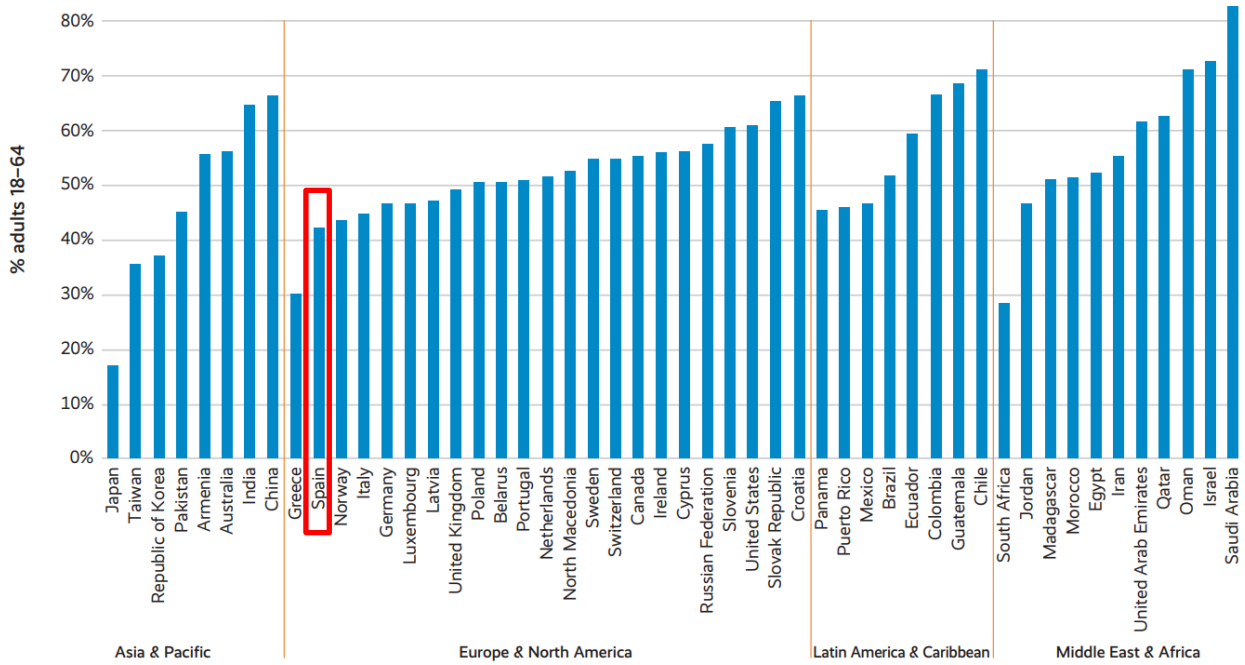
According to Cotec's 4th Survey on the Social Perception of Innovation (Cotec, 2021[28]), the pandemic has improved how the Spanish population regard innovation (77% see it as something positive, 4 points higher than in 2019), while contributed to reducing their perception of Spain as an innovative country. Spain is no longer regarded as being "close to the EU average" (57% al 44%) and a majority now place it under the "least advanced countries in the EU" (up from 33% to 50%). The percentage considering large Spanish firms as innovative declined from 47% to 39%. The vast majority of respondents (78%) continue to think that the country's investment in R&D and innovation is insufficient, that regulations do not favour innovation (68%) and that the education system is not preparing well for society for the challenges of the future (70%).

Spain does indeed score very close to the OECD average in terms of the PISA 2018 Science scores, a measure of the scientific literacy of 15 year-olds in the use of scientific knowledge to identify questions, acquire new knowledge, explain scientific phenomena, and draw evidence-based conclusions about science-related issues (OECD, 2021[29]).

The study by Sanz-Menéndez and Cruz-Castro (2019[30]), which finds that scientific information is more credible if supplied by the scientific institutions themselves than by the government or the business sector, and by government than by business, is indicative of a

degree of societal mistrust towards business and private interests. While this is not unique to Spain, it might be illustrative of deeper cultural factors that impact on the social representation of innovation compared to science, which could be perceived as belonging entirely to the public sphere (universities, labs and hospitals). The challenges with culture of innovation appear to have to do less with knowledge and understanding of science and technology itself, and more with a relative shortage of positive examples in the social discourse and actual personal experiences of innovation across its full diversity. Indeed, results from the Global Entrepreneurship Monitor (GEM) report show Spain as one of the countries exhibiting the lowest awareness of entrepreneurship in the most immediate context (Figure 22).

Figure 22. Knowing someone who has started a business in the past two years (% adults)



Source: GEM Adult Population Survey, 2019, www.gemconsortium.org/report/gem-2019-2020-global-report

According to the GEM study, the proportion of adults who are actively engaged in starting or running new businesses in Spain (total early stage entrepreneurial activity) is also among the lowest in Europe and North America. Furthermore, among employees, the proportion of individuals who are developing new activities for their employer, such as developing or launching new goods or services, or setting up a new business unit, is less than 2%, compared to 4% in Portugal or over 6% in Germany and the United States.

Overall, the available evidence points to the need for further consolidation of critical elements in the country's culture of innovation as well as policies. The promotion activities of FECYT as a government agency could be slightly reoriented towards raising the visibility of innovation alongside its portfolio of science communication and promotion activities.

Key issues requiring further research and policy analysis include securing a better understanding of a) how personal career aspirations are shaped, and the role of socially transmitted preferences towards jobs perceived to be safe and permanent; b) society's appreciation of the world of business and the role of innovation as driver of competitiveness; c) personal experiences of innovation in workplaces, in terms knowledge-basis of work, ability to use initiative to propose improvements and take calculated risks; d) creative

consumption patterns that enable user innovation processes. All these points are ultimately very important determinants of Spain's innovation capacity and the basis on which fruitful science-business collaboration can be built.

2.3. The governance of Spain's innovation system

The Spanish Law of Science, Technology and Innovation of 2011 provides a formal definition for the "Spanish Science, Technology and Innovation System" (SECTI) as "the set of agents, public and private, that carry out financing, execution, or coordination functions in it, as well as the set of relationships, structures , measures and actions that are implemented to promote, develop and support research, development and innovation policy in all fields of the economy and society." This represents an appropriately broad and inclusive formulation of the notion of an innovation system consistent with that introduced at the start of this section, although the number of functions outlined appears to be somewhat more limited, as denoted in Table 1, and the use of the concept in a more narrow sense results in apparent contradictions. [21]

Table 1. Functions foreseen by law in the Spanish Science, Technology and Innovation System

Functions	Actors
Coordinating	Coordination agents are the Public Administrations, as well as the entities linked or dependent on them, when they carry out functions […] to carry out common actions in matters of scientific and technical research or innovation, in order to facilitate the reciprocal information, the homogeneity of actions and the joint action of the agents of the Spanish System of Science, Technology and Innovation, to integrate the actions in the overarching system. The general coordination of actions in the field of scientific and technical research will be carried out by the General State Administration (central government), through the instruments established by this law
Financing	Public Administrations, entities linked or dependent on them and private entities, when they assume the costs of scientific and technical research activities or innovation carried out by other agents, or provide the necessary financial resources to carry out these activities.
Execution (sic) / Performance	Public and private entities that carry out or support scientific and technical research or innovation.

Source: BOE Ley 14/2011, de 1 de junio, de la Ciencia, la Tecnología y la Innovación. Accessed from https://www.boe.es/eli/es/l/2011/06/01/14/con

According to the law, the SECTI is integrated, as far as the public sphere is concerned, by the public policies developed by the General State Administration (central government) and by those developed, in their own sphere, by the autonomous regions (regional governments).

Spain has a three-tier formally decentralised government system with central, regional and local governments. There are 17 autonomous regions (*Comunidades Autónomas* or CCAA, in Spanish), 2 autonomous cities, 50 provinces and more than 8 000 municipalities. The map of competences is regulated in the Spanish Constitution and while some are exclusively managed by the central government, many are shared between the central and regional

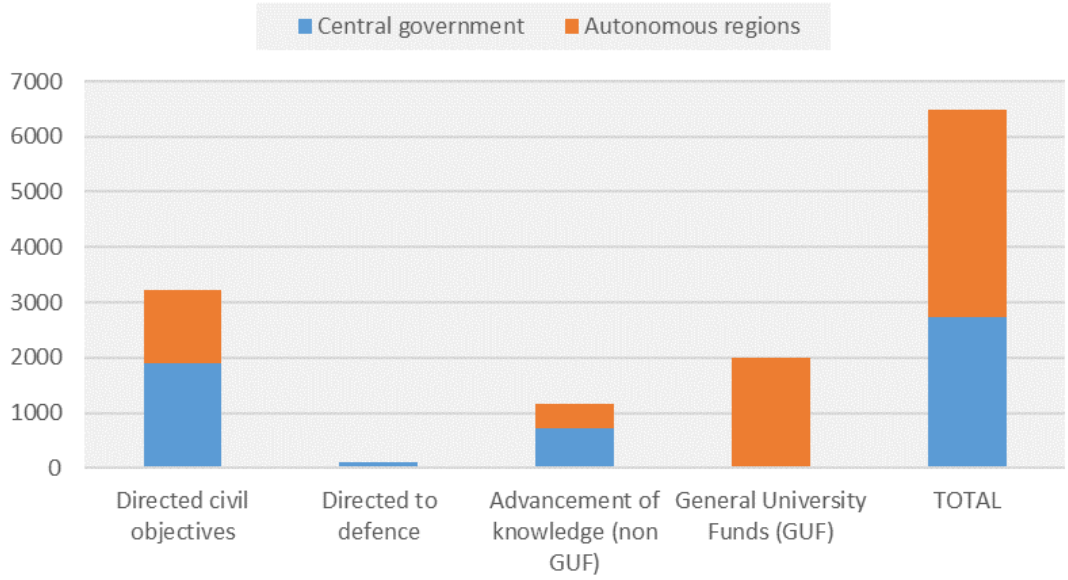
[21] However, the same piece of legislation adopts a narrow view of the SECTI when it regulates contractual modalities of access as research personnel to the system (art. 22) when in fact referring to employment modalities in the public sector. This contributes to reinforcing a widespread perception among researchers, documented further below, that full participation in the system is only possible through formally regulated roles within the public sector.

governments and others are fully transferred to the regions. Specifically, the central government passes basic legislation and regions regulate and implement their own laws. The Spanish Constitution, in its Article 44.2, vest in the general government ("poderes públicos") the responsibility for "promoting science and scientific and technical research in the public interest". The central government ("Estado") has according to Article 149.1.15 exclusive competence in matters of promotion and general coordination of scientific research. Article 148.17 allows autonomous regions to assume competences in promoting research. The Constitution does not refer to innovation literally, but does assign responsibility to the general government for "modernising and developing all sectors" (Art 130.1). Effectively, the promotion and financing of R&D and innovation is a shared responsibility between central government and the autonomous regions.

As shown in Figure 23, government budgetary funding for R&D is mostly allocated by the autonomous regions, although an important share of the latter consists of general university funds that are allocated to universities to allow them cover the R&D component of their costs.

Figure 23. Central and regional government budgets for R&D, 2019

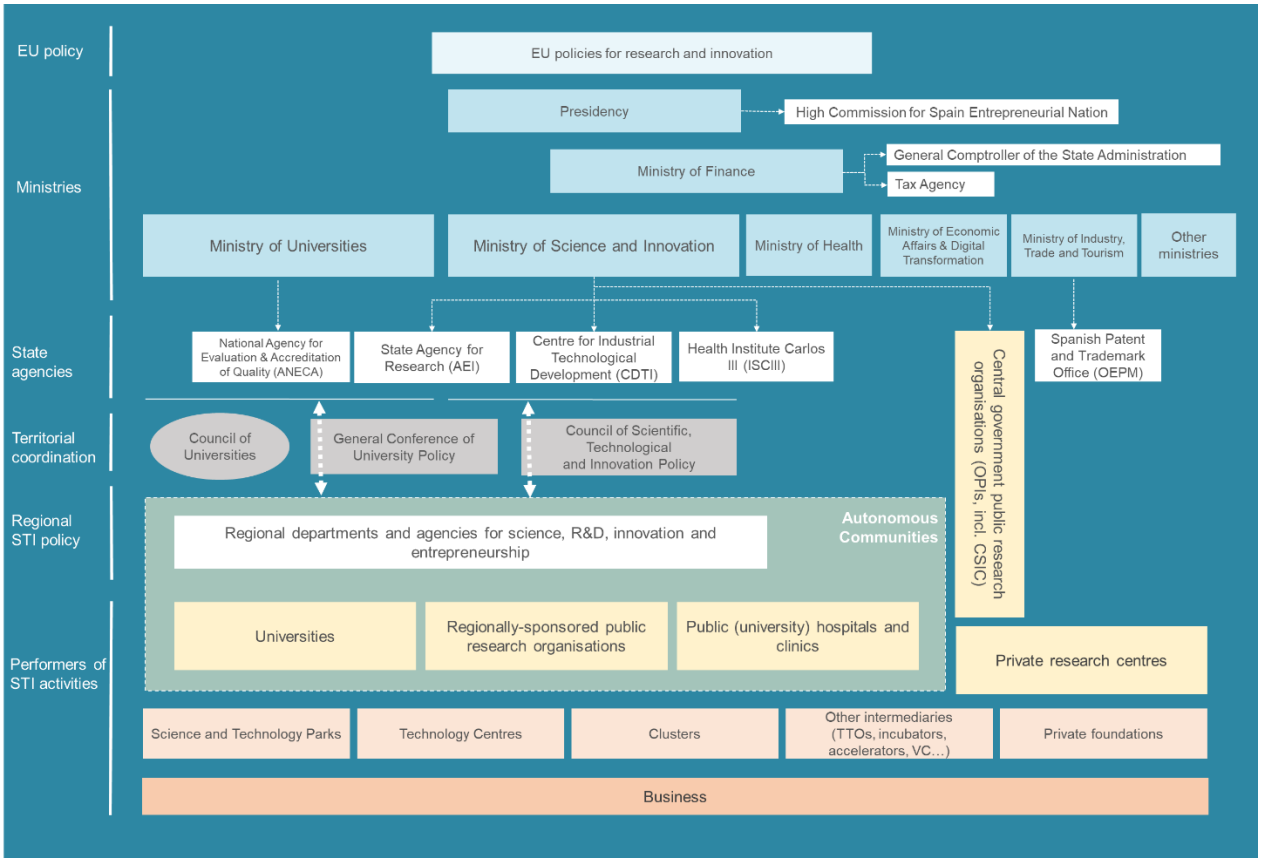
Total GBARD by level of government and group of socioeconomic objectives, EUR million



Note: Government budget allocations for R&D (GBARD) include the component of general university funds notionally assigned to R&D but exclude repayable financing costs and science and innovation related activities that do not qualify as R&D. They also exclude the cost of R&D and innovation tax incentives provided to firms.
Source: Estadística de Créditos Presupuestarios de I+D+I. Subdirección General de Planificación, Seguimiento y Evaluación https://www.ciencia.gob.es/site-web/Estrategias-y-Planes/Sistema-de-Informacion-sobre-Ciencia--Tecnologia-e-Innovacion--SICTI-/Presupuesto-de-gastos-en-I-D-I/Estad-stica-GBARD.html

Figure 24 outlines the main actors in the system's policy governance, highlighting in contrast to other national innovation systems the mirroring features of regional policy governance systems with central government systems, as well as the overarching layer resulting from Spain's membership of the European Union which is depicted at the very top of the figure and has broad regulatory and financing implications through the entire system.

Figure 24. The policy governance of Spain's science and innovation system, 2021



Source: OECD own elaboration.

2.3.1. Central government

General structure and bodies

The legal regime applicable to Spain's central government and the bodies and entities that depend on it are laid out in the Law 40/2015. This piece of legislation is particularly important for understanding the room for operation among public actors in Spain's STI landscape, as it defines the degree of autonomy and applicability of general or specific public or private law rules to different aspects ranging from engagement in collaboration agreements, budgetary resources, control and audit, as well as applicable contracting and employment regimes.

Rather succinctly, the central government-dependent public sector is formally separated between a) the central government's general administration (*Administración General del Estado*), which comprises the ministries, collegiate bodies and the territorial services representing the central government within Spain and abroad; and b) the remaining institutional public sector (SPIE). SPIE institutions can be classified as follows:

- Central government public bodies, which enjoy management autonomy as well as their own public legal personality, assets and treasury, but report to a specific executive government entity that is accountable for their strategic management, evaluation and control of results. They include:
    - Autonomous central government bodies (*organismos autónomos estatales* - OAEs), with civil service and standard labour statue employment regimes.

  - Central government agencies (*agencias estatales* - AEs). A distinguishing formal feature with the "autonomous bodies" is the fact they operate under multi-year management-delivery contracts with their sponsoring ministry and the rules that define their creation.
  - Public business entities (*entidades públicas empresariales de ámbito estatal*- EPEs), which while public law entities engaged in administrative activities, can also engage in remunerated service delivery activities using more flexible private law instruments. Its personnel is subject to standard labour statue employment regimes. This structure is used among other things for setting up financing structures and service-providing infrastructures.
- Independent administrative authorities of the central government, a category that is currently only applied for a limited number of independent regulatory bodies, such as the Nuclear Security Council and the Markets and Competition Authority.
- Public business enterprises of the central government (*sociedades mercantiles estatales*), private law companies that are controlled by central government institutions. Unlike EPEs, they are fully subject to private law and they do not have public administration responsibilities.
- Consortia. These result from collaboration agreements within or outside the public sector, and depending on their set up may be classified as part of the public sector.
- Public sector foundations under central government responsibility, which are non profit organisations controlled by the public sector, and as discussed further below, have become increasingly popular instruments for channelling public research and technology activity of a predominantly non-market nature, particularly because of their standard labour employment regime and greater contractual agility than central government bodies.
- Public universities not developed to regional administrations, such as UNED (Spain's "Open University").

Ministerial and agency responsibilities

At the **national (central government) level**, different ministerial configurations have over time hosted the array of core science and innovation policy responsibilities. Science and innovation policy in general and knowledge transfer in particular fall under the current configuration principally under the responsibility of the **Ministry of Science and Innovation** (MICINN in Spanish) (Figure 25), shared in part with the Ministry of Universities.

The MSI is in charge of Spain's framework of reference for R&D and innovation policy, the **Spanish Strategy for Science and Technology and Innovation**, which lists the main strategic objectives. These are aimed at promoting the country's scientific, technological and business leadership and increasing the innovation capacities of society and the Spanish economy. The objectives include improving research quality (e.g. excellence) and its broader scientific-technical, social and economic impact, as well as increasing participation of businesses in R&D and innovation activities.

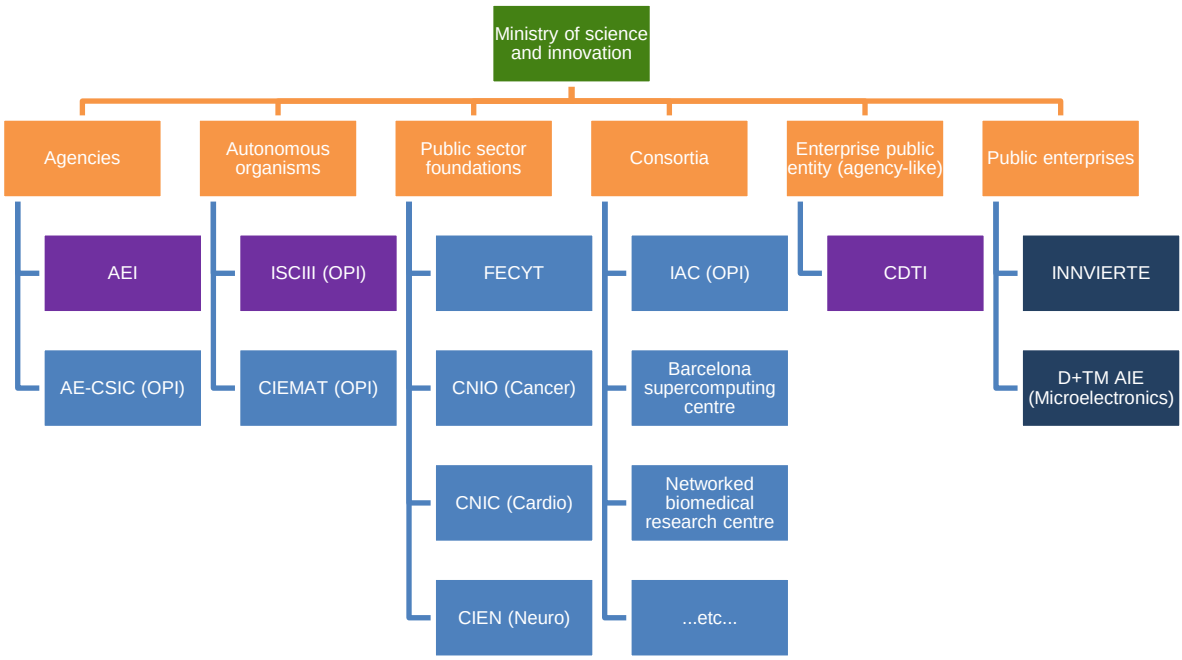
The **State Plan for Scientific and Technical Research and Innovation** is the fundamental instrument of the central government for the development and achievement of the objectives of the Spanish Strategy for Science and Technology and Innovation, and it includes state aid provisions in this area. The State Plan comprises a series of programmes that correspond to the general objectives established in the Spanish Strategy for Science and Technology and Innovation.

The **annual action programs** are the budget planning instrument of the State Plan and they include the actions that are called each year and the multi-year commitments provided for in each of the public calls. In addition, it allows the monitoring of the Plan indicating the calendar of the calls for aid, management units, specific objectives and the main characteristics of the aid. It also contains the performance management and monitoring indicators.

The MSI affiliated entities and agencies with executive responsibilities include the following:

- The Spanish State Agency of Research (AEI in Spanish), created in 2017, and in charge of scientific research funding programmes principally oriented towards the public system of research.
- The Centre for Industrial Technological Development (CDTI in Spanish), the agency in charge of business R&D and innovation support programmes, such as the Cervera Programme for technology centres, which is also responsible as sole shareholder for the investment vehicle INNVIERTE for the equally named business innovation support programme.
- The Health Institute Carlos III (ISCIII in Spanish) is the main public research body with combined responsibility for funding, coordinating and conducting research in the fields of biomedicine and public health.

Figure 25. Public sector entities directly overseen by the Ministry of Science and Innovation



Note: Only entities principally overseen by the Ministry displayed, and only a few examples displayed under the consortia category. Classification on legal basis as provided by IGEA (boxes in orange), with small explanatory items by OECD within brackets and indicative colour coding for entities with primarily funding agency roles.
Source: OECD own elaboration based on IGEA. Institutional public sector registry. Accessed on July 2021 from https://www.pap.hacienda.gob.es/invente2/pagBuscadorEntes_SPI.aspx?Filtros=0

The diversity of MSI-dependent entities reveals the importance of public sector foundations and consortia. Public sector foundations have become increasingly important actors at the national and also regional levels given the greater degree of operational flexibility compared to formal agencies and autonomous bodies (Box 4). As previously noted, the Spanish Foundation for Science and Technology (FECYT in Spanish) has responsibility for the promotion of scientific culture and open science, including knowledge infrastructure support for the monitoring of Spain's science and innovation system and administrative operations.[22] CNIO and CNIC are relatively new PROs with responsibilities for R&D into cancer and cardiovascular diseases, respectively.

Box 4. Public foundations as research and innovation policy instruments in Spain

The management model of several government and public sector bodies in Spain has proved to be too rigid for several purposes, especially with respect to budgetary, financial and human resources (HR) management. Over time, this has led to a proliferation of entities with more flexible legal frameworks (OECD, 2014[31]). Public sector foundations are a case in point. They have a dual public and private nature, using private law structures set within the public sector and public law statutory rules for budgeting, control and auditing, as well as contracting. The law of 2015 on the legal regime of the public sector sets the regime for central government foundations together with the 2002 law of foundations, while regional legislation sets the framework for foundations that depend on the autonomous regions. The 2014 OECD Public Governance review of Spain noted that up until that point, the lack of regulation governing public sector foundations might have contributed to their abuse given the significant number of foundations created by governments, often insufficiently justified, and whose activity might not have always followed the provisions of the legislative framework on foundations. The review also observed that the control and performance evaluation of these foundations had been limited.

The governance of Spain's research and innovation system has been significantly transformed by the proliferation of foundations. A key defining flexibility feature of foundations is their ability to sidestep the civil-service career official regime for public sector employees using contractual labour staff (*personal laboral*) arrangements. Central government and autonomous regions have been making intense yet variable use of its possibilities to set up research and innovation funding and promotion agencies, as well as structures dedicated to research, technology and innovation outside the traditional organisms/institutes framework. However, despite regulation on the tasking framework for public sector organisations and a 2017 law of public sector contracts aiming to clarify the complex confluence of public and private dimensions, there remains considerable uncertainty about their governance and functioning. Several stakeholders interviewed as part of this study referred to this uncertainty, which is also influenced by government decrees that can overnight transform budgetary and financial control rules as well as a non-negligible degree of scope for political interference.

Source: Authors' own elaboration, drawing on stakeholder interviews and on OECD (2014[31]).

The **Ministry of Universities** (MU) is responsible for higher education policy at central government level in Spain, a policy area devolved to regional administrations. The National Agency for the Evaluation and Accreditation of Quality (ANECA in Spanish), affiliated to

[22] FECYT has been hosting for several years the ICONO platform for indicators and metrics of Spain's STI system, while promoting inititatives in this area. https://icono.fecyt.es/que-es-icono

the MU, is in charge among others for the "*sexenio"* system of academic merits and pay enhancements, as well as the accreditation system for new research and academic personnel.

Under the current ministerial configuration, other ministries are engaged to a varying degree in science and innovation promotion policies, among which it is particularly important to refer to:

- the **Ministry of Economic Affairs and Digital Transformation** (MINECO), given its role as coordinator of the National Reform Programme for Spain and in charge of policies to enhance business performance and competitiveness, as well as in the area of entrepreneurship and digital talent;
- the **Ministry of Industry, Trade and Tourism** (MINCOTUR), in particular regarding policies to support SMEs and clusters. The Spanish Patent and Trademark Office (OEPM) is an autonomous central government body affiliated to this Ministry and is responsible for intellectual property protection and promotion, with the exception of copyrights which are under the responsibility of the Ministry of Culture;
- the **Ministry of Health**, given the relevance of R&D investments in the area of health and its regulatory oversight over medical treatments and products;
- the **Ministry of Defence** (MINDEF), in charge of the Defence Technology and Innovation Strategy (ETID), which seeks to establish a public reference guide for defence-oriented R&D and technological innovation projects, setting out technological goals to be used as a basis for prioritisation, coordinate national defence R&D stakeholders and to cooperate with end-users and technology developers in defining and conducting technological activities[23];
- the **Ministry for the Ecological Transition and the Demographic Challenge** (MITECO), given the relevance of R&D and innovation investments in the fields of energy transition, climate change mitigation and adaptation and water management among others;
- the **Ministry of Agriculture, Fisheries and Food** (MAPA), which has interests and programmes in the areas of agricultural innovation and digitalisation, bioeconomy as well as Agricultural Knowledge and Innovation Systems.

The High Commission for Spain Entrepreneurial Nation, created in 2020 and hosted at the **Spanish government Presidency**, reflects the central role that entrepreneurship policy (and in particular science- and technology-based entrepreneurship) has in the government's policy agenda.

Unlike other OECD countries, Spain does not have a governmental **scientific advisory body** attached to the Presidency or government cabinet.

The **Ministry of Finance** is responsible for the management, control and execution of public expenditure. It is also responsible for the application and management of the regional and local financing systems and the provision of information on the economic-financial activity of the different public administrations, as well as the strategy, coordination and regulation of

[23] The Ministry of Defence is also responsible for the National Institute for Aerospace Technology (INTA), one of the remaining PROs with OPI status in Spain. It is responsible for performing scientific research activities and prototypes in its field of knowledge, as well as for providing technological services to companies in the industry, universities and other institutions. INTA specialises dually in technological research and development in aerospace, aeronautics, and hydrodynamics, and in security and defence technologies. The Ministry of Defence is also responsible for a number of university centres related to the training academies for the different services, as a well as public enterprise, namely Spanish Defence Engineering Systems.

public procurement. Under the Ministry of Finance, Spain's **Tax Agency** (Agencia Tributaria) is responsible for the tax incentive regime for R&D and innovation activities.

Also under the Ministry of Finance, the **General Comptroller of the State Administration** (IGAE in Spanish) sits the internal supervisory agency of the state (central government) public sector, and the direction and management centre for public accounts. As a supervisory agency, the IGAE is responsible for verifying, through continuous financial control, public audits, and financial control of subsidies that the state public sector's economic and financial activity complies with the principles of legality, economy, efficiency and effectiveness. As a centre for the management of public accounts, it is responsible for providing reliable, complete, professional and independent accounting information about public management. The importance of IGAE decisions for the public system of research increased markedly in the aftermath of the GFC, following the 2012 Law of Budgetary Stability and Fiscal Sustainability, throughout a very challenging period of fiscal consolidation in which PROs became subject to far more stringent procedures than in the past. This led to the Ministry of Finance and the IGAE in particular to become key gatekeepers for public expenditure on science and innovation and a fundamental actor in the effective implementation of STI policies.

The **Commission for Science, Innovation and Universities** is a parliamentary commission of the national Parliament's Deputies Chamber (*Congreso de los Diputados*) that oversees the actions of the Ministries of Science and Innovation and Universities, and analyses, debates and prepares legislative proposals to be discussed in the Parliament. The Parliament also decided to create, in 2020 an **Office of Science and Technology** aimed at providing scientific advice to the Parliament. The Office will be set in place with support from FECYT.

2.3.2. Regional governance and inter-territorial coordination

Spanish regional governments have become increasingly active in developing their own science and innovation policies within the powers allowed by the Spanish constitution, leading to a complex multi-level governance system. The coexistence of regional and national initiatives enables the addition and reorientation of resources for science and innovation and their alignment to specific regional needs and opportunities in light of Spain's diversity. It has often been argued that the regional level of intervention is more efficient in fostering bottom-up agglomeration dynamics to better connect science with regional industry needs (Rip, 2002[32]). The heterogeneity of regional innovation systems in Spain also calls for differentiated policies rather than a one-size-fits-all approach. Moreover, regional initiatives offer new spaces for policy experimentation that may later be transferred throughout the country (Morgan, 2018[33]).

However, shared responsibilities over science and innovation policy between different levels of government can also lead to fragmentation, duplication and overlap, policy inconsistencies and incoherence, bureaucratic and political conflict, and lack of consensus when setting priorities (OECD, 2011[34]; Magro, Navarro and Zabala-Iturriagagoitia, 2014[35]). The proliferation of public support programs at different levels can lead to higher transaction costs, more bureaucracy, and confusion among target beneficiaries. Spain is particularly vulnerable to those risks associated with decentralisation given its administrative structure and the persistence of central-regional political tensions. Indeed, prior studies have emphasised that the weak coordination between national and the regional governments has hampered the efficiency of science and innovation policies in Spain (Borrás and Jordana, 2016[36]; Fernández-Zubieta, Ramos-Vielba and Zacharewicz, 2018[37]; OECD, 2010[38]).

The highest-level formal coordination mechanism currently in place is the **Council for Science, Technology and Innovation Policy**, established in the Science Law of 1986 and maintained in the STI Law of 2011. It is chaired by the Minister of Science and Innovation

and brings together the Ministers of other ministries with related responsibilities (a long list of ministries indeed is recognisant of the horizontal nature of innovation policy) as well as the senior elected officials (*Consejeros* in Spanish) in charge of science and innovation within each of the regional governments. The council's formal functions include developing proposals for the Spanish strategy, increasing awareness about the State plans and regional plans related to research and innovation, and promoting joint action.

Over the past decade, the Council has met very seldom (only three times between 2012 and 2019), with an increase in meeting frequency since 2020. Several of the experts interviewed for this report have argued that the Council has not lived up to its promise to adopt a leading role in fostering central-regional coordination, with its meetings often limited to information sharing, typically with the central government informing regions of recent policy developments but without fluid interactions or debates that would support the co-creation of policies and implementation approaches. Therefore, the operations of this Council and the structure of its meetings might need to be reconsidered while pursuing other more flexible modes of coordination.

Along those lines, it is worth highlighting the role of **Red IDI**, created in 2010 as a new multi-level strategic coordination network to support research, development and innovation policy in Spain. Compared to the Council for Science, Technology and Innovation Policy, which is a high-level policy forum, Red IDI focuses more on the operational and technical side of policy implementation. Its main objective is to coordinate the different agents of the Spanish science and innovation system to improve innovation public support frameworks, thus favouring the mobilisation of resources and access to financing from European funds and, in particular, from ERDF funds. Red IDI is co-chaired by the Ministry of Science and Innovation and the Ministry of Finance. Its Technical Secretariat, comprising three employees, is located at CDTI. The network's activities are co-funded with ERDF funds. It organises various workshops and seminars aimed at sharing experiences, providing training, and offering a networking space open to representatives from all Spanish regions. In recent years, Red IDI has played a very relevant role in the development and coordination of regional smart specialisation strategies. It has also recently launched a new website that will aim at providing structured information on the main technological centres and research groups in Spain across different strategic technology fields.[24] In July 2021 it established a working group on innovation and knowledge transfer, also involving regional development agencies, focused on the joined-up assessment of the situation and implementation of specific measures in this area.

In the domain of higher education and universities in particular, regions have devolved responsibility in their territory, including their core funding, and in most cases have their own higher education quality assurance agencies and legislation. In light of their competences, the Spanish regions are in charge of the public funding of university education as well as general funds for research (payroll for academic staff and so on). The majority of regions have adopted specific legislation for the universities within their territories.[25] The **General Conference of University Policy** (CGPU) is the main formal coordination mechanism currently in place to coordinate national-regional higher education policy and enhance cooperation across regions. One of its functions to propose and assess policies to promote the collaboration between universities and businesses.

At the strategic level, national-regional coordination is embedded in the process of development and adoption of the **Spanish Strategy for Science, Technology and**

[24] http://redpoliticasidi.es/es

[25] See https://www.boe.es/legislacion/codigos/codigo.php?id=133&nota=0&tab=2

Innovation (the last of which covers the period from 2021 to 2027), because regional governments need to endorse the national strategy. In the process of strategy formulation, the national government is obliged by law to make consultations with regional governments, to increase coherence between the national strategy and the regional strategies developed within the context of the European smart specialisation strategies. However, the converse does not apply, as the central government does not have any formal role in the process leading to the development of regional strategies. The central government could play a more active role in facilitating exchanges across regions during the process of development of smart specialisation strategies. Such dialogue would contribute to avoiding excessive duplications, increasing the focus on territorial strengths and helping to identify opportunities for cross-regional cooperation. Indeed it has been argued that the experience from the first programming period of smart specialisation strategies (2014-2020) points to a tendency by Spanish regions to adopt very broad strategies covering many areas of specialisation and often imitating what neighbouring regions are doing rather than focusing on the intrinsic strengths of their territories (Di Cataldo, Monastiriotis and Rodríguez-Pose, 2021[39]).

In addition to ongoing efforts to coordinate regional smart specialisation strategies with the national science, technology and innovation (STI) strategy, there have been other noteworthy initiatives attempting to achieve a greater national coherence, such as the **Map of Singular Scientific and Technological Infrastructures.** It was set up in 2007, in agreement between the central and the regional governments, with the aim of determining the optimal location for new large-scale scientific and technological infrastructures of public ownership, avoiding duplication and wasteful overlaps between regions. The map is the long-term planning and development tool for these infrastructures in coordination with the regions, and it is updated every four years within the Council for Science, Technology and Innovation Policy.

More at the operational level, another mode of national-regional coordination are **bilateral agreements** (or "*convenios*"), which may be used for co-financing research infrastructures and for the joint programming of policy instruments. The OECD (2011[34]) has highlighted the 'relational' nature of partnership agreements, highlighting the important trust-building, information-sharing, and capacity-building role of partnerships that facilitates multilevel governance. There are many possible design options, but the general idea is to share responsibility over the selection and funding of science and innovation programmes in order to create synergies and strengthen policy coherence. In Spain, bilateral cooperation has been particularly successful for the development and joint-funding of large scale scientific infrastructures of international scope, with additional European co-funding, such as the Barcelona Supercomputing Centre consortium or the sub-headquarters of the European Spallation Neutron Source (ESS) in Bilbao.

More recently, new policy instruments have been launched with a marked regional scope, such as the Cervera programme to support regional technology centres and promote alliances between those working on similar areas from different regions (see section 4.4.1).

However, bilateral contracts between central and regional governments aimed at the **joint-programming and joint-financing** of policy instruments have barely been used in Spain, and there are no examples of success on this front[26]. This helps explain why joint programming was set as a new priority objective in the Spanish Strategy for STI 2021-2027. Joint programming will likely become increasingly important in the near future against the need to jointly articulate ambitious projects in the context of the Next Generation EU funds.

[26] For example, the State Research Plan introduced a joint programming element by allowing those proposals that were not selected for funding but were rated positively to be transferred directly to regional governments, allowing them to fund those projects with a streamlined evaluation process. However, according to the director of the Spanish State Research Agency (AEI), this procedure has never been used in practice.

Along those lines, in May 2021, the Ministry of Science and Innovation announced a new policy coordination and co-governance initiative ("Complementary Plans") to co-finance 2-year R&D programmes in partnership with regional governments, focusing on a set of eight priority areas aligned with national and regional smart specialization strategies (see section 6.1.1).

In addition to those formal institutional arrangements, other types of **informal coordination mechanisms** such as thematic working groups, ad hoc meetings, information exchange and on-going dialogue are often critical to enhance co-operation between regional and central government (OECD, 2011[34]; Hessels, 2013[40]). Indeed, policy officers from the Ministry of Science and Innovation have informal contacts on a regular basis with their regional counterparts across all Spanish regions, and the same holds for national agencies such as CDTI with its counterparts.

Improving formal and informal coordination mechanisms across different levels of government is critical. In its 2020 Semester report on Spain, the European Commission took note of recent measures to improve coordination and synergies around science and innovation policies, cautioning about the challenges faced in order to guarantee an effective multilevel governance system.[27] Many stakeholders interviewed throughout this project highlighted that in view of the accumulated experience and of the existing national-regional overlaps in certain policy instruments, it would be advisable to establish thematic working groups around specific policy instruments to share good practices and discuss future possibilities for joint programming, for instance in the area of policy initiatives to support industrial doctorates, in view of the proliferation of regional initiatives in this area (see sections 4.4.2 and 5.6). Several also argued that the central government should work further to strengthen its contribution towards common strategy by seeking for coherence and economies of scale, while avoiding wasteful duplication across regions. However, they noted that its approach to coordination should shift away from top-down control towards horizonal facilitation, capacity building and support and as facilitator of interregional cooperation.

2.3.3. Universities and their governance

Accounting for close to a quarter of Spain's investment in R&D, Spanish universities deserve dedicated and separate discussion about their governance because of their unique status and split allocation of policy responsibilities between central and regional governments. The governance of higher education encompasses the structures, relationships and processes through which, at both national and institutional levels, policies and practices for higher education are developed, implemented and reviewed. It comprises a complex web of the legislative framework; the characteristics of the institutions and how they relate to the whole system; how money is allocated to institutions and how they are accountable for the way it is spent; as well as less formal structures and relationships that steer and influence behaviour (OECD, 2008[41]).

In 1983, the University Reform Law set out for the first time the principles for Spanish universities under democracy. It granted more autonomy to universities, strengthened research and set the formal basis for knowledge transfer. This reform allowed universities to establish their own criteria to select researchers, organise, and structure their departments and research groups. The 1983 Law also introduced a collegial model of governance that has prevailed since. The Organic laws of 2001 and 2007 subsequently added modifications to the Law of Universities, and changed certain procedures, but the governance has remained the

[27] https://eur-lex.europa.eu/legal-content/ES/TXT/HTML/?uri=CELEX:52020SC0508&from=EN

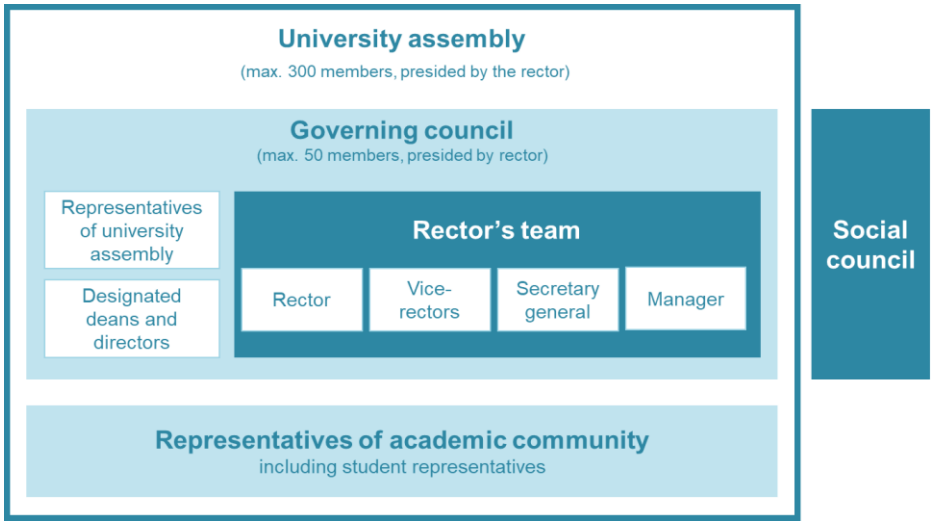
same although the landscape has significantly evolved in several ways not foreseen at the the outset.

According to the 2007 Organic Law of Universities (LOU)[28], a university, public or private, provides a public service through research, teaching and learning, and its obligations to society are:

- The creation, development, diffusion and criticism of science, of techniques (technology) and culture;
- The preparation of students for professional activities which require knowledge, scientific methods and artistic creation;
- The diffusion, evaluation and distribution of knowledge for culture, the quality of life and economic development;
- The distribution of knowledge and culture by university extension and lifelong learning.

According the LOU, the main governing individual roles and collegial bodies of Spanish public universities are the following (Figure 26) (Gobierno de España, 2007[42]):[29]

Figure 26. Main governing bodies in Spanish Universities



Source: Author's own elaboration based on Conferencia de Consejos Sociales (2020[43]) and Universitat de Girona (2021[44])

- The **rector**, the highest academic authority elected directly by university representatives or indirectly by the university assembly. The rector governs and manages the university, develops strategic lines of action approved by the collegial bodies below mentioned. The rector is elected by the university assembly or by

[28] A project to reform this Law is currently underway. See section 6.1.3

[29] Private universities determine their own governance structure and internal rules. However, the representation of the university's different groups needs be assured in each of the internal governing bodies, with a satisfactory gender balance. Bodies with responsibility for academic matters should have a majority of teaching and research staff. Nominations for individual positions also need to consider certain requirements such as, for some positions, holding a doctoral degree.

members of the academic community (mainly professors with doctoral degrees who are permanent employees of the university), as required by the university's statutes, which also regulate election procedures as well as mandate length[30]. In contrast to many other countries, rectors in Spain can only be selected among full professors (*catedráticos*) with permanent positions within the same university prior to their appointment.

- The **rector's team** *("equipo rectoral*" or "*consejo de dirección*"), selected by the rector, assists the rector on the tasks alluded to above. The team comprises a) the vice-rectors (auxiliaries to the rector who manage activities delegated by the rector), b) the secretary general ("*secretario general*"), who acts as a secretary to the various governing bodies, and c) the manager ("gerente"), who manages the administrative and economic services of the university.

- The **governing council** ("*consejo de gobierno*"). This body, presided by the rector, includes the secretary general, the manager and a maximum of 50 members including the vice-rectors and representatives of the university community. This governing council establishes the strategic and programmatic lines of the university in the areas of teaching, research and knowledge transfer, and guidelines for their application. It is responsible for the functioning of the university and the application of the strategy. Since the 2007 LOU reforms, up to three external members to the university (from the social council – see below) can be part of the governing council. With such a limited presence, this represents more of a testimonial external presence rather than an effective voice.

- The **university assembly** ("*claustro*"): it is presided by the rector, the secretary general and the manager and has a maximum of 300 elected members pertaining to the academic community including student representatives. The *assembly* is responsible for the election of the members of the governing council and can elect the rector. It approves the programmatic lines set-up by the governing council and can formulate recommendations and proposals for approval by the governing council.

- A supervising entity, the **social council** (*"consejo social*"), which includes representatives of firms, trade unions and representatives of the government of the region within which the university is located. Social Councils also include members of the Governing Council, namely the rector, the secretary general and the manager ("*gerente*") as well as a representative of the university administration and a professor designated by the Governing Council. Each region establishes its own legislation for Social Councils (although tasks and mandate remain the same across the country) and the president is nominated by the respective government of the region. The Conference of Spanish Universities' Social Councils (CCS), created as an association in 2005, supports the activity of Social Councils. The mandate of these social councils is to connect universities with society, promote universities' relationship with its surrounding communities through economic activities and services and seek external funding for university activities. To this end, they adopt an annual plan with activities to promote the relationship between university and social, cultural, and economic stakeholders. Social councils also approve the budget and the multiannual strategic

[30] The Conference of Rectors of Spanish Universities (CRUE) represents an ensemble of 50 public and 26 private universities. Within CRUE, the Sectoral Commission on R&D and Innovation is involved in two domestic working groups relevant to knowledge transfer: the Network of Research Management Units (REDUGI in Spanish) and the Network of University TTOs (Red-OTRI).

programme set by the governing council of the university. The specific competences vary according to the different regional regulations, generally including[31]:

- Liaising with academic stakeholders to ensure that external stakeholders are involved in the establishment of education programmes for students;
- Advising the governing bodies on decision-making and approving the annual budget of the university;
- Promoting the relationship between universities and surrounding communities, through knowledge transfer activities and adaptation of its activities to the needs of society;
- Gathering information, surveys, reports to collect information and inform other decision-making organs within the university.

The categories described do not neatly correspond with the canonical roles of institutional governance, since the governing council in Spanish universities combines executive committee and governing board-like functions, to the detriment of social councils. The governance of public universities in Spain is organised in a way that ensures the representativeness of its own communities (e.g. academic staff, non-academic staff and students) in its governance.

The OECD Review of Tertiary Education in Spain (OECD, 2009[45]) reflected on Spain's university governance and its unique type of participatory and representative government, associating it to a logical reaction to the control imposed from outside the universities during the dictatorial regime. The review pointed out that attempts to limit the tendency for universities to be inward looking, such as the establishment of Social Councils, had not been successful in meeting the objectives established for them by the LOU to act as a bridge between society and the university, as discussed in Box 5.

Our own study tends to coincide with the 2009 assessment of Spain's university system in describing it as fundamentally "supply-driven and producer-dominated" and "academically-driven and inward-looking". These features put it at a disadvantage when it comes to responding to the diverse needs of the present-day economy and society, as well as slow in adopting new management practices. The collegial governance arrangements have paradoxically resulted in a system that is significantly exposed to politicisation of university life which results in a significant degree of structural inertia. University governance arrangements, as they stand, are not particularly conducive to knowledge transfer and collaboration, as the following sections will show in greater detail. Universities have autonomy within the restrictions imposed by their multi-layered regulatory framework. A notorious set of restrictions which limit the discretion of universities concerns staff recruitment, pay and promotion (Box 6).

[31] Conferencia de Consejos Sociales (2020[43])

Box 5. The challenge of bringing Spanish society into universities' governing institutions

The OECD review of Tertiary Education of 2009 concluded that an influential external membership in institutional governing bodies would likely bring a range of benefits in Spanish universities, by providing useful perspectives and insights, enhancing the relevance of tertiary institutions to their communities and promoting greater accountability. More than a decade later, progress on this front has been limited, revealing a preference for maintaining universities' corporate identity (membership being effectively confined to academic, non-academic staff and students) but probably at the expense of innovation and engagement with society.

The 2009 OECD review recommended at the time that "educational authorities should consider, and consult on this with the institutions, the possibility of giving Social Councils more significant powers". Granting some specific powers to this body – e.g. effective financial oversight; agreeing and revising the mission and setting the broader strategic plans of the institution, as advised by and in consultation with the academic staff; oversight of senior post-holders – could encourage the active participation of external stakeholders. The review observed that when councils have real powers, external members tend to take them very seriously and it is possible to recruit both wise and influential people to help institutions to shape their future.

As revealed throughout interviews with Spanish and international stakeholders, knowledge transfer and collaboration between university and business in particular may have been hampered by the prevailing governance arrangements that curtail the influence of society on how universities make use of public resources. The rather modest contribution of social councils to decision making within universities raises questions about the extent to which they and the system under which operate is truly fit for purpose. From the evidence that our project has gathered, social councils appear to:

- be subject to inconsistent membership appointment procedures and lack clarity on the expectations that go with the role, including the level of commitment;
- lack resources to fulfil their functions or the statutory autonomy to secure and utilise those resources to fulfil their objectives;

While an improved governance arrangement solution could be based on the strengthening of the role and capacities of Social Councils, this would be neither necessary nor a sufficient condition for greater engagement. Universities should also aspire to equip themselves with greater management capacities by removing many of the existing barriers to attracting the necessary talent. More substantive reforms could be envisaged such as rethinking the current dual system and implementing a consolidated arrangement in which external membership can be effectively incorporated, attracting truly committed members of industry and civil society into the governance of universities.

Source: OECD, partly based on OECD (2009[45]).

Box 6. Human resource management at Spanish public universities

Spanish public universities employ mainly two categories of staff: teaching and research staff and administrative and support staff. **Teaching and research staff** (PDI, *Personal Docente e Investigador*) (or academic staff) comprise civil servants in public institutions (*funcionarios*), who enjoy nearly unconditional tenure, and various categories of salaried employee staff (or non-civil servant staff). Civil servant university teachers belong to a category that is regulated at the national level by the national government, although they are actually employed and paid by universities that are under the jurisdiction of (and principally funded by) autonomous regions. This civil service regime, which shares features with OPIs and other parts of the research system, is "the mechanism" through which academics in Spain can achieve fully tenured status. This allows for preserving academic freedom but involves several rigidities for both employers and employees. It is worth noting that in Spain, progression in several public service functions such as health and teaching also involves career paths, defined by the nature of the employer, expected to lead onto or even start as tenured civil service-like roles. The rationale for this is linked to the need to protect individuals from politically motivated patronage in the allocation of public sector jobs. The resulting safety of these jobs has contributed to making the pursuit of civil service careers a major social aspiration across different generations. This landscape makes it difficult, in the absence of credible long-term higher education and research funding commitments, to conceive, agree and implement flexibility-inducing reforms that do not result in diminished employment protection in academia and public research compared to the *status quo* or that can at least compensate for it.

Categories of civil service academic staff at public universities include full professor (*catedrático*), associate professor (*profesor titular* or *catedrático de escuela universitaria*, CEU) and college professor (*profesor titular de escuela universitaria*, a category designed for teaching in first cycle professional courses). Salaried employee academic staff are also divided into several categories, which may vary across autonomous regions. Some have a permanent labour status (a novelty, with specific regulation since 2002), while others are on fixed-term contracts in the early stages of their academic career. Within adverse budgetary settings, the system "adjusts" itself including by reducing the supply of tenured positions, leading to lengthening queues to see employment terms to be converted from fixed term to permanent, as well as from labour to civil service status. This plays an important motivational role in academic careers, often at the expense of external engagement and mobility.

In the complex and lengthy procedure for the selection and hiring of civil servant (tenured) academic staff, applicants are screened mainly in accordance to their research achievements by evaluation commissions comprising full professors with a track record in research in the area concerned. The competition is organised at national level, and those deemed qualified become eligible to enter the internal competitive process organised by universities with an open position in the relevant area. Selected individuals are then formally made members of the civil service. In spite of the formal requirements aimed at guaranteeing a fair competition at national level, this system has allowed the development of a considerable degree of "inbreeding", with many universities recruiting candidates from their own ranks. Acknowledging this failure, a new selection system was put in place by two regulations of 2007 (Real Decrees 1312 and 1313) and henceforward all those who want to be eligible for civil servant positions at universities must undergo an "accreditation" procedure organised by the national quality assurance

agency (ANECA) with more objective criteria for the evaluation of their merits. Only those who get this "accreditation" may apply for positions open at individual universities, the latter now being responsible for organising their own selection procedures.

Administrative and support staff (PAS, *Personal de Administración y Servicios*) (or non-academic staff) employed at public universities are subject to the same division between civil servants and salaried employees. Responsibilities include supporting, assisting and advising academic staff and fulfilling administrative and management functions in areas such as human resources, administration, financial matters, data processing, record keeping, libraries, laboratory maintenance, information and general services. Personnel at technology transfer offices (TTOs, OTRI in Spanish) often fall under this group. Various categories of staff often work together in the same administrative department, doing the same work without enjoying the same benefits.

Source: Adapted and updated from OECD (2009[45])

Spain's university system has been described as under-diversified in terms of its educational offer and specialisation. There are however instances of public universities making greater use of their autonomy to adopt more internationally competitive models, such as those of Pompeu Fabra University in Barcelona and the University Carlos III of Madrid, among others.

The relationship between institutional funding and performance in Spanish universities is still relatively underdeveloped, as formula-based funding, targeted funding and the use of performance indicators in formula-based funding are not common practice across the country. In some regions where formula-based funding and targeted funding have been established, the extent to which public funding, coming mostly from the autonomous regions, relates to indicators of the quality of services provided is rather limited. This limits institutional incentives for the strengthening of quality across all dimensions of university activity. There has been some slow progress in introducing strategic components among the streams used to fund institutions, particularly in connection with regional smart specialisation strategies, but a modest level of funds are allocated on a targeted basis to achieve explicit objectives, limiting the extent to which public institutional funds help steer universities towards a better alignment with national, regional and local economic and social goals (OECD, 2009[45]).

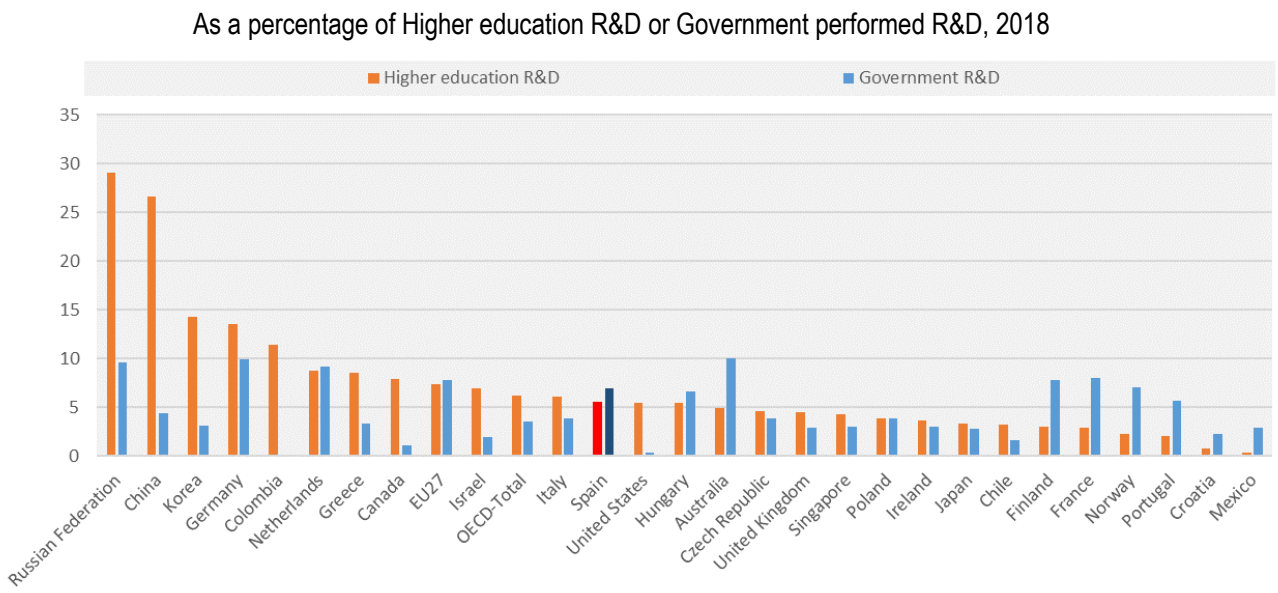
3. A picture of science-business knowledge transfer and collaboration in Spain

3.1. Knowledge transfer and collaboration from the business perspective

3.1.1. Indicators of business collaboration with the research base

Indicators of R&D funding flows across sectors show how the lack of R&D capacity in the business sector, already explored in section 2, limits the scope for business funding of R&D carried out in universities and public research organisations in Spain. This is particularly the case in comparison with countries like Germany and Korea, although the share of higher education R&D financed by business is not so different from the OECD/EU averages (Figure 27). The same can be said about the role of business financing for R&D performed within government institutions.

Figure 27. Financing by business of R&D in the Higher Education and Government sectors



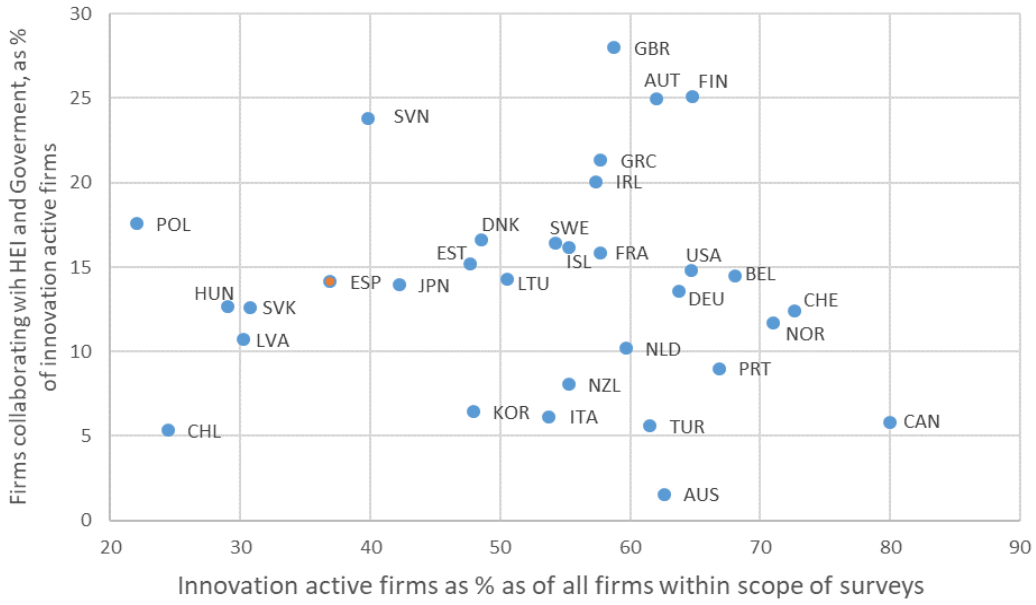
Source: OECD R&D Statistics, http://oe.cd/rds

Data on extramural R&D funding by business provides another indication, from the perspective of business, about which partners are generally more trusted to carry out R&D on behalf of Spanish companies. Spanish businesses prefer to outsource R&D activity to other firms (which as indicated in previous sections includes the majority of technology centres), within or outside their group, rather than to domestic universities or PROs, who only account for close to 7% of business extramural R&D funding. This share, although apparently small, is broadly in line with other countries. Excluding business R&D funding to other domestic or international affiliated business, this share goes up to 11% of R&D funded among on an arms-length basis.

The contractual and collaborative funding mechanism allows firms to claim a share of the resulting outputs from the R&D work carried on their behalf out by universities or PROs, depending on the arrangements emerging out of negotiations. Companies can access the outputs of higher education and PRO R&D activities in other ways not captured by this indicator, for example by directly acquiring the rights to the resulting IP or by acquiring the spin offs that grow out of HEIs and PROs.

Indeed, if one looks at the extent of collaboration between business active in innovation[32] and the ensemble of HE and public research organisations, Spain's profile is largely in line with the average at close to 15% of firms having that sort of collaboration in place. However, in relation to the total number of firms, the overall extent of collaboration is limited because of the rather small share of companies in Spain (only over a third over a three-year reference period) that engage in innovation activities (Figure 28). This helps identify one of the key obstacles to knowledge transfer and collaboration (KTC) in Spain, namely the lack of capacity in the system to drive demand for inputs for innovation. An increase in such demand would likely lead business to identify suitable avenues for engagement with the science and research base in Spain.

Figure 28. Innovative businesses and collaboration with higher education institutions, 2014-16



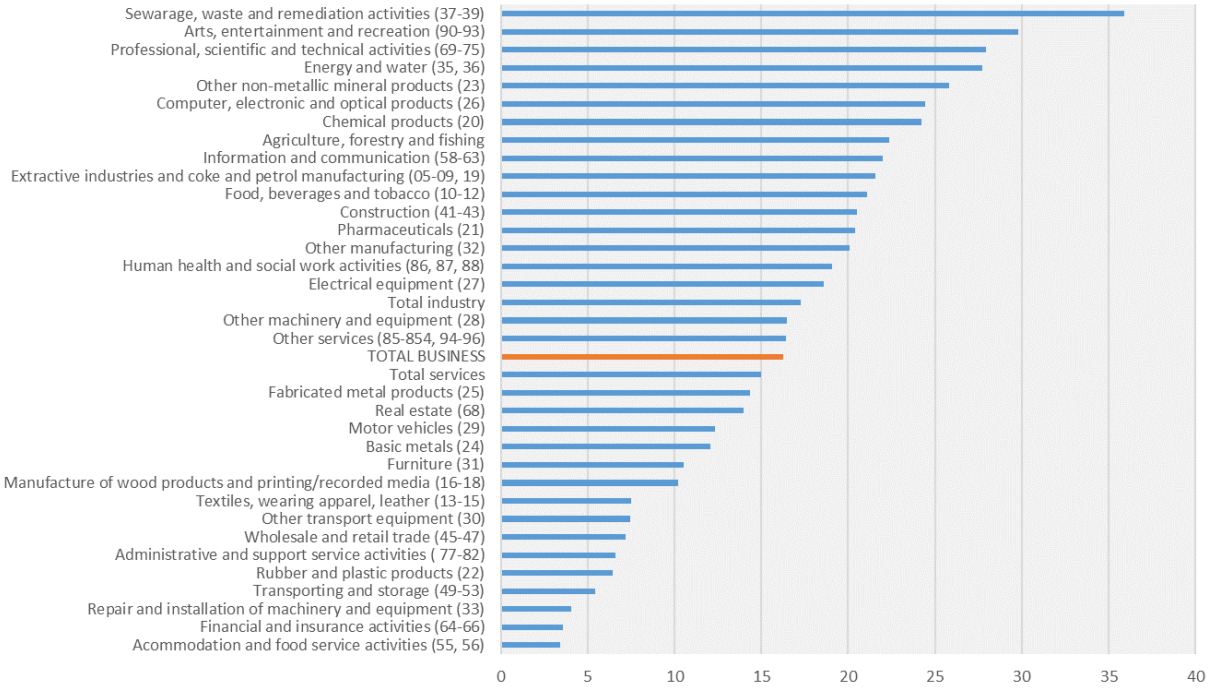
Source: OECD Business Innovation Statistics, https://oe.cd/innostats

Figure 29 shows how industries differ in terms of PSR oriented collaboration intensity, highlighting that differences between manufacturing and services are not that marked and that differences appear to be more related to aspects connected with the ability of PSR institutions to provide knowledge-based solutions to the problems faced by these industries. Agriculture, food, extractive, water treatment, chemical and pharma and ICT industries, in addition to professional services, are the industries with relatively higher close connection in Spain to the PSR. Services such as logistics, repairs, hotels and restauration, and even high tech industries such as transport equipment, tend to collaborate relatively less often with PSR institutions, largely reflecting that the main innovation partners can be counted among their suppliers and customers.

[32] A business innovation is a new or improved product or business process (or combination thereof) that differs significantly from the firm's previous products or business processes and that has been introduced on the market or brought into use by the firm.

Figure 29. Industries by degree of innovation collaboration intensity with PSR institutions, 2018

Percentage of innovation collaborating firms citing Universities and PROs as main innovation partners

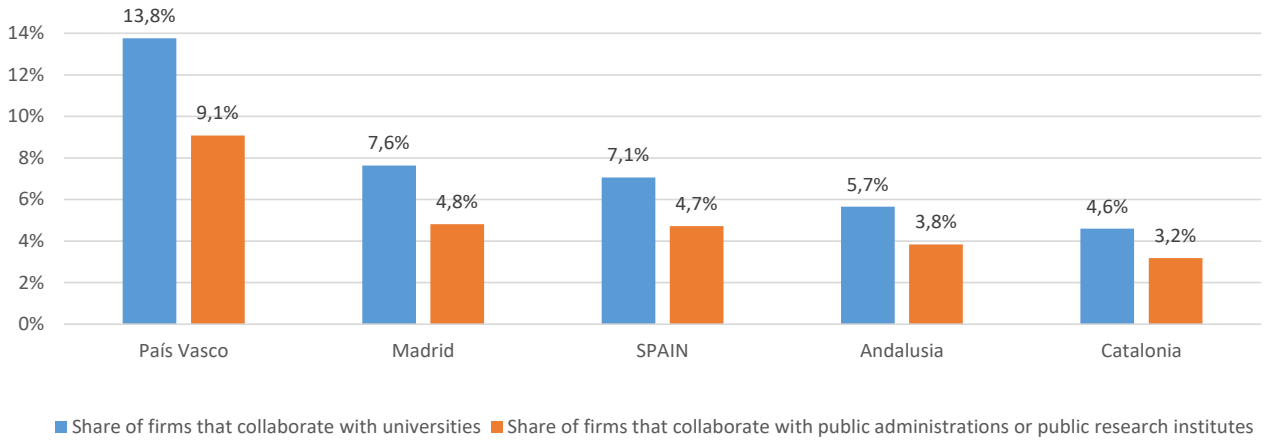


Note: This is an indicator of the relative (not absolute) importance of PSR institutions as collaboration partners for innovation relative to other actors in the system.
Source: INE. Business innovation survey 2018 statistics. CIS2018.

While these results need to be analysed in more detail, they help identify where collaboration with PSR is less of an attractive proposition for firms, and may also suggest that collaboration may not be necessarily oriented towards actual outcomes of R&D activities.

Figure 30. Firms that cooperate in innovation with universities or public institutions, 2019

As % of innovative firms, within selected autonomous regions



Source: OECD calculations based on INE (2020), Business Innovation Survey 2019, https://www.ine.es/dyngs/INEbase/es/operacion.htm?c=Estadistica_C&cid=1254736176755&menu=ultiDatos&idp=1254735576669

The Spanish innovation survey reveals different propensities of firms to collaborate with universities and public research institutes across Spanish regions, pointing again to the Basque Country as the most advanced region in this regard (Figure 30). There are also differences across regions with respect to the main actors engaged in science-industry collaboration and to the policy approaches used to foster such linkages.

3.1.2. Insights from stakeholder interviews

A number of barriers to science-industry engagement were highlighted during interviews with business representatives. Although some are common to all types of firms, it is important to note that the capacities and demands on public research differ significantly across firms (SMEs, large firms, multinational firms) and sectors, and thus the obstacles faced also depend on those factors.

Barriers resulting from the sectoral composition of the economy and the weak tradition of science-industry collaboration in Spain include the following:

- **Low levels of absorptive capacity[33] of Spain's productive system**: As documented in section 2, the structure of Spanish productive system is characterised by high share of SMEs in low-tech sectors that invest little on R&D and innovation activities. This hinders their levels of absorptive capacity and thus their ability of recognising the potential benefits of engaging in collaborations with research organisations. Stakeholders coincide in pointing out that initiatives to support collaborative R&D activities are too complex and demanding for most business to attempt to engage in them.

- **Low levels of trust**: Mistrust (mostly due to the lack of previous interactions, low awareness about each other's activities and the use of different 'languages') is also preventing companies, universities and research centres from building and strengthening ties. Some stakeholders highlighted that actors in the PSR sometimes distrust business commitment to investing in knowledge. Some stakeholders even mentioned that a minority part of the research community still hold some prejudicial or "hostile" attitude against companies. In turn, companies often do not feel confident in hiring individuals coming from the PSR as they fear they may lack motivation, seek to pursue their own independent agendas or lack the necessary skills to function in fast paced, solution driven environments.

- **Low awareness of the research activities conducted in the PSR**. Companies (particularly SMEs but also large firms in mid- and low-tech sectors) often lack awareness of potentially relevant R&D activities carried out in universities and research centres, even when these may be closely related to their activities. This is much more the case when they are located at a certain geographical distance. To address this barrier, several stakeholders highlighted the need of developing a centralised catalogue of research groups/projects and key competences of universities and PROs across the country, as well as catalogues of commercialised technologies developed by those institutions. These would increase the visibility of the existing offer of knowledge and technological capacities in universities and PROs, and would reduce searching costs involved in the identification of potential partners. Initiatives such as the CONNECTA Platform, created by CTA, goes in this direction.

  It is important to note however that the relevance of this barrier highly varies across firms and sectors. Firms in science-based sectors, such as biotech, have strong

[33] Absorptive capacity is defined a firm's ability to recognise the value of external knowledge, assimilate it, and apply it to commercial ends.

connections to universities and PROs (in many cases firms themselves emerged as spin-offs of those organisations), and appear to be more aware of the research projects being conducted and the teams being engaged in research related to their activities.

- **Differences in research agendas and timelines of public researchers and business**. Public researchers are often engaged in long-term lines of research and driven by the objective of advancing the frontiers of knowledge in a specific area. Such research agendas are often disconnected from market considerations and PSR researchers may themselves lack the interest of motivation to pursue themselves such avenues. In turn, firms tend to be interested in shorter-term engagements to progress in the development of specific marketable solutions or the improvement of their internal processes.
- **Differences in knowledge transfer and exchange practices across research institutions.** The lack of common, standardised procedures for knowledge transfer activities across institutions is also a source of confusion and can in some cases have a deterrent effect for companies that would consider engaging in collaborative R&D and innovation activities.
- **Innovation culture is not sufficiently embedded in business strategies**. Several interviewees in all sectors argued that a majority of companies in Spain do not have long-term innovation strategies, and innovation activities take place in a non systematic, ad hoc fashion. Some stakeholders also highlighted that internal evaluation of R&D and innovation departments are often too focused on short term financial aspects. In this context, subcontracting research activities from universities and PROs is considered a cost, instead of an investment that can critically contribute to improving their products or processes and therefore the long-term performance of firms.
- Multiple factors contribute to a **biased and all too limiting perception of innovation as a necessarily R&D-based activity restricted to specific sectors**. Companies not fitting that mould often fail to properly account for their innovations as they organise themselves, seek assistance from and report to third parties. Factors contributing to this include the very unique use in Spain of the triad "I+D+i" or just IDI, to denote R&D and "lower case i" for innovation when referring to policies, targets or activities, the reiterated use of the term "technological innovation" around policy statements and accreditation schemes (Box 7). This is also compounded by the fact that up until now the collection of data on general innovation within Spanish businesses takes place within the same official survey oriented towards the collection of data on R&D from firms. As it has been documented for several countries that transitioned from an R&D framed innovation survey to a self standing one, subject framing can account for a sizeable part of the measured innovation gap between countries (OECD/Eurostat, 2018[6]). This appears to have contributed to some mistrust in published figures. Decoupling the surveys would require a non negligible investment and careful design in order to avoid over burdening enterprises with survey completion requests.

Box 7. The official "innovative SME" status in Spain

Regulated by a public order of 2015 and restricted to SMEs, the conditions that define the eligibility as innovative SME include different possible avenues:

- Receipt of public support in the previous 3 years a) under the framework of the State Plan for Science, Technology and Innovation; b) from R&D&I projects awarded by CDTI; or c) from the European Framework or Horizon programmes
- Demonstrable eligible activity:
  - Own patent holding.
  - Project approved for R&D tax incentive purposes.
- Being accredited according to any of the following standards:
  - Young innovative firm (JEI), according to national AENOR EA0043 standard.
  - Small or micro innovative firm, according to AENOR EA0047 standard.
  - Certified under UNE 166.002 « I+D+i management systems».

Being in possession of the innovative SME status results in the accredited firm being listed in a public register (https://sede.micinn.gob.es/pyiINFO/) and entitles the firm to use the official "innovative" label. As of the 20 July 2021, there were 4371 firms in the register. One of the intended uses of the credential is to facilitate access to public procurement of innovative solutions that do not exist in the market. The so-called innovative status also allows SMEs to benefit from relief on social security contributions and enables them to access a number of public financing lines from the Official Credit Institute (ICO).

Source: BOE num. 139, of 11 June 2015, https://www.boe.es/eli/es/o/2015/06/05/ecc1087

A number of **regulatory and bureaucratic barriers** were also highlighted as posing important obstacles to such engagement. These are explored in more detail in section 4.3. Among them, it is worth highlighting the bureaucratic burdens that exist to process collaboration agreements with public institutions. The 2015 Law on the Legal Regime of the Public Sector sets multiple steps to be followed by any entity that aims to establish a collaboration agreement with a public entity. These procedures pose an excessive bureaucratic burden for companies (especially SMEs), and discourage or delay the start of collaborative activities. The models adopted by technology centres (outside the public sector) as well as research centres sponsored by regional governments (e.g. through CERCA) allow for greater flexibility and agility in processing collaboration agreements. The lack of specific regulations on the ownership and revenues of intellectual property rights developed in the context of public-private research activities – which are set at the institutional level – also increases transaction costs, creates uncertainties and ultimately discourages engagement (see section 4.3.4).

Stakeholders also highlighted a number of **factors that discourage the participation of business in policy programmes supporting science-business engagement**. These barriers are explored in more detail in section 4.4.1. Financial support mechanisms are not sufficiently attractive to firms, especially SMEs. A large part of the support under offer is only available in the form of partly-repayable loans, which require a pay-back guarantee from a bank and

adhering to strict reimbursement conditions, in addition to going through a costly process of preparation of project proposals. These processes are overall overly complex for many firms, especially SMEs that do not have experience in applying to public support programmes. One identified challenge is the difficulty in establishing effective communication between funders and potential beneficiaries while calls for support are open while ensuring fair and equal treatment of all firms. Furthermore, frequent changes in policy priorities and financial commitments for policy programmes supporting science-business engagement were also raised as factors that create uncertainty among actors and possible confusion. Long processing times between the deadline for submission of project proposals, the final resolution of the call, and the disbursement of financial support also discourage applications.

Business stakeholders have also requested **enhanced policy support in several areas**, in particular the following:

- increase the resources and capacities of technology transfer offices and other knowledge intermediaries (see sections 3.4 and 6.2.4)
- more (seed) funding and intermediary support for spin-offs and science- and technology-based start-ups (see section 4.4.6);
- investments in demonstration facilities that are open to firms, following other international examples such as the *Mittelstand* 4.0 Competence Centers in Germany. These infrastructures, which would also count with highly qualified experts, would enable firms to test new technologies in real-world environments (see section 4.4.5)
- streamline and address current challenges that prevent a wider use of R&D tax incentives by firms, and consider the possibility of including tax deductions for collaborative R&D activities in the entire territory (see section 4.4.7);
- increase the use of public procurement of innovation solutions, by building capacities within the administration to effectively implement such programmes (see section 4.4.7).

3.2. Indicators of knowledge transfer and collaboration from the perspective of scientists and researchers

It is particularly important to gain a researcher-based view of knowledge transfer and collaboration on aspects that are particularly hard to capture from an institutional perspective. Unweighted, provisional results from the 2021 OECD International Survey of Science (ISSA) – based as of July 2021 on over 500 responses while still in the field – provide several insights on the degree of knowledge transfer and collaboration between scientists and business as well as the factors that contribute to it.[34]

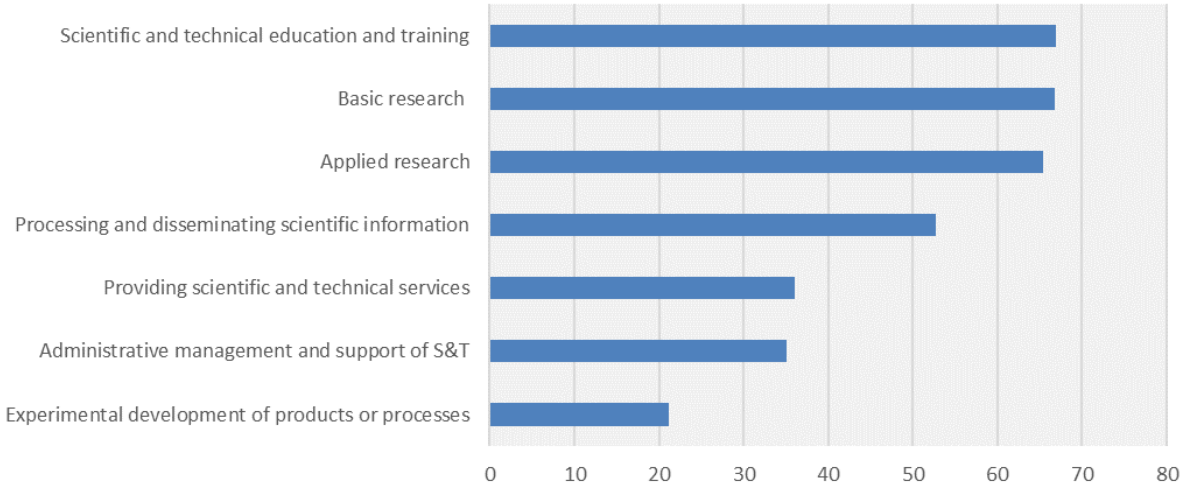
As shown in Figure 31, the self-reported activities and outputs of the majority of Spanish scientists are closely connected to academic pursuits. S&T education and training coexists with both basic and applied research, as well as scientific information processing. Other

[34] ISSA2021 was designed to help inform questions on KTC arising from this particular project and was first piloted in Spain starting March 2021 before being launched globally. The median respondent for Spain is male (57% of resp.), aged between 45 and 54, has a doctorate degree (85%) and worked during the previous year (97%). Respondents in the natural sciences are majority (45%) followed by Engineering and technology (20%), and over 50% work in Higher education, with just over 40% working in Professional, scientific and technical activities (ISIC72). Over 80% are employed by public sector, non-business organisations, while a further 10% declare to be employed by business or non-profit organisations controlled by government. Over 40% work for organisations with more than 5 000 employees. As ISSA2021 advances in other countries it will be possible to provide a number of international comparisons among selected dimensions of the study.

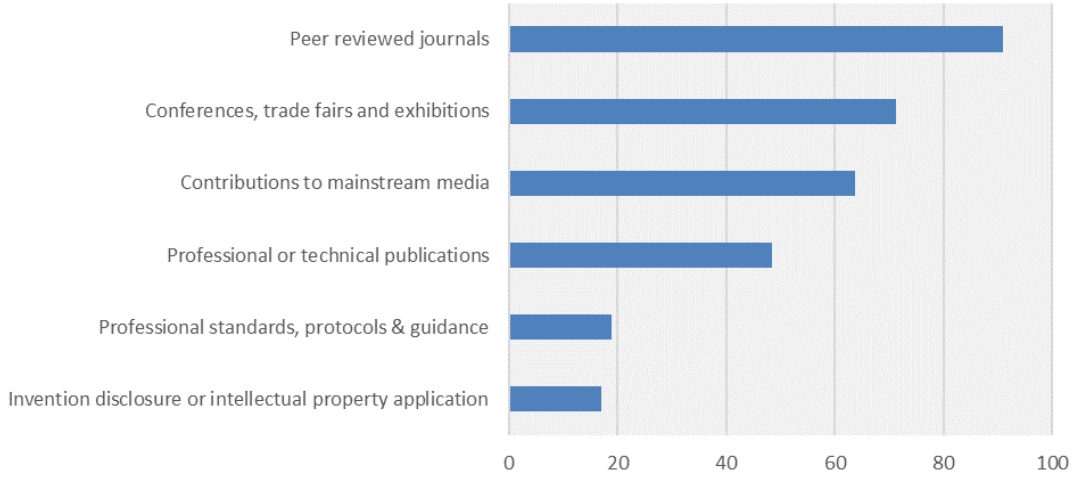
activities such as the D for experimental development in R&D and S&T services apply to a non-negligible minority. In terms of outputs, the publication of scholarly output and the communication activities related to it dominate the landscape, with some appreciable effort to disseminate results through mainstream media. Traditionally considered third mission outputs are less common.

Figure 31. Activities and outputs generated by Spanish scientists, 2020

Activities in connection with science and research, as a percentage of respondents



Outputs featuring results of scientific work, as a percentage of respondents

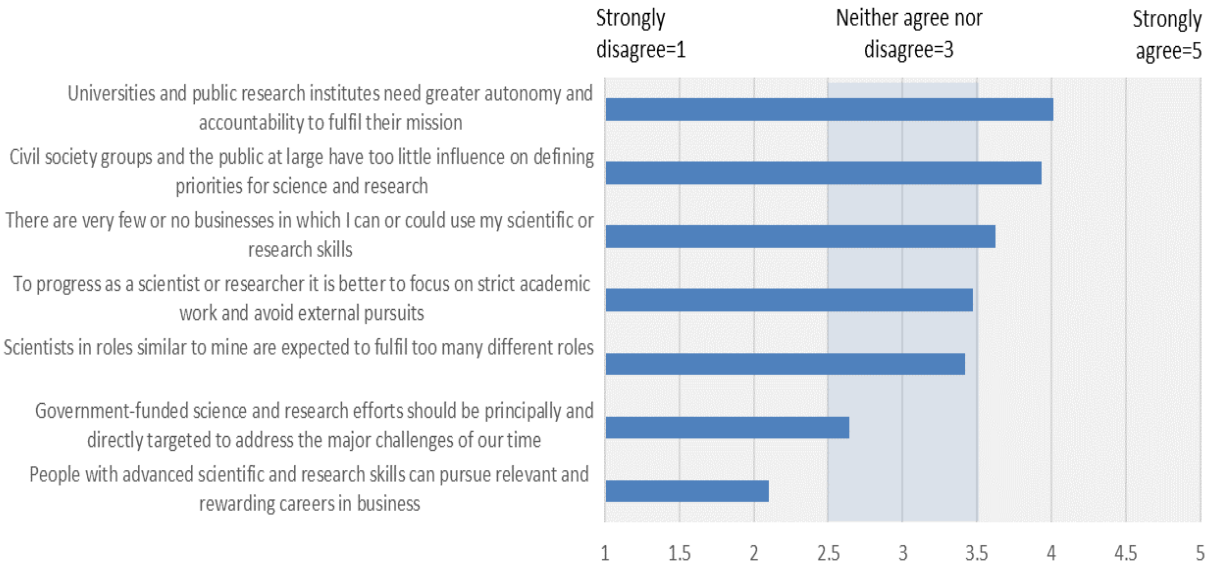


Note: Multiple answers are possible for both questions. Results are preliminary, unweighted and at this point not representative of the Spanish research community.
Source: OECD International Survey of Science, ISSA2021. Experimental and highly preliminary results.

As depicted in Figure 32, consistently with observations made in the previous section, respondents are rather unanimous about the need for greater autonomy and accountability of universities and PROs in order for them to fulfil their mission, as well as the need for greater engagement of civil society on the definition of priorities for science and research. However, they tend to disagree that public research efforts should be principally targeted to specific challenges, apparently implying that funding mechanisms should support curiosity driven research.

Figure 32. Spanish scientists' views about science careers and science in society, 2021

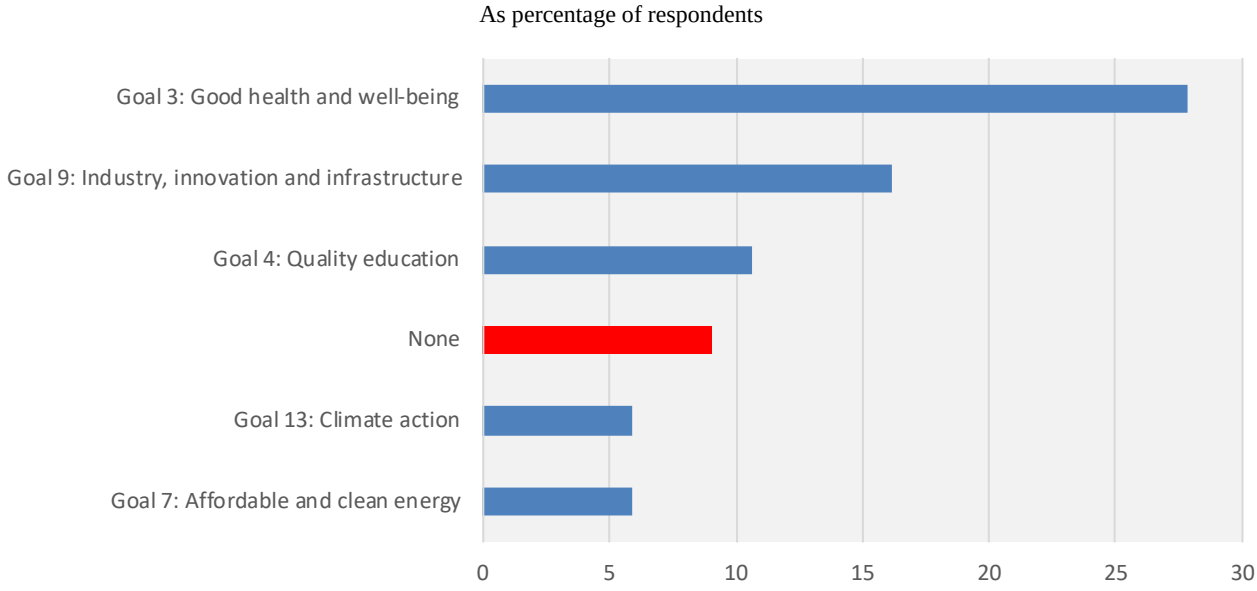
Average agreement scores among survey respondents



Note: Results are preliminary, unweighted and at this point not representative of the Spanish research community. Question only addressed to a random subset of respondents not affiliated to business enterprises.
Source: OECD International Survey of Science, ISSA2021. Experimental and highly preliminary results.

This does not imply that their research is not relevant to societal challenges; on the contrary, 92% of respondents were able to identify their work as being directly or indirectly connected to one UN Sustainable Development Goal (Figure 33). Among respondents, SDG3 on Health is the most common at 28% of cases, followed by SDG9 on Industry and innovation and SDG4 on Education at 15% and 10% of cases, respectively. This appears to imply a degree of reservation among Spanish researchers about adopting an entirely directed or mission oriented approach to research prioritisation since connections to societal goals can be both direct and indirect. At present, Spanish scientists do not generally perceive being faced with too many missions and roles (Figure 32), although this appears to be in a context in which their activities entail principally research and education/training as indicated in Figure 31.

Figure 33. Main Sustainable Development Goal addressed in research work by Spanish researchers



Note: Results are preliminary, unweighted and at this point not representative of the Spanish research community. Goals eliciting less than 5% of responses not depicted. These omitted categories account all combined for 24% of responses.
Source: OECD International Survey of Science, ISSA2021. Experimental and highly preliminary results.

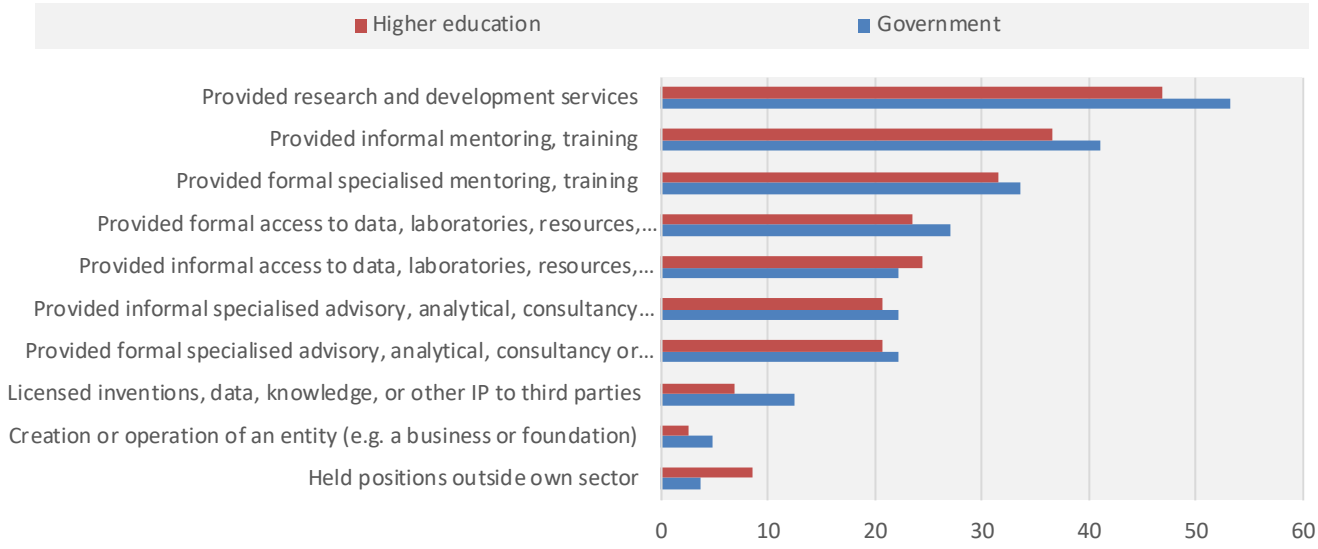
The preliminary ISSA2021 results suggest that scientists perceive an important disconnect between their research skills and research they conduct, and the demands from the market. As a result, most of them find that they are constrained from being able to pursue a relevant and rewarding career in business. This leads a significant majority to believe that in order to progress as a researcher it is better to focus on strict academic work whilst avoiding external pursuits.

When asked specifically about their knowledge transfer and collaboration activities during the previous year, close to three quarters of researchers have had at least one type of engagement activity beyond their own sector of employment. The most common form of external engagement (Figure 34) is around R&D services and collaborative projects, followed by mentoring and training and consultancy.

Informal engagement is very common, and since information about it is unlikely recorded by the parent organisation, this justifies a measurement approach that does not rely solely on institutional sources while formalisation efforts are ongoing (as prompted by initiatives like the KT sexennium dicussed in Section 4). The provision of access to research resources follows next, both formal and informal. Commercialisation activities are rather infrequent and apply to a very small minority, especially start up activity and job mobility. Patterns are fairly similar for researchers in the Higher Education and Government sector, with a slightly higher propensity for engagement within Government especially for licensing, although researchers in HE appear to be more likely to hold positions outside the sector.

Figure 34. Participation in extra-sectoral KTC activities by Spanish HE and Government researchers

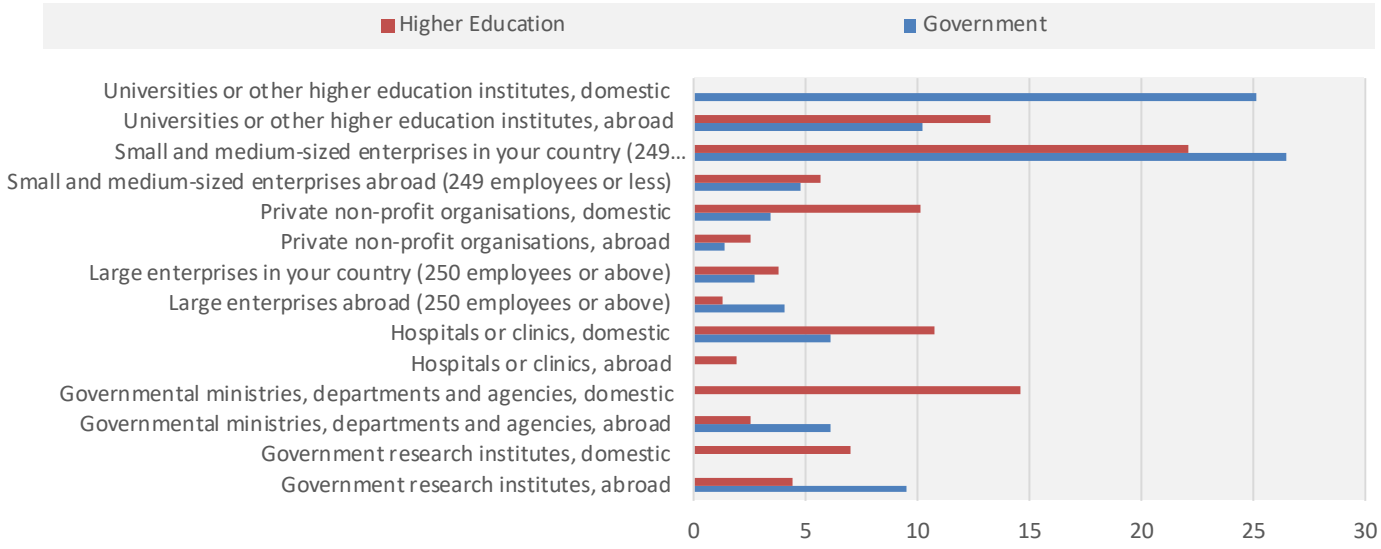
As a percentage of researchers engaged in extra-sectoral activities, by sector



Note: Results are preliminary, unweighted and at this point not representative of the Spanish research community.
Source: OECD International Survey of Science, ISSA2021. Experimental and highly preliminary results.

Figure 35. Main partners for extra-sectoral knowledge transfer and collaboration in Spain

As a percentage of researchers engaged in extra-sectoral activities, by sector



Note: Results are preliminary, unweighted and at this point not representative of the Spanish research community.
Source: OECD International Survey of Science, ISSA2021. Experimental and highly preliminary results.

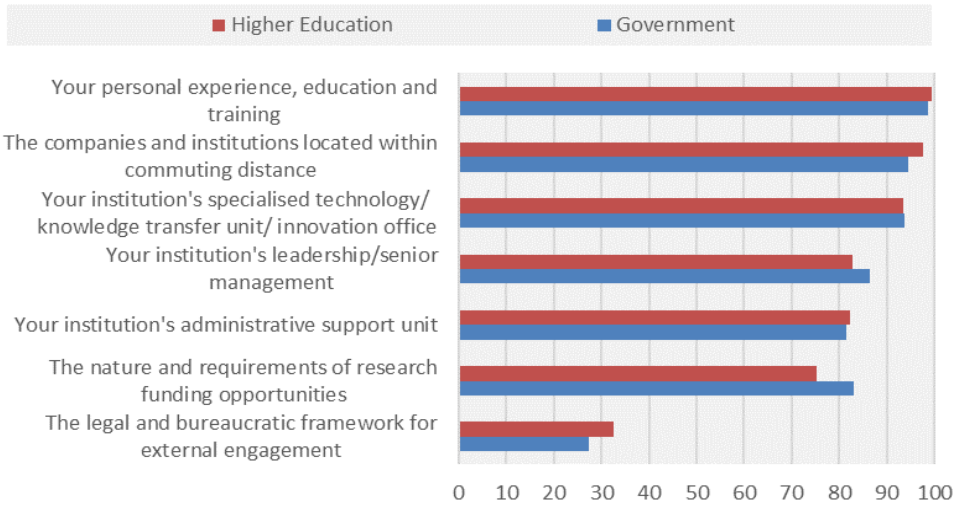
Interestingly, the most frequently reported extra-sectoral partner for both researchers in HE and government are domestic SMEs, accounting for 25% of cases which represents a ratio of over 5 to 1 in comparison with large enterprises. While the vast majority of firms in Spain are SMEs and 64% of business employment is in SMEs (see section 2 in this report), for research-based engagement this is a striking difference compared to the share of business R&D that is carried out by SMEs, which is half of the total. Researchers in government

institutions tend to cite domestic universities as main partners almost as frequently as SMEs, while respondents in Higher education institutions present a more distributed pattern, including foreign universities, domestic hospitals and private non-profit organisations.

Among the factors contributing to external engagement that respondents were asked to rate as positive, neutral or negative, the only one eliciting a consistent negative response refers to the legal and bureaucratic framework for external engagement (Figure 36). It is noteworthy the majority of positive views that respondents harbour towards the contribution of their own personal experience and competences, organisations and firms in their immediate environment, as well as that of knowledge transfer offices. The overall assessment is also positive towards senior leadership and administrative support teams. This stands in contrast with some qualitative impressions gathered throughout the project, and is probably explained by the format of the question which only elicits whether the relevant factor (or actor) is perceived as having more of positive than negative role in facilitating engagement. Other results presented below will help indeed qualify these results.

Figure 36. Factors and actors making a positive contribution to extra-sectoral engagement in Spain

As a percentage of respondents, by sector

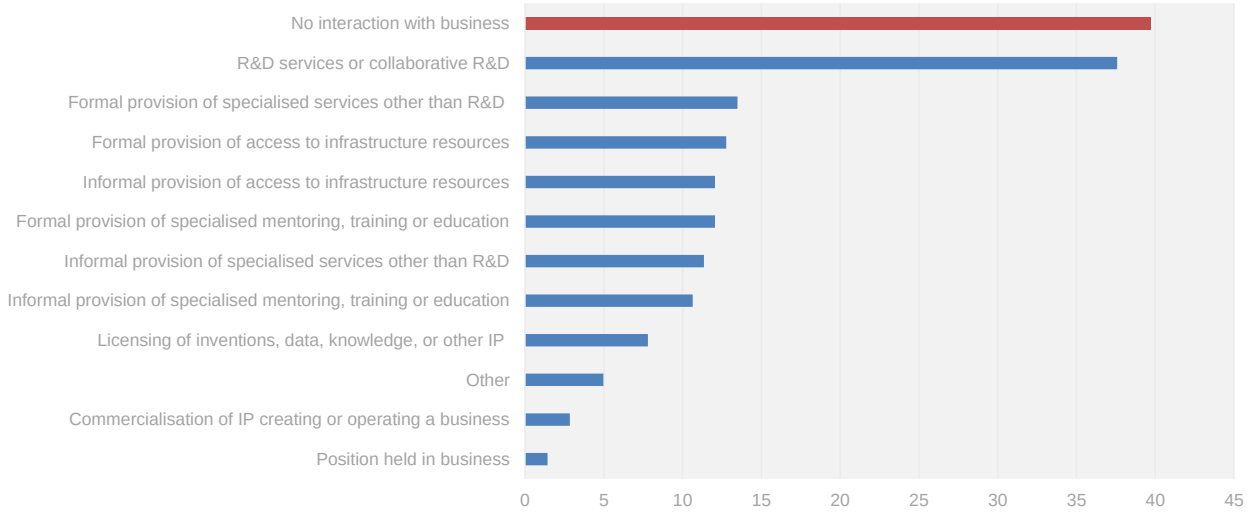


Note: Results are preliminary, unweighted and at this point not representative of the Spanish research community.
Source: OECD International Survey of Science, ISSA2021. Experimental and highly preliminary results.

ISSA2021 enquired in more detail about interactions of researchers outside the business sector with businesses. Nearly 40% of respondents point that they had had no interaction with businesses in the previous year. Among those that engaged with businesses, as for the general response, the most common channel of interaction was the provision of R&D services or the engagement in collaborative R&D activities (around 37%). Other channels are much less common, including the provision of specialised services other than R&D, the provision of access to infrastructure resources, the provision of mentoring, training or education, as well as the licensing of inventions, data, knowledge or other IP (Figure 37).

Figure 37. Knowledge-based engagement with business among Spanish researchers

As a percentage of respondents outside the business sector

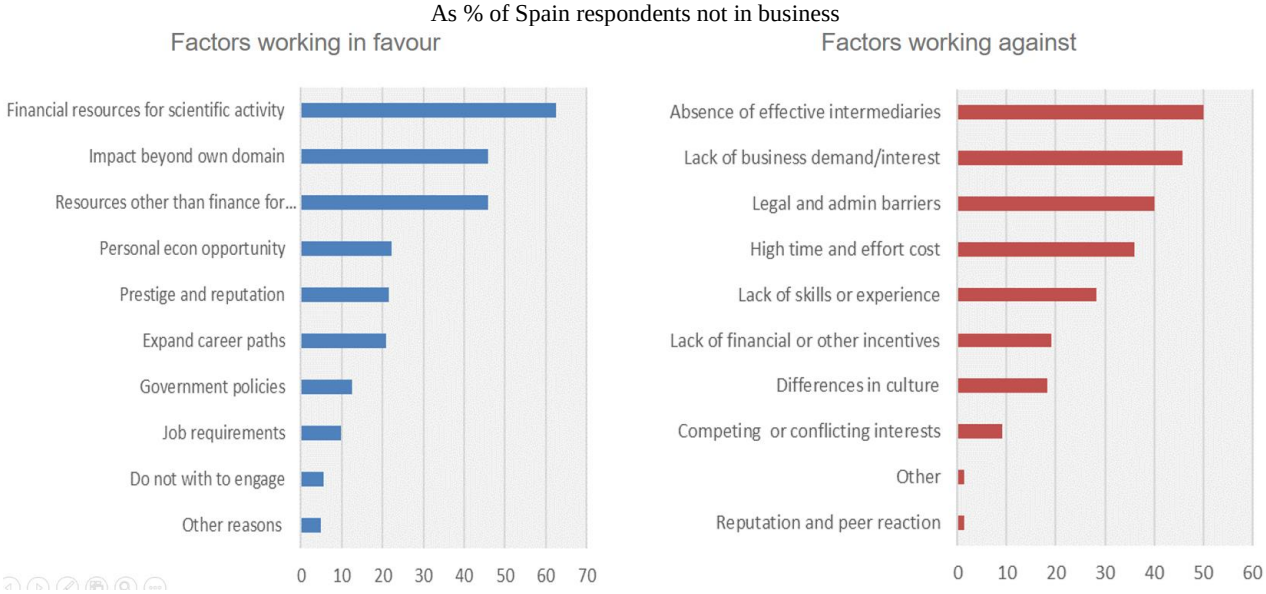


Note: Results are preliminary, unweighted and at this point not representative of the Spanish research community. Question only addressed to a random subset of respondents not affiliated to business enterprises.
Source: OECD International Survey of Science, ISSA2021. Experimental and highly preliminary results.

Over 70% of survey respondents in Spain in sectors other than business have implied expressed through their response a preference for higher levels of engagement with industry than at present, compared to just over 20% who find the current level appropriate. In light of such broad-based interest in increasing engagement, it is important to understand what factors are perceived as supportive and which ones as deterrents.

Figure 38. Positive and negative factors influencing engagement with business

As % of Spain respondents not in business



Note: Results are preliminary, unweighted and at this point not representative of the Spanish research community. Question only addressed to a random subset of respondents not affiliated to business enterprises.
Source: OECD International Survey of Science, ISSA2021. Experimental and highly preliminary results.

ISSA 2021 results suggest that the main motivation for researchers to engage in knowledge transfer and collaboration is to increase opportunities to sustain and improve their core scientific work, and to a lesser extent to have an opportunity to have an impact beyond their "domain" (Figure 38). Respondents indicate that they are however constrained by the lack demand from business for their skills, the absence of effective knowledge intermediaries and the existing legal and administrative barriers. Responses suggest that there is no perception of conflict of interest between the public and private sectors, while differences in work culture are only cited in 15% of cases. Survey responses also suggest that only a minority of researchers, under the current set up, are motivated to engage in knowledge transfer by economic and other formal factors. In turn, while universities and public research organisations may have a generic duty towards knowledge transfer, hardly any public sector researchers perceive this is part of their "job description" (Figure 38).

A study conducted by Spanish researchers (Project Extra) provides a similar picture, highlighting the following barriers (Ramos-Vielba, Castro-Martinez and D'Este, n.d.[46]):

- Institutional barriers
    - Bureaucracy and management flexibility (61% of respondents)
    - Managerial capacity (38%)
    - Lack of technical support (30-35%)
    - Conflicts of interest or unrealistic expectations (20-29%)
- Cognitive barriers
    - Risks to scientific autonomy (16-36% of respondents)
    - Risks to scientific credibility (8-14%)

Overall, these and the ISSA results, pending the completion of the survey data collection and analysis, including comparison with other countries, portray a picture of collaboration incentives in which scientists in the PSR are open to engaging with business but only under terms that are favourable to their dominant academic incentives with a view to further their research activity. So while there is no longer a cultural barrier, the types of collaboration that a significant proportion of researchers may be incentivised to engage with will not necessary match the market oriented logic and timeliness of business.

3.3. Knowledge transfer and collaboration from the institutional perspective of universities and PROs

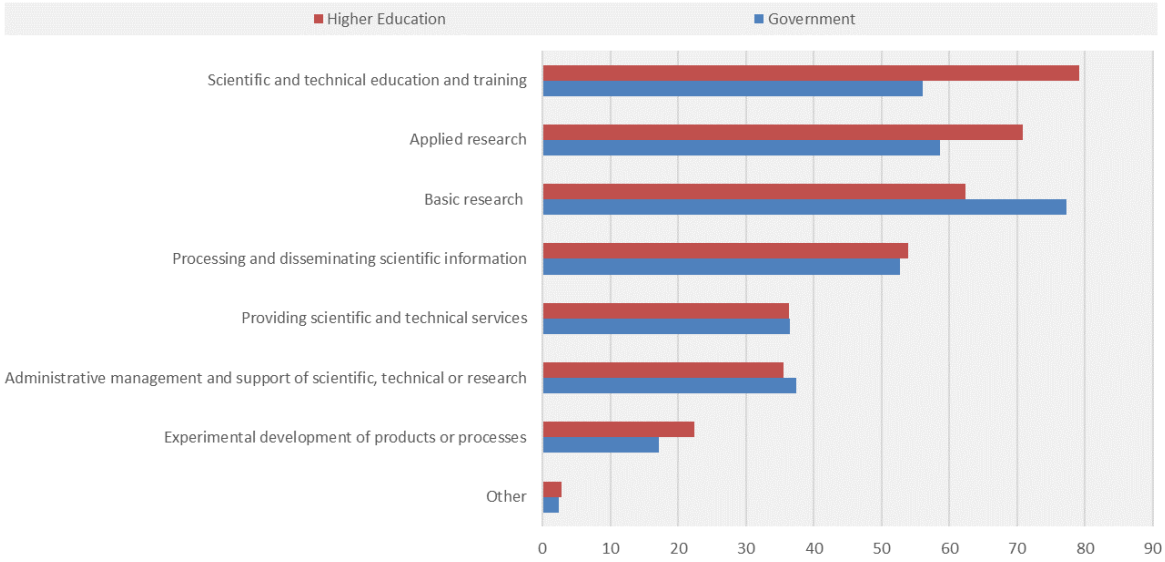
Institutions in the public system of research (PSRs) are responsible for a wide range of knowledge outputs that can be the object of knowledge circulation and exchange. They offer a range of services to society leveraging on their human resources as well as intellectual and physical infrastructures, not all of which represent outcomes of their own research and experimental development (R&D) or innovation activities as formally defined by OECD (OECD, 2015[5]; OECD/Eurostat, 2018[6]). This is particularly salient in the case of teaching, training and mentoring activities that help transform mind-sets and cannot be separated from the individuals that benefit from such services. The application of accumulated knowledge, expertise and know-how by members of the PSR to contribute to the functioning of other organisations and address their practical problems spans all knowledge domains. It represents a key mechanism for valorising such knowledge, even though they are not consistently captured in conventional statistics.

As previously indicated, Spain has a dual PSR in which both higher education and government institutions play a significant research role with a relatively high number of

institutions on both sides for a country of its size. Within PROs not attached to universities, the priority assigned to knowledge transfer varies across organisations in relation to their evolving mandate and rationale. Several others emerged, at a time when universities would prioritise teaching functions, out of the need to organise resources[35] towards basic (fundamental) and to some extent also applied research endeavours, which may potentially but not necessarily conceived to result in the development of technologies suitable for development to a higher degree of maturity and market testing. This research focus is the dominant paradigm across the majority of CSIC centres and institutes, many of which are joint with universities or other bodies. In fact, formal careers within CSIC comprise those of researcher, trainee researcher, research support technician or administrative support technician.[36] Among participants in the ISSA survey, the basic research paradigm appears to be more salient among researchers in government than in higher education institutions (Figure 39).

Figure 39. Research-related activities in Spain, government and higher education compared

Percentage of ISSA2021 participating researchers reporting each activity, within each affiliation group



Note: Results are preliminary, unweighted and at this point not representative of the Spanish research community.
Source: OECD International Survey of Science, ISSA2021. Experimental and highly preliminary results.

However, many PROs or units within them have in their roots a mandate to address defined economic and social impacts priorities, having close ties with industry and government users. Among those with OPI status[37], one may list within the former category the likes of INTA (dependent of the Ministry of Defence and closely related to the aerospace sector), ISCIII

[35] The Spanish National Research Council (CSIC), founded in 1939, is the successor of the Committee for Extension of Studies and Scientific Research (JAE), created in 1907 and whose first president was Santiago Ramón y Cajal. The CSIC continued to lead scientific activity in Spain but gave more importance to applied science than its predecessor (https://www.csic.es/en/csic/about-csic/history).

[36] It is often ignored that the concept of researcher in the OECD Frascati Manual applies not only to those who are responsible for the oversight of research activity but also experimental development activity, thus including more senior engineering and technical roles, i.e. researchers *and developers*.

[37] Several PROs with an applied orientation, e.g. towards specific diseases or challenges, particularly those of new creation, operate in many instances along a broader technological maturity spectrum.

(with its close ties to the Health ministry and health sector), as well as several CSIC institutes and also a number of former OPIs very recently integrated into the CSIC structure, such as IEO, IGME and INIA, with their strong applied focus on the areas of marine resources, mining and extraction and agro-food, respectively. CIEMAT had as its foundational mandate the need to support the development and safe implementation of nuclear energy in Spain, recently evolving towards renewable energies. Last but not least, while IAC is more focused towards astrophysics scientific research and dissemination, its infrastructure development requirements involve a considerable degree of technology sourcing from other scientific infrastructures and business. It is important to recognise these types of PRO-government user relationships because they engender forms of knowledge transfer that are more difficult to monitor on defined standardised metrics and contract upon but can result in significant socioeconomic benefits, for instance when applied scientific advice helps save lives and jobs in a pandemic context or other emergency situations. For several OPIs, a key point is whether the presence of a foundational rationale to assist the government still calls, in today's world, for specific forms of institutional governance, funding arrangements and internal capabilities that differ from those that tend to be used when knowledge generation is the primary objective of an organisation. The combination of institutional missions and funding/governance arrangements for several central government PROs is by no means apparent to an outside observer. Interviewed stakeholders have indeed highlighted the current regulations affecting the establishment of research agreements as the main barrier to knowledge transfer and collaboration affecting OPIs. These are explored in detail in section 4.3.1.

In the case of **universities**, third mission activities have progressively evolved from traditional "knowledge/technology transfer" to a broader engagement agenda promoting collaboration with other actors in the ecosystem, with the objective of benefiting surrounding communities and contribute to societal well-being (CRUE, 2018[47]). Over the past decades, Spain has developed a normative framework aiming to help universities become more autonomous and develop research and knowledge transfer initiatives, including the creation of technology transfer offices (TTOs), science and technology parks and joint research centres (research centres in collaboration with external stakeholders), discussed later in this section. However, while the normative framework and financial support has enabled researchers to engage in knowledge exchange activities, several challenges persist.

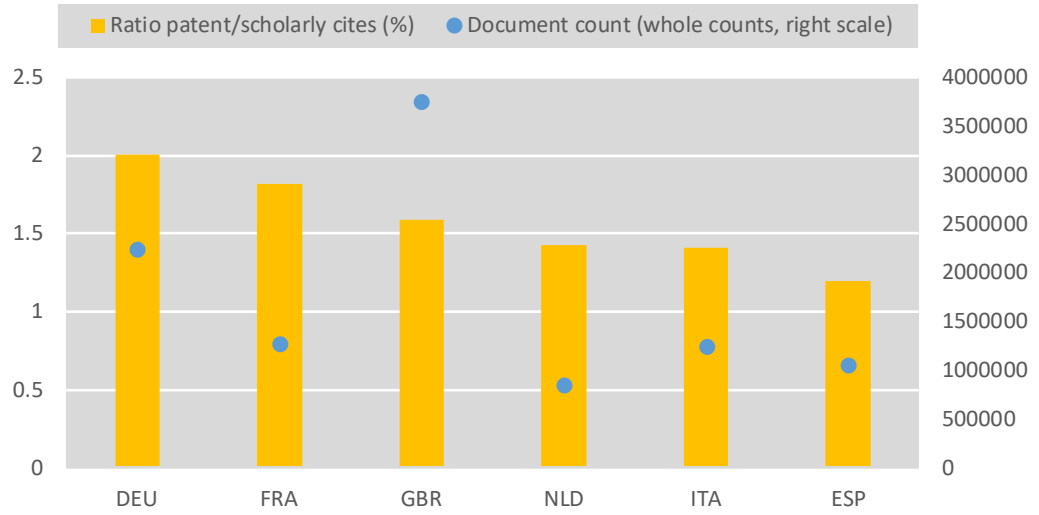
This section examines some of the available indicators of knowledge transfer and collaboration in the Spanish context from the perspective of universities and PROs, and presents insights from stakeholder interviews as well as the existing literature.

3.3.1. Indicators of knowledge transfer and collaboration in the research base

Evidence of knowledge transfer and collaboration through scientific publications

Scientific publications are mechanisms of scholarly communication of peer-reviewed material. This may a priori suggest that these provide limited information about engagement with business. However, citations of scientific literature in patents can convey useful insights about the extent to which scientific outputs provide a basis for inventions. In this regard, Spain's scientific output, while notable in size, can be noted as having less of an invention relevance than the scientific output of other countries, as implied by the ratio of patents versus scholarly cites (Figure 40).

Figure 40. Scientific and invention citation impact of scholarly publication output



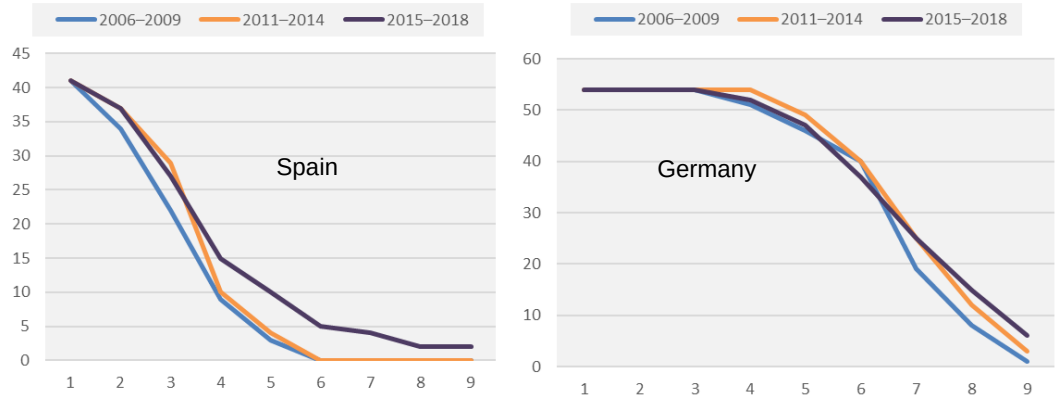
Source: OECD analysis based on The Lens database, https://www.lens.org/

The top 10 applicants of patents citing scientific literature involving Spain-based authors include CSIC in first place, followed by foreign based universities (University of California, MIT and Harvard, USA), PROs (CNRS, France), and several companies in pharma and ICT (Genentech Inc, IBM, Hoffmann La Roche, Novartis and Du Pont).

Although companies do not typically get involved in scientific publishing activities themselves, and when they do so it is often for strategic purposes, for instance, to lay out prior art that invalidates claims for patent protection by competitors, some evidence of science business engagement can be inferred from indicators based on publications jointly authored between PSR institutions and industry. The indicators produced by CWTS in Leiden University track co-publication between universities and industry. This pattern of co-publication is indeed relatively uncommon but helps provide revealing comparisons across universities and countries. As shown in Figure 41, Spain's universities tend to co-publish significantly less with industry than Germany's. This impact is visible across the entire spectrum of universities with sufficient publication figures. However, there is a significant improvement in co-publications with industry in recent years particularly among those that already engaged more with industry.

Figure 41. Co-publishing between universities and industry, Spain and Germany

Number of universities (left axis) with at least x% (bottom axis) proportion of co-publications with industry



Note: Visualisations based on variable PP_industry_collab.
Source: OECD analysis of CWTS Leiden Ranking 2020, https://www.leidenranking.com/ranking/2020

The largest levels of co-publication in Spain are generally found for the physical sciences and engineering, biomedicine, and to a lesser extent life and earth sciences. The top 5 universities on physical sciences and engineering are the University Carlos III of Madrid, the Technical University of Madrid, Pompeu Fabra University, University of Las Palmas de Gran Canaria, University of Navarra and University of Seville. On life sciences, the top 5 universities are University of Navarra, the Polytechnic University of Catalonia – BarcelonaTech, Pompeu Fabra University, the Technical University of Madrid and Rovira i Virgili University.

Evidence of knowledge transfer and commercialisation at universities and PROs

Data on publications and patents, which are visible and easily accountable outputs, are not sufficient to characterise the inputs, process and full range of outputs related to knowledge transfer. The knowledge transfer and collaboration process is often restricted to the realm of private contracts protected by confidentiality (OECD, 2013[48]). In contrast, institutional surveys have traditionally allowed to obtain information on the number and income from research and development contracts, collaborations, consulting or licensing agreements. Nonetheless, although there have been several attempts to develop guidelines at the international level, a common approach does still not exist (Campbell et al., 2020[49]; Finne et al., 2009[50]). Reasons for this lack of harmonisation include differences of view as to what represents the relevant scope of measurement, i.e. which types of institutions should be covered, what forms of knowledge transfer and collaboration should be measured, and whose responsibility it is to carry out the data collection. In this landscape, there have been very few attempts to provide with an official view of knowledge transfer involving the PSR.

Surveys administered by national associations of university knowledge transfer offices have for a long time been the main available source for many countries, including the RedOTRI-CRUE survey in Spain, but international comparisons remain a challenge due to methodological differences across countries. The survey carried out among its members by RedOTRI-CRUE has been over several years one of the main sources of information about the knowledge transfer activities of universities in Spain. Conesa (2019[51]) carried out an indicative international comparison of aggregated results from ASTP, AUTM and RedOTRI-

CRUE surveys corresponding to 2016 for a selection of key variables[38]. Unsurprisingly, US institutions outperform EU and Spanish ones, which partly reflects the more selective nature of the survey base.

Table 2. Selected knowledge transfer indicators for United States, Europe and Spain, 2016

Unit value per institution (primarily universities)

Indicators, Number / value per institution	United States AUTM universities	Europe ASTP members	Spain RedOTRI-CRUE universities
Number of invention disclosures	131	28	17
Number of priority patents	84	17	8
Income from R&D contracts	EUR 22m	EUR 4.8m	EUR 3.6m
Income from licensing agreements	EUR 14.4m	EUR 1.3m	EUR 0.1m
Number of spin-offs created	5	1.6	1.6
Knowledge transfer office staff (FTEs)	5.7	9.9	13.8

Note: ASTP information is uneven in terms of countries represented and gathers information both from individual members of linked national associations. AUTM information refers to some 200 entities, mostly universities, but also other academic institutions such as federal laboratories or research hospitals. However, AUTM does not include information from all US universities and colleges, with more than 4,000 institutions of a very diverse nature, but only those active in research and knowledge transfer. In the case of REDOTRI-CRUE, the information reflects the Spanish university system as a whole, but not other research centres. For the last indicator, differences in interpretation of the concept of Knowledge Transfer Office may account for observed differences, especially if European and Spanish institutions include teams dealing with research grant applications.
Source: OECD, based on Conesa (2019[51]).

A more focused and recent comparison between Europe and Spain for 2017 income and number of spin-offs (Figure 42) shows a similar picture. The low average income from patent licensing by Spanish universities and PROs is the most salient feature of international comparisons. Spanish institutions obtained on average the paltry sum of EUR 60 000 in gross revenues from IP in 2017 compared to an average of EUR 1 million for European institutions (including Spanish ones).

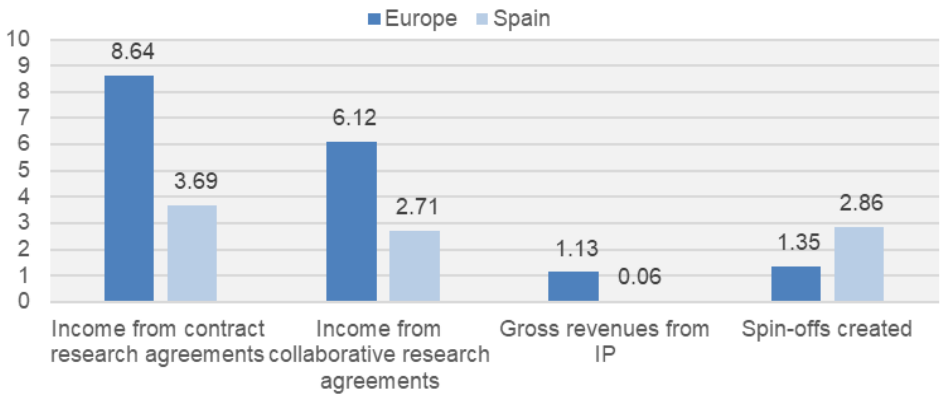
The distribution of income from IP licensing is highly skewed, with few blockbusters accounting for most of the revenue. One example of a Spanish blockbuster is the "ϕ29" patents owned by CSIC and invented by the team of Margarita Salas, whose work provided a faster, simpler and more reliable way to replicate trace amounts of DNA into quantities large enough for full genomic testing. The ϕ29 patents are to date the most profitable in the history of CSIC, having brought around EUR 6.6 million in licensing royalties by 2019, adding up income from multiple years of licensing.[39]

[38] ASTP aggregates survey results from national associations of TTOs across European countries, including those from the RedOTRI-CRUE survey in Spain. AUTM administers an annual survey on licensing activities to its members (TTOs in the United States and Canada).

[39] https://cincodias.elpais.com/cincodias/2019/06/28/fortunas/1561743415_948861.html

Figure 42. Spain-Europe comparison on selected knowledge transfer metrics, 2017

Millions (income/revenues) and numbers (spin offs) per institution



Note: Aggregate averages hide heterogeneity across institutions, particularly for highly skewed variables.
Source: OECD analysis based on data from ASTP and RedOTRI knowledge transfer surveys.

Conesa (2019[51]) has argued that the provisions under article 83 of the Science Law for enhancing personal remuneration might shape the KTC profile of Spanish universities by biasing interest in favour of R&D and consultancy contracts with third parties, as a mechanism for knowledge transfer, relative to ex-post commercialisation strategies. Contracts provide a lower risk pathway, particularly in connection to consultancy and customised training services.

While this point does a lot of the explaining, a demand-based perspective is still missing from the analysis. Firms might also appear to value more the provision of concrete services and when it comes to using results from research, prefer to engage through collaborative arrangements. These can be designed to give firms a significant stake on the resulting IP if the project turns out to meet key scientific and technical success criteria, before having to commit to a full commercialisation and innovation pathway. This allows them to minimise their exposure if that is not the case or the commercial conditions do not favour the additional investment. The lack of IP revenue may therefore reflect that the IP that is being generated may not entice the interest of users both domestically and abroad. Several interviewed stakeholders have also argued that imperfectly timed disclosures made in Spain's science base may invalidate the right to formal patent protection, connecting this behaviour to the concrete short-term incentives from publishing as opposed to uncertain commercialisation outcomes.

As part of the steps taken towards the development of the Information System for Science, Technology and Innovation (SICTI)[40], the Ministry of Science and Innovation created a working group of representatives of universities and research organisations for the definition of a set of Knowledge Transfer and Innovation Indicators that could be used in a novel survey

[40] Included in the Science Law 14/2011 as an instrument for data collection and analysis for the preparation and monitoring of the Spanish Strategy for Science, Technology and Innovation (EECTI), and its development plans. The SICTI webpage is progressively incorporating additional material covering different aspects of the STI system https://www.ciencia.gob.es/site-web/Estrategias-y-Planes/Sistema-de-Informacion-sobre-Ciencia--Tecnologia-e-Innovacion--SICTI-.html

to be administered by the Ministry to all relevant actors: the Knowledge Transfer and Innovation Survey (*Encuesta de Transferencia de Conocimiento e Innovación*, ETCI).[41]

The ETCI 2018 survey, carried out at the end of 2019 by the Spanish Ministry of Science and Innovation provided a comprehensive view of the Spanish system by different types of actors in the public system of research, including PROs and technology centres. The survey was structured into five sections: 1) protection of results, 2) exploitation agreements, 3) spin-offs, 4) contracts, and 5) collaboration. An important difference with respect to the RedOTRI-CRUE survey mentioned earlier, apart from its higher level of detail in the questions, is that the ETCI survey includes not only universities, but also other actors in the research field in Spain, such as public research organisations and technology centres, more recently extended to health research organisations. In total, the institutions surveyed in the 2019 ETCI survey represent the bulk of the academic and non-corporate research sector in Spain with a response rate of 80%. Results provide a very complete picture of IP protection, exploitation and transfer in 2018, and can be summarised as follows:

- 550 priority patents were filed, of which 239 were co-applications with other institutions (among the latter 29% were with companies and 21% with foreign institutions).
- IP licensing income (for all IPRs) amounted to EUR 10.9 million.
- 285 invention exploitation agreements for the exploitation of patents, utility models and plant varieties were signed, of which 71% with firms, 16% with spin-offs and the large majority with Spanish entities (93% are licensing agreements and 3% transfer of ownership). 70% of those agreements correspond to public universities, 20% to public research bodies (OPIs), and although for public universities almost all agreements are for patents, for OPIs about half relate to plant varieties.
- 78 spin-offs were created in 2018 and 85% of the spin-offs created five years before, in 2013, were still active.
- More than 85,059 research contracts were signed, for a total of EUR 761.5 million, which makes an average of EUR 8,952.5 per contract. Interestingly, although on average 76% of the research contracts are with firms, the OPIs stand out with a much lower share of contracts signed with firms (26%) than public universities (75%). Technology centres registered the highest share of contracts signed with firms (94%).
- 5,629 collaboration agreements were signed, for a total of EUR 189.4 million, which makes an average of EUR 33,655 per agreement (Table 3).

[41] The ETCI survey has been thus far already implemented on three occasions, first in December 2018, as a pilot for 2017, second in November 2019 to gather the first official edition of the survey based on information from year 2018, and third in 2020. Results from the survey implemented in 2020 have not yet been made available, and results from the 2019 survey were shared with surveyed institutions, but to date results have not been published more broadly at the time this was written although publication has been flagged as imminent.

Table 3. Knowledge transfer indicators, by type of institution, 2018

	Public universities	Private universities	Central gov PRBs (OPIs)	Regional gov PROs	Other regional PROs	Technology centres	Total
Collaborative agreements by type (I33)							
Chairs	350	31	0	0	0	11	392
Sponsorships	436	55	43	7	0	64	605
Industrial doctorates	258	42	13	10	0	109	432
Other	2101	426	36	393	53	1191	4200
Total collaboration agreements	3145	554	92	410	53	1375	5629
Total income for collaborations (EUR m)	87.2m	12.1m	4.7m	6.9m	3.4m	74m	189m
Invention disclosures (I36)	1125	76	232	91	27	383	1934
Discarded invention disclosures (I37)	298	20	42	58	8	20	446
Researchers engaged in knowledge transfer (I38)	21787	1320	2173	539	196	1696	27711
Knowledge transfer staff (FTEs) (I39)	2.726	110	68	64	237	560	3.767
Number of observations / target population	47 / 48	21 / 32	8 / 8	20/32	5/5	59/77	160/202

Note: The ETCI survey does not include PROs embedded in hospitals and clinics but they have been included in more recent editions. The ID of the corresponding question in the ETCI are indicated in parenthesis, i.e. I33 is the question relative to collaborative agreements, which are broken down by different types (chairs, sponsorships, industrial doctorates and other) and include also information on total number of agreements and total income from agreements.
Source: Spanish Ministry of Science and Innovation, summary of results of the Encuesta de transferencia de conocimiento e innovación (ETCI) 2018

3.3.2. Specific insights on technology transfer in universities

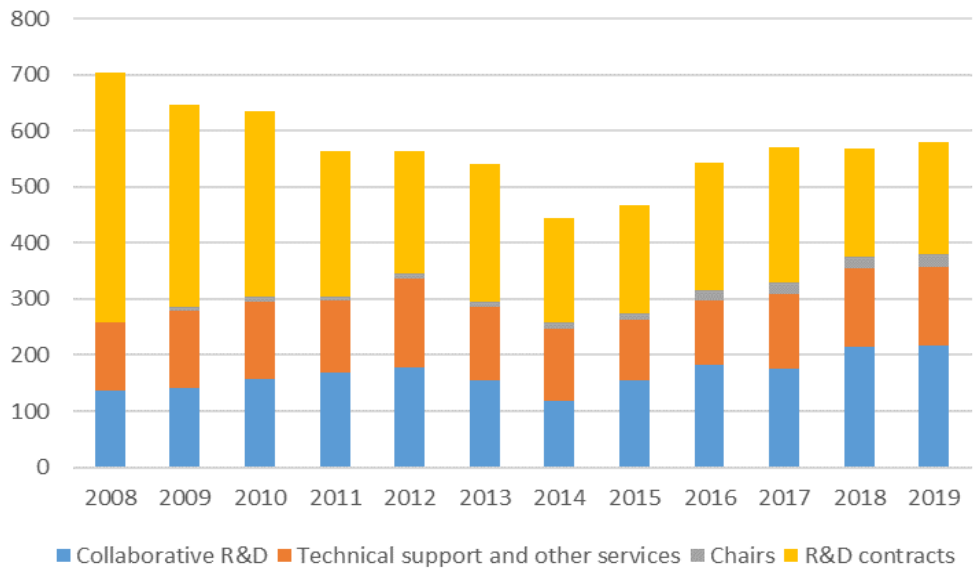
During the interviews, representatives from universities and university TTOs reported governance and organisational features (many of them described in section 2.3.3) that often impede effective knowledge transfer. These challenges have been the subject of several domestic reports, such as CYD (2020[52]) and Fundación Alternativas (2017[53]), which provide a comprehensive view of the technology transfer landscape for universities.[42]

According to the 2018 survey by the Sectorial Commission CRUE I+D+i, growth in the contracted volumes by universities appeared to have stalled since 2015 after six years of successive falls. In 2018, external funding from collaborative R&D, chairs, technical support and R&D contracts reached altogether EUR 569 million, practically at same level as in 2017. In 2019, it rose to EUR 581 million. This value is still far from the highest volume contracted prior to the start of the previous crisis financial (EUR 704 million). Figure 43 shows this evolution and allows to identify the drop in R&D contracts after the GFC as the main responsible for the decline in third stream income within Spanish universities. Several stakeholders have pointed out the connection between this decline in R&D contract income and the evolution of funding provided to business for R&D projects involving subcontracting to third parties.

[42] This study (Informe CYD2019) is also a particularly valuable source of knowledge transfer and collaboration case studies covering several different perspectives (both for university and business and covering different knowledge exchange mechanisms) while also illustrating new trends.

Figure 43. Third stream university income in Spain, 2008-19

EUR millions



Source: Informe de la Encuesta de I+TC 2016,2017 y Resultados 2018 and 2019 de la Comisión Sectorial CRUE-I+D+i. Accessed from Fundación CYD Reports (CYD, 2020[52]) and 2021 (Chapter 3, Figure 22 in both editions).

The CYD report also highlights a similar decline in the number of licensing contracts, especially in the case of those based on patents that went from 216 in 2015 to 133 in 2016 and 127 in 2017, as well as in the number of university spin-offs over a similar period.

University governance as an overarching concern among stakeholders

Stakeholders have amply commented on the need to reform the governance of universities to ensure a more diverse societal representation in decision-making bodies, which are current dominated by insider university stakeholders, as a means to address the current deficiencies in the knowledge exchange landscape. Three key objectives have been highlighted as desirable shifts:

- Adoption of governance and professional management mechanisms in line with functions as knowledge-creating and transmitting organisation, and less so with those of bureaucratic administrative organisations from whom they often borrow procedures on a "by default" basis.
- Increase accountability towards universities' major funding providers, direct stakeholders and society at large.
- Ensure effective autonomy to pursue the objectives assumed by universities with their stakeholders, currently curtailed at several levels by externally imposed rules, e.g. on contracting.

The OECD heard from a number of stakeholders about different proposals for governance reform, entailing different degrees of transformation with respect to the status quo. A common element to those, as noted in the previous section, concerns the need to address the misalignment between the current role and capabilities of Social Councils and the need for an effective organ for external engagement in university governance for decision making and social accountability (see sub-section 2.3.3). While these governance issues transcend the

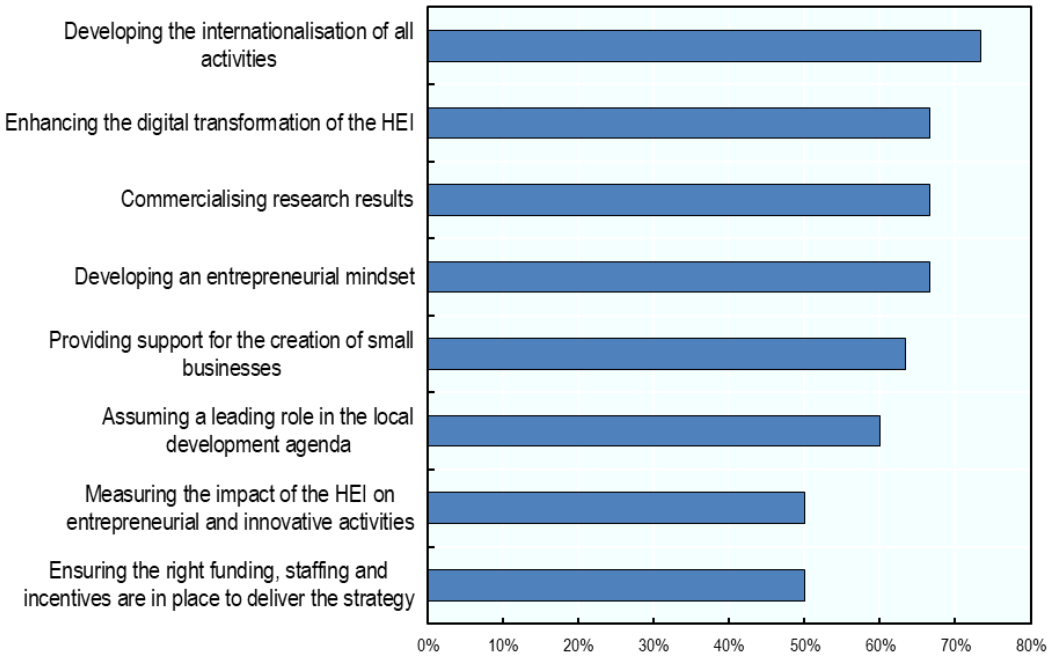
specific objectives of this project on knowledge transfer and collaboration, our assessment, further elaborated in this document's final section 6, is that structural reform of Spanish universities remains a necessary condition for the unleashing of knowledge creation and exchange forces.

Insights from the OECD/EU leadership survey of Spanish universities

In addition to the stakeholder interviews, representatives from the rector's team of all universities in Spain have been invited to answer to the Leader Survey – a survey elaborated by the OECD and the European Commission, aimed at collecting more information on HEIs' knowledge transfer and entrepreneurship support activities, as well as governance settings to support these activities. The response rate was moderate, with 30 completed surveys[43]. The survey reflects the views of the universities' leadership (staff working at the rector's office) on progress achieved regarding activities, incentives and metrics for knowledge transfer.

Some survey respondents reported that their universities' institutional strategy included knowledge transfer and collaboration activities. Such activities include developing an entrepreneurial mind-set in students or supporting the creation of start-ups by students and staff, commercialising research results through technology transfer and spin-offs (see Figure 44)

Figure 44. Objectives included in universities' strategies



Note: Based on 30 responses from university contacts to the question "please indicate which of the following elements, if any, feature in your HEI's strategy"
Source: OECD HEI Leadership Survey of Spain (2021)

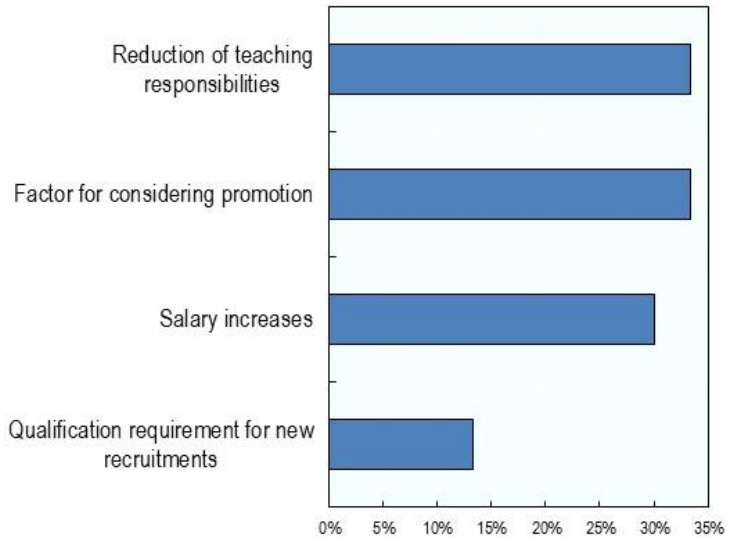
Furthermore, almost all respondents (27 out of 30 respondents) assured that their universities have dedicated staff and structures to support commercialisation of research, twenty-seven

[43] While university contacts were asked to submit a single response per university, the anonymous survey design does not allow to assess the potential incidence of multiple responses from the same university.

declared having dedicated staff and structures to support entrepreneurial development and professors teaching entrepreneurial skills.

In terms of incentives, 60% of respondents flagged that their university had in place mechanisms to reward staff members that engaged in entrepreneurship and knowledge transfer activities, while 26% claimed not having any such incentives available. Figure 45 illustrates most common rewards used for staff (including salary increases, factor for promotion, etc.) according to the university leadership contacts.

Figure 45. Incentives used by universities to reward staff members for their involvement in third mission activities

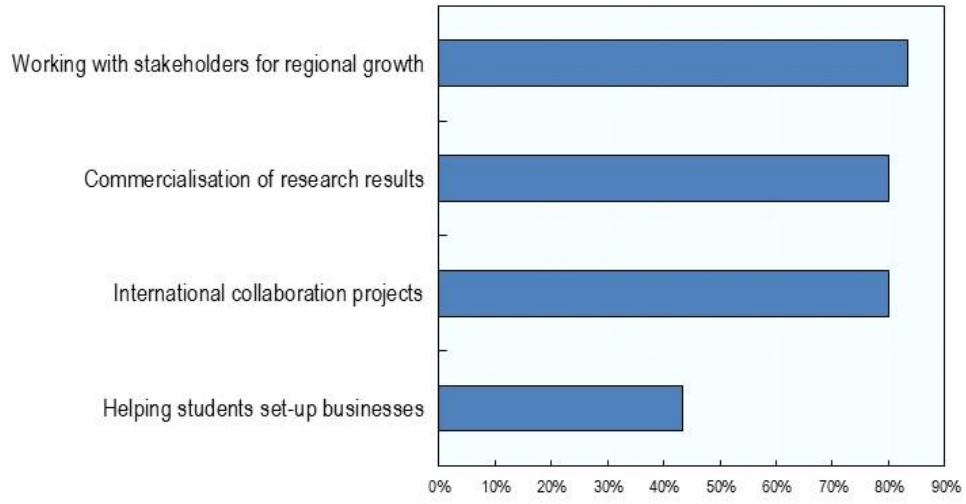


Note: Based on 30 responses to the question "Does your HEI reward staff members for their involvement in commercialisation of research, supporting entrepreneurship (incubators), teaching entrepreneurial skills (courses, mentoring) – alongside their standard job responsibilities? If yes, please specify"
Source: OECD HEI Leadership Survey of Spain (2021)

University leadership contacts report that entrepreneurial support measures are put in place to support undergraduate and post-graduate students, alumni, and faculty. The type of activities and structures for entrepreneurial support developed vary across universities, often including consulting services, research with external stakeholders, student internships in firms during their studies, development of spin-offs and start-ups, and the provision of continuous learning. Twenty-four respondents declared that their university has a technology transfer office responsible for a variety of services (Figure 46).

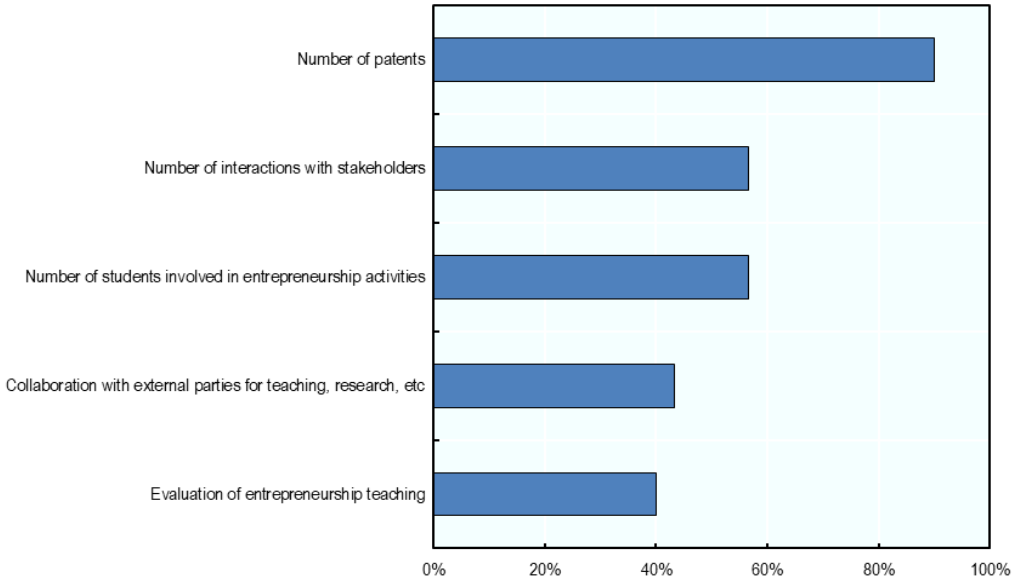
Assessment practices are also gaining momentum. 63% of participating contacts reported that their university carries regular evaluation of their knowledge transfer activities, using a mix of quantitative and qualitative indicators. The quantitative indicators used include number of patents, licenses, spin-offs, start-ups, number of students involved in entrepreneurship activities (Figure 47).

Figure 46. Main activities of technology transfer offices



Note: Based on 30 responses to the question "Is there an office at your HEI that coordinates the knowledge exchange activities (e.g. a Technology Transfer Office)? - If yes, in which activities is this office involved?"
Source: OECD HEI Leadership Survey of Spain (2021)

Figure 47. Indicators used by universities to monitor knowledge transfer activities



Note: Based on 30 responses to the question: "What are the indicators that are measured or the dimensions that are assessed?"
Source: OECD HEI Leadership Survey of Spain (2021)

Novel experiences in business-university collaboration in Spain: Chairs and centres

In addition to project-based, short-term contractual agreements to develop research, consulting or teaching activities, over recent years Spanish universities have relied on new institutional arrangements to foster longer-term collaboration with firms.

Business university chairs

In particular, many universities have created Chairs (*Cátedras*) or University-Company Lecture Halls (*Aulas*) in partnership with companies. These instruments are used to establish

long-term agreements between the university and one or various companies (public or private). The regulatory framework is established by each university (under the Law of Universities). Lecture halls are normally limited to supporting teaching and training activities, while Chairs represent a potential means to establish strategic and lasting collaborations between the university and a company or entity, in order to carry out training, research and development or knowledge transfer activities in an area of common interest. For the collaborating entity, university-company chairs offer direct access to the university's human resources and certain infrastructures, being able to support different actions (scholarship programs for the completion of End-of-Degree Projects, exploratory or technological surveillance, or promotion of outreach and dissemination days). For the university, they represent an opportunity to secure regular funding for lines of research, instruments for training students and researchers or exchange of personnel, and commercial exploitation of the results of their research.

In some cases, university-business foundations facilitate the administrative implementation of the Chair-based partnership (e.g. Fundación Universidade da Coruña facilitated the creation of the Inditex Chair of Social Responsibility at the University of A Coruña, sponsored by the global retailer Inditex in Galicia). In other cases such foundations are the sponsors of University Chairs (e.g. the Ramón Areces Chair on Retail Management at the University of Oviedo, sponsored by the Fundación Ramón Areces, connected to the El Corte Inglés Group). In light of their rapid proliferation across the country, covering different topics of interest (such as big data, pharmaceuticals, biotechnology, chemical industries, renewable energies, etc.), business-university chairs are broadly perceived as having been a recent success emulating the experience of other countries. Box 8 sets out the case of the University of Zaragoza-BSH Innovation Chair.

Box 8. The University of Zaragoza- BSH Electrodomésticos Innovation Chair

In 2006, the University of Zaragoza signed an agreement with the electro-domestic Spanish company BSH Electrodomésticos España to create a long-term partnership for cooperation in teaching, training and R&D for household appliance business. The partnership includes initiatives such as "*la empresa innovadora*" (the innovative company), whereby professors from the University of Zaragoza and BSH professionals teach corporate innovation processes for students of the faculty of Economics and Enterprise and the School of Engineering and Architecture. This course combines theoretical training with practical teaching (company management, open innovation), and students are able to visit the company's logistics centre. In a similar fashion, under this partnership BSH and the University of Zaragoza created "*Factor Idea*" – problem-solving sessions for students of all disciplines, who are invited to solve (either in-group or individually) challenges that respond to the innovation needs of the electro-domestics sector. These sessions allows students to use their academic knowledge in practical situations. BSH also awards grants for doctoral students in areas of interest to the company. In addition, the university through its Vice-Rectorate for Technology Transfer and Innovation has launched a new program with BSH in 2020 - "PIVOTA IDEAS"- to trigger the entrepreneurial spirit of PhD and master students, postdoctoral researchers and research staff at the university. An entrepreneurial workshop was held in September 2020 to help participants transform their research projects into business ideas. Twenty different candidates participated with seven projects in different fields.

Source: OECD, based on Universidad de Zaragoza (2020[54]), BSH Group (2021[55]).

Joint programmes and centres

Some universities also engage with multiple external stakeholders to create education and research programmes around cross-cutting topics. For example, the Madrid Polytechnic University's Innovation and Technology for Development[44] Centre (ITC) focuses on addressing the UN Sustainable Development Goals (SDGs) by connecting students, researchers and professors with a variety of external stakeholders from the private sector, government, civil society organisations and affiliated research groups. The ICT centre has developed specific training programmes for students, including practical educational programs as such as diploma of Sustainable Development Goals in Cities and a Master in Strategies and Technologies for Development. The centre also facilitates multi-stakeholder platforms to tackle important related to SDGs such as energy access or sustainable cities. For example, the centre has partnered with Iberdrola and the IS Global (Global Health Institute of Barcelona) to create a platform ("*el dia después*") aimed at producing innovative research to achieve SDG goals. The centre receives funding from contracts with private entities (21% of its budget in 2019) and from participation in tenders issued by public entities (74% of its budget). Another notable exception is the Airbus-Carlos III University of Madrid (UC3M) Joint Centre for Aeronautic Systems Integration, situated at the UC3M Science Park. This centre hosts 38 research groups that have already developed new technology for Airbus Group integrating aeronautic and space systems (UBC, 2016[56]).

However, the development of more ambitious joint centres through public-private partnerships, where business and universities work together in joint R&D projects over the long term, has hardly been used in Spain to date. There have not been any specific policy programmes in Spain aimed at promoting this kind of joint centres, in contrast with successful experiences in other countries such as Germany and Portugal (see Box 17 in section 4.4.5). Another relevant international experience that could inspire Spanish stakeholders is the case of the eight joint university-industry laboratories established by Telecom Italia since 2012 with five major Italian universities (Mahdad et al., 2020[57]).

3.4. Intermediation for in fostering knowledge transfer and collaboration

In an innovation landscape with business and research base actors characterised by apparently different and often opposing paradigms and objectives, intermediaries play an essential role connecting actors and facilitating mutually beneficial processes of knowledge exchange. Spain's intermediation landscape, understood as the set of actors with explicit knowledge intermediation roles, is highly diverse, complex, often complicated by the already alluded tendency to develop legal forms and registers that operationalise generic types of intermediation in ways that may differ in scope from the term they refer to. Another major feature of Spain's intermediation system is that a significant proportion are units placed within actors in the publicly funded scientific research base. That is indeed the case of technology transfer offices (TTOs) within universities and PROs, which have already been mentioned as this report documented the perspectives of business and individual researchers.

Thus, overall, key attributes of intermediaries in Spain's innovation system include whether they have their own legal personality and what form they take (something that defines the legal framework within which they operate), the extent to which they are attached to or controlled by another organisation (which also connects to their autonomy), but above all, what type of intermediation function they are intended and equipped to serve. This subsection attempts to provide a succinct description of the key intermediary actors in Spain's innovation system by reference to these defining features and their performance. Being the

[44] See itdUPM (2021[150]).

object of national and regional policies, through regulation, financial support and other means, their role as policy instruments will be subject to more extensive discussion in sections 4, 5 and 6.

3.4.1. Technology transfer offices

Following the Science Law of 1986, the first national plan for R&D enabled the establishment of the first technology transfer offices (TTOs) attached to universities and PROs principally ("*Oficinas de Transferencia de Resultados de Investigación*", or OTRI) (Fernández de Lucio et al., 1996[58]). According to their legally defined mandate, Spain's TTOs have the mission to boost relations between the various agents, identifying science and technology (S&T) needs and facilitating knowledge and technology transfer. TTOs are responsible for stimulating public research-business collaboration in R&D activities and managing this relationship. Their tasks typically entail the following:

- Management and protection of intellectual property generated in universities and PROs.
- Management of collaborative research projects with businesses and external organisations, including international R&D projects and associated consortia.
- Supporting the creation of spin-offs based on knowledge.
- Negotiation of agreements with external organisations (consortia, material transfer agreement, licensing, etc.).
- Negotiation of collaborative agreements and contracts for R&D, technical consultancy and other services with businesses.
- External promotion and commercialisation of research groups' capabilities vis-à-vis potential external clients and partners.

TTOs were subsequently officialised by a ministerial order in 1996, which put in place an official OTRI register which falls under the responsibility of the Secretary General for Innovation.[45] As of December 2020, there were 201 registered TTOs in Spain, mostly based within individual universities (or their foundations) and public research organisations, but also attached to technology centres, industry associations and science and technology parks. TTOs rely on a variety of different funding sources. For the most part, TTOs are funded from the budget of the university or foundation to which they are attached. Some generate income for their activities based on fees they charge to projects and contracts they manage. But very few if any can claim to be self-sufficient. Inclusion in the official TTO register entitles structures and the entities to which they are affiliated to participate in and benefit from specific government support programmes, although in recent years and up until recently, funding from central government has not been particularly forthcoming.[46]

Following their creation, Spain's TTOs soon encountered several practical problems, particularly to adapt to the overall host/client organisation structure, find adequate staffing and accomplish all their tasks within their mandates given the allocated resources. The range of tasks foreseen for TTOs in Spain appears to be rather broad compared to the usual tasks foreseen for TTOs in other countries, already entrusted with promoting research valuable to

[45] See https://sede.micinn.gob.es/rot/
http://www.aei.gob.es/stfls/MICINN/Innovacion/FICHEROS/Convocatorias_OTRIS/DirectorioOTRI.pdf

[46] In the past, some programmes were launched to provide direct funding to OTRIs, such as the Sub-programme to Support the Transfer Function in Research Centers (INNCIDE). These direct public transfers from the central government do no longer exist, other than sporadic funding for specific activities or projects (e.g. from FECYT).

businesses, identifying and connecting to companies' research and development needs, as well as the strategic and administrative management of multiple KTC mechanisms (Bolzani et al., 2021[59]). According to interviewees, this wide diversity of tasks in Spain tends to be dominated in practice by administrative procedures associated with standard research project management, for instance procedures associated with strictly academic projects funded by the government and the EU (Mas Verdú, 2021[60]). This leaves less time for TTO staff to dedicate to fostering long-standing collaboration relationships with business or even showcasing their achievements (Box 9).

Box 9. Showcasing university-business collaboration: the case of the University of Murcia

Showcasing success stories is an important element contributing to the health of the knowledge transfer and collaboration landscape in Spain. Universities, PROs and their TTOs help raise awareness among business and society at large of potential benefits of collaboration, particularly those in traditional sectors. The emphasis on the contribution to the local economy and its modernisation as well as the wellbeing of its citizens is critical.

For instance, the University of Murcia (UMU), situated in one Europe's largest producer regions of fruits, vegetables and flowers, has developed close ties with its local industrial fabric over the past 30 years. The OTRI at UMU reports on how it has promoted the creation of university-industry collaboration projects oriented towards horticultural, floriculture and enological innovations that have helped to differentiate and build competitive advantages for both local producers and UMU itself. Examples include UMU-Empresa collaborations that have contributed, among several others, to enhance the nutritional value of eggs; implement zero-waste artichoke production process innovations; improve the intestinal health of piglets; and develop artificial vision applications for intelligent and precision agriculture.

To be fully effective, the communication of success cases also needs to be accompanied by information that allows building realistic expectations about the demands and potential effects of university-business collaboration, explaining how knowledge intermediaries such as the TTOs can help firms and researchers alike define objectives and navigate this process.

Source: OECD, based on examples reported in https://www.um.es/web/otri/empresas/casos-de-exito

This barrier to act as truly innovation-enabling offices is exacerbated by the fact that technology transfer offices are understaffed and lack of dependable financing, as reported by virtually all stakeholders to the OECD team during the interviews. The presence of qualified personnel across key dimensions, and the availability of related incentives, is widely acknowledged as a major prerequisite for the effective operation of TTOs (Micozzi et al., 2021[61]). While TTOs are accredited as institutional structures using the standard UNE 166002:2006 "R&D&i management: R&D&i management system requirements", there is still much scope for increasing the professionalisation of the services they provide. There is broad consensus that staff working in Spain's TTOs very often lack sufficient commercial training and understanding of the marketplace for technology and business needs. According to several interviewees, limited training opportunities are available to professionals working

in TTOs, with a few having the opportunity to engage in training offered by recognised centres of excellence abroad[47].

In addition, the profession of "technology transfer officer" lacks the status and incentives that can be found for academics and researchers, whose career tracks are better defined. TTO staff members are often hired under precarious conditions with little career perspectives and having to multi-task with very little resources. This point is illustrated in a recent study that gathers evidence for the autonomous region of Galicia, which finds that 65% of staff working in TTOs have temporary contracts, despite having on average 13 years of experiences in knowledge transfer activities. Salaries for those professionals are also relatively low. This generates a high turnover of staff, resulting in high volatility in capabilities available in TTOs and limited capacity to consolidate multidisciplinary teams with complementary competences. It also requires the continuous allocation of efforts to the training of new staff (Barrada Beiras et al., 2021[62]). In a context like Spain's where career regulation specifies trajectories for most public sector workers, the lack of a regulated career represents a marked disadvantage leading several stakeholders to call for such a development. However, it is unclear whether such would be an effective approach given the practical difficulties of specifying a prototypical role. A rigid civil service career approach might actually discourage the attraction of talent from within business into technological and commercial engagement roles. It appears that several university TTOs equipped with an appropriate legal structure and with the necessary institutional support are able to offer reasonably attractive packages to attract such profiles.

3.4.2. Knowledge transfer and collaboration through university-business foundations

The diversity of TTOs in the Spanish innovation landscape in relation to the organisations they are both directly and indirectly attached is revealing of the institutional "innovation" in structures that has taken place in recent years in order to maximise opportunities to achieve operational freedom whilst being eligible for public support programmes. For instance, several TTOs are attached to university or university-business foundations or are foundations in their own right. Over the past decades, many university-business entities, often under the form of foundations, have been created in Spain to bridge the gap between the teaching and research dimensions of academia with the market and society more broadly.

University-based foundations often have the legal form of non-profit private foundations. As such, their activities are governed by the will of the founder as expressed in the founding act, by their own statutes and by the Law 30/1994 on foundations, which establishes a single legal regime for all foundations, regardless of the public or private nature of the founders. As a result, these entities benefit from high flexibility to engage with business, including the right to receive monetary compensation for the services they provide. These services can go well beyond the management of R&D contracts or the provision of training, to include a range of professional services that in some cases can be considered to enter in the realm of private sector activities (Del Saz Cordero, 1998[63]).

These entities sometimes result from the initiative of a single university (e.g. University-Business Foundation of the University of Valencia), but can also be the outcome of collective action by several universities (e.g. University-Business Foundation of Madrid), or universities in collaboration with chambers of commerce and/or other institutions or firms

[47] A recent study that gathers evidence for the region of Galicia finds that among all TTO professionals interviewed, only one possessed an international accreditation of Registered Technology Transfer Professional. Interviewees pointed out that more specialised training for TTO staff was needed, particularly to strengthen legal and business development skills (Barrada Beiras et al., 2021[62]).

(e.g. the Galician Enterprise-University Foundation, FEUGA). University-business foundations carry out awareness initiatives to train researchers and staff to collaborate more with business, promote joint R&D projects, and support technology transfer and the creation of spinoffs. They also help researchers find external partners for R&D projects to participate in national and European R&D financing programmes and offer administrative support for the management of R&D projects with firms. Twenty-one of these foundations from different autonomous regions decided to associate and create a network (REDFUE) to work on overarching priorities and have a representing entity to dialogue with the regional and national governments.

3.4.3. Mutualising intermediation efforts for greater synergy

In some cases, universities have engaged in mutualising initiatives, i.e. pooling together resources towards shared objectives whilst keeping their own identity, involving other universities for the development of combined on-campus/off-campus services with greater added value and international scope.

An example of mutualisation initiative in Spain is *Univalue Valorización*, a company created by the *Grupo 9 de Universidades* (G-9) (Universidad de la Rioja, 2011[64]). This company was created to support the knowledge transfer activities of TTOs of nine universities, commercialising patents and technologies stemming from research projects. Simultaneously, each university organised webinars or training courses on patent development and commercialisation for researchers and individuals holding doctorate degrees. Over the years, *Univalue* also expanded its portfolio of services to include assistance in the preparation of project proposals for EU funding. The board of directors (composed of the vice-rectors for research and transfer of the nine universities) decided to close Univalue in 2015 due to the difficult years that followed the 2008 crisis, which had an impact on Univalue's ability to attract customers for the universities' patents and technologies.

Another very relevant example is the *Innotransfer* initiative in Valencia, which brings together the autonomous region's five public universities, as well as business associations and research centres. Innotransfer[48] is funded by the Valencian Innovation Agency with the aim of promoting science-business cooperation in key sectors aligned with the region's smart specialisation strategies. In light of the institutional challenges associated to merger activity at the level of universities and many PROs, mutualising initiatives become essential mechanisms to achieve economies of scale and scope in knowledge intermediation.

3.4.4. Technology centres, S&T parks and clusters

In addition to technology transfer offices and university-business foundations, there are several other actors in Spain that play an important role as intermediaries supporting the exchange of knowledge between the PSR and the wide business sector.

Technology centres (CTs and CTAIs) as knowledge intermediaries

Briefly introduced in section 2, technology centres[49] as defined in the Spanish legislation are non-for-profit organisations regardless of their legal form (typically private associations or

[48] https://innotransfer.org/

[49] The majority of CTs (close to 70) and CAITs (13) with state-wide scope of activity and their status is recognised by an official register maintained by the Ministry of Science and Innovation, which is not necessarily all encompassing of all entities functionally under this category, AAbout half of them (35) are part of the Spanish Federation of Technology Centres (FEDIT). https://sede.micinn.gob.es/inforct/imprimirTodos.mec.

foundations) that conduct applied research, experimental development and provide technological services to firms. In that regard, they could be more aptly described as research and technology organisations (RTOs). Their features and legal requirements for insertion in the official central government register[50] are displayed in Table 4. These rules define what appears to be a rather narrow space for eligibility, as the limits set out for a maximum level of institutional non-competitive funding are (for both CTs and CTAIs) below the "one thirds" reference benchmark often alluded to in the case of Fraunhofer Centres in Germany, combined with a minimum 35% of income from companies. This setup risks placing CTs and CTAIs in a position that is overall too dependent on competitive project-based funding, a concern that was voiced by several stakeholders. In addition, there are several employment composition criteria which can prove difficult to verify, and there is a potential concern about whether some of these rules can act as a deterrent to non-incumbent entities wishing to evolve to operate in this type of space.

Table 4. Features and requirements of state-wide accredited technology and technological innovation support centres

Statute defined features	Technology centres (CTs)	Technological innovation support centres (CTAIs)
Profit motive	Non-profit	Non-profit
Defined legal personality and constituted in Spain	Yes	Yes
Goal	contribute to the general benefit of society and the improvement of business competitiveness	facilitate the application of the knowledge generated in research organisations, including technology centres
Activity	through the generation of technological knowledge, carrying out R&D and innovation activities and developing applications	through their intermediation between them and companies, providing innovation support services
	This knowledge application function includes among others.: carrying out R&D&i projects with companies, intermediation between knowledge generators and companies, provision of innovation support services and dissemination through technology transfer and training activities	
	Carry out R&D (art 4.1c)	
Technical requirements for accreditation as state wide centres (previous 3 years) (Art. 5))	a) at least 15 university graduates as indefinitely employed technical and research staff that have a minimum staff of indefinite, of which at least 7% must have a doctorate degree (13% after 5 years and 20% after 10). b) non-competitive public financing of the centre must not exceed 30% of total income. c) at least 35% of its annual income must come from its own or contracted R&D&i activities, excluding technical assistance, training, dissemination and standardized and repetitive technological services are excluded, if not part of an R&D&i project; d) turnover with companies higher than 30% of income and correspond to at least 25 clients (20 for R&D&I activities);	a) at least 10 university graduates as indefinitely employed technical and research staff; b) non-competitive public financing of the center must not exceed 20% of the total income c) at least 35% of total annual income comes from activities contracted with companies; d) at least 15 different tech dev and innovation clients in the last three years

Note: Autonomous regions may also have their own specific regionally accredited centres.
Source: OECD, based on BOE 2009. BOE.es - BOE-A-2009-1111 Royal Decree 2093/2008 https://www.boe.es/diario_boe/txt.php?id=BOE-A-2009-1111

As of January 2021, there were 65 technology centres registered in Spain, jointly employing around 5 000 researchers and with an annual budget of around EUR 500 million. Although they are present throughout Spain's territory, their scale and the scope of their activity varies across the territory and often tend to have a regional focus.

[50] See https://sede.micinn.gob.es/rct/

Box 10. Tecnalia: a leading technology centre from the Basque Country

Tecnalia was set up in 2011 as a non-profit private foundation through the merger of 8 pre-existing technology centres from the Basque Country, the oldest dating back to the 1950s. Over the years, Tecnalia has played a key role in the modernisation of the Basque industry and has become the Spanish institution with the second highest number of patents, only after CSIC, as well as one of Europe's largest and most advanced technology centres. It also ranks first among Spanish private organisations in terms of participation and leadership of European Horizon 2020 projects. As of January 2020, it had 1 446 employees, among which 255 with a doctorate degree. 50% of its annual income in 2019 of EUR 155 million came from contracts with private firms, 30% from competitive public funding (mainly from EU programmes) and 20% non-competitive public funding (from the Basque government). Basque government financial innovation support provided to firms has traditionally required the latter to collaborate with technology centres (Salazar-Elena et al., 2020[65]).

Key areas of specialisation include health, advanced manufacturing, sustainable mobility, energy transitions, urban ecosystems, and digital transformation. Most of Tecnalia's clients are manufacturing SMEs, which outsourced a large part of their R&D needs to Tecnalia and rely on its technological capabilities to develop new products and improve their processes. Besides traditional technology development projects, Tecnalia has launched other new programmes to support SMEs, such as the so-called **ORAIN programme**, whereby a specialist from Tecnalia stays one day a week in a client firm during one year, diagnosing its needs and defining technological priorities. This programme has been recently enhanced with the possibility to include company based traineeships in the context of a **dual education programme**, under the joint supervision of the designated specialist from Tecnalia and the education institution's supervisor.

Tecnalia develops new technologies to meet business needs in in close cooperation with universities in the Basque Country and other Spanish regions, building on different collaborative agreements including joint labs with universities. It has also successfully developed a **dual model of employment**, with researchers affiliated both to Tecnalia and to a university. In recent years, its collaboration with universities has also spanned internationally, with a new unit specialised in high speed robotics in France and another one in medical devices in Serbia, both located within universities but financed by Tecnalia. This forms part of Tecnalia's **internationalisation strategy**, based on tapping into foreign knowledge that is of interest for the upgrading of Basque industries, as well as generating new flows of income through contracts with international clients. Outside its Basque HQ, Tecnalia has offices in Madrid and 7 other countries.

In addition to supporting existing firms, another mission of Tecnalia is to foster spin-offs. As part of this strategy, **Tecnalia Ventures** was set up in 2013 as a subsidiary to provide acceleration, incubation and venture building services for Tecnalia's most promising technologies. With over 20 employees as of 2019, Tecnalia Ventures has developed a portfolio of 14 spin-off companies with annual turnover of 33.5 million euro and 267 employees (Rufino, 2019[66]). On average, close to 40 business opportunities are in the accelerator. Tecnalia Ventures has also developed a consulting arm that provides R&D commercialisation services to a wide array of organisations ranging from governments to universities, companies and investors around the world.

Source: OECD, based on interview with Tecnalia management; Rufino (2019[66]); Salazar-Elena et al., (2020[65]) and https://www.tecnalia.com/

By a considerable margin, the largest technology centre in Spain is Tecnalia, which was set up in 2011 through the merger of eight pre-existing technology centres in the Basque Country and currently has over 1 400 employees (Box 10). In addition to Tecnalia, there are also several smaller technology centres operating in Spain and in different industries. Section 5.2 provides a more detailed overview since technology centres are major agents of government innovation and technology transfer policy.

Technology centres often have strong relationships with universities, particularly those from the regions from which they originate, to complement their applied research and technological activities with the research conducted at universities. In practice, this also means that CTs often outsource some of their tasks for firms to other actors in the system or act as intermediaries given their unique position and dual exposure to the research base and business. Also noteworthy is the role of CTs and CTAIs in assisting firms in assessing their technology needs and devising consistent innovation strategies, an important service within a system with relatively low business innovation capabilities, which requires business users to trust the advice provided by these centres. It is therefore important for advisory and solution development lines of activity within CTs and CTAIs to be structured in ways such that conflicts of interest can be avoided.

It has been noted there is a risk of potential displacement in CT's offerings towards one-size-fits-all generic solutions in order to minimise transaction costs arising from a growing number of potential users (Mas Verdú, 2021[60]). In order for CTs to provide adequately customised solutions for smaller-sized customers, it must be possible for CTs to develop sustainable service portfolios, hence the importance of an adequate institutional funding cushion tied to overall performance objectives.

Science and technology parks

S&T parks are urban sites under the management of a promoting entity, exclusively used by private or public entities with the main objective to generate scientific knowledge and promote technology transfer.

As in the case of technology centres, the first Spanish parks were established in the 1980s in regions such as Basque Country and Asturias, which were at the time suffering most from the industrial crisis, and used them as a tool to diversify the local economy towards new activities. Most other regions followed this model during the 1990s, mainly to attract high-tech multinational firms and to promote technology-based start-ups. As of January 2021, there are 51 parks registered as members in the Spanish Association of Science and Technology Parks (APTE), spanning across 15 autonomous regions. Although there is a large heterogeneity with respect to their size and institutional profile, all focus on promoting local innovation ecosystems and provide support services and dedicated spaces to host innovative start-ups. In 2018, over 8 000 firms were installed in these parks with close to 180000 persons employed within them (CYD, 2020[52]). Spanish science and technology parks have established strong connections with universities in their regions and many of them are even located within the premises of university campuses. Some studies have documented evidence of the positive impact of parks on firms' innovation outcomes, suggesting that they have been an effective policy approach in Spanish regions (Vásquez-Urriago et al., 2014[67]) as well as potential effects on the effectiveness of TTOs (Box 11) (Caldera and Debande, 2010[68]).

S&T parks faced a particularly challenging phase following the GFC as the entities in charge of their promotion experienced directly the economic shock to real estate activities. Several were left with a significant debt overhang while demand and revenues faltered, requiring support from national and regional governments. Formally recognised parks are eligible for a series of funding calls for support, including debt relief, as well as tax benefits. S&T parks in Spain recovered their dynamism as reference spaces for knowledge exchange.

Stakeholders coincide in highlighting the important shift from an apparent emphasis in the physical image of park sites prior to the GFC, to greater strategic focus on functional aspects concerning the facilitation of knowledge exchange between actors, including through networks bringing together different sites and parks. APTE is involved in advocacy and horizon scanning for the parks sector especially through its strategic plans as well as through the provision of networking, training and platform related services.

Box 11. Factors influencing technology transfer in Spanish universities

The role of university rules, TTO features and science parks

The study of contracting, licensing and spin off activity in Spanish universities by (Caldera and Debande, 2010[68]) showed that **university rules on conflicts of interest between academic teaching responsibilities and external activities** appear to be associated with better university performance in terms of R&D contracts, licenses or spin-off creation. The results further showed that **universities' royalty sharing policy** was strongly connected with licensing income. Granting a higher share of licensing royalties to the inventor appears to stimulate licensing activities. Furthermore, universities allowing academic scientists to take leave to create a new firm generate more spin-offs. This suggests that creating more certainty for the appropriation of research results matters for university performance. Designing the right incentives and sharing the risk optimally between parties involved in the commercialisation of research is a key component of an efficient technology transfer strategy.

The authors also found further evidence that the **presence of a science park** has a positive effect on the commercialisation of university research. Science parks play an incubating role reducing the costs associated with converting scientific findings into marketable products or processes. However, they found **mixed evidence regarding the impact of TTO characteristics** on university performance. TTO size has a positive effect on R&D contract activity and on the number of licenses and spin-offs created, but it does not appear to affect licensing income. Furthermore, TTO experience only correlates with R&D contract activity (consistently with what stakeholders indicate as dominating activity) and that TTO specialisation only appears to influence the number of R&D contracts generated, but not other outcomes.

The authors concluded that results question an approach to knowledge transfer based on the 'multiplication' of TTO structures in most universities and call for investigation of potential complementarity between TTO and science parks.

Source: Caldera and Debande (2010[68]).

Often in conjunction with Science and Technology parks are business and technology incubators and accelerators that give support (although not exclusively) to entrepreneurial ventures derived from public research outcomes (also see section 5.3). Both incubators and accelerators promote the growth of innovative companies and help start-ups grow. Incubator programmes include several forms of mentorship and support in early stages of an entrepreneurial venture. Business accelerators offer business advisory services to minimise lack of experience errors or management problems, and are meeting, training and networking spaces for start-ups. Although most incubators and accelerators in Spain were traditionally associated with public institutions including higher education and research organisations, there has been a notable growth throughout the country of privately promoted incubators in recent years. For example, as of June 2021 the Barcelona Metropolitan Area alone counts with over forty-five such entities. Similarly, there has been a significant growth in the number

of co-working and pre-incubation spaces in Spain at the disposal of budding entrepreneurs and their ventures, many specifically oriented towards entrepreneurial initiatives spun-off from public research organisations.

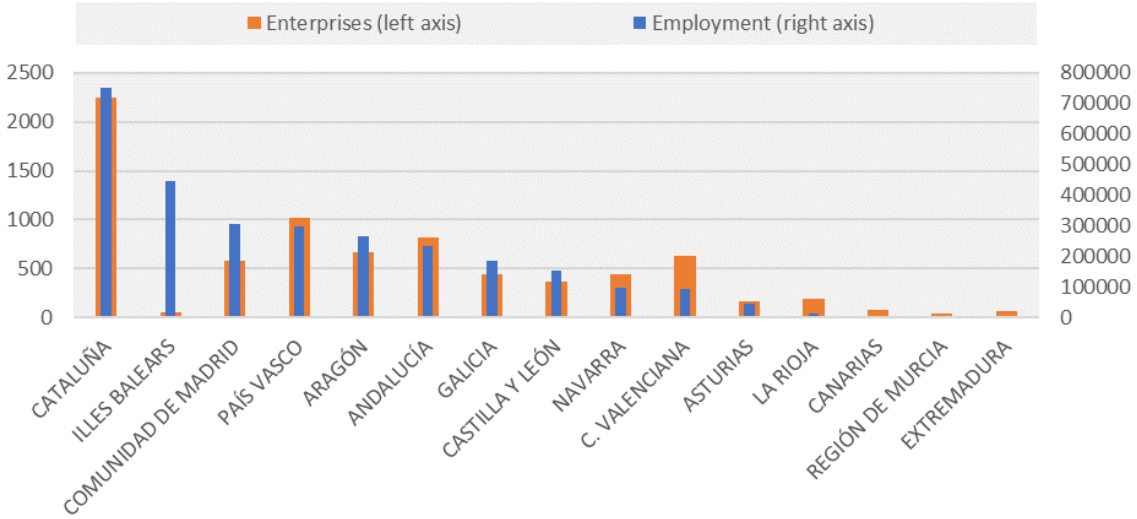
Business innovation clusters

Clusters are geographic concentrations of interconnected companies and institutions (e.g. research centres, universities) linked by common technologies and skills (OECD, 2009[69]). Clusters aim to create an environment conducive to innovation, as geographic proximity facilitates formal and informal interactions, and nurtures trust among its actors. Cluster associations can be formally constituted as such and engage in a range of activities to strengthen their ecosystem, for instance through the launch of talent attraction programmes, the organisation of sessions to explore joint opportunities and reinforce synergies, as well as the promotion of joint research projects. Examples of clusters in Spain include the Basque Energy Cluster, the Biotechnology Cluster in Galicia, and the Audiovisual Cluster in Catalonia. In common to other intermediary structures, and as also discussed in section 5 on KT policies at the regional level, "business innovation clusters" are the subject of explicit regulation and accreditation in Spain.

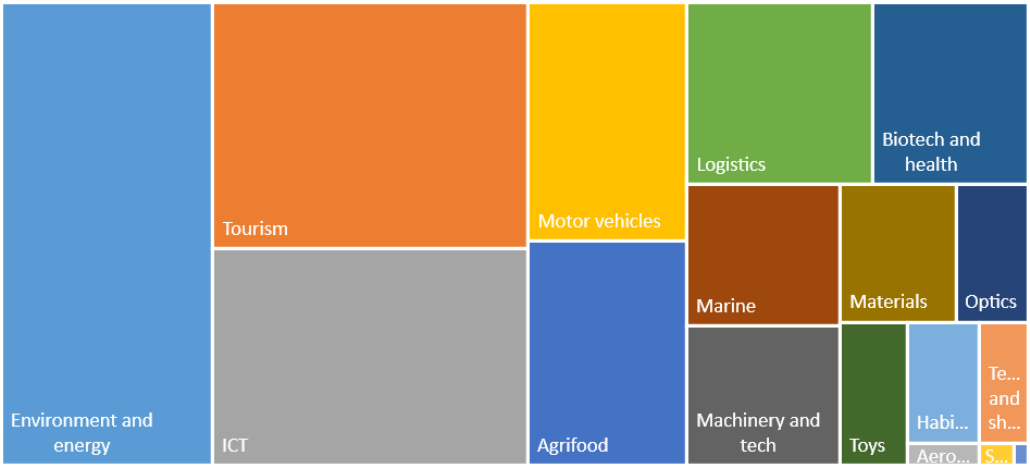
According to the statistics compiled by Spain's Ministry of Industry, there are 84 formally registered clusters, involving a total of nearly 8 000 companies, a majority of which are SMEs, as well as 507 technology centres, a figure that suggests that a given technology centre might be counted under more than one cluster. Catalonia stands out as the region with the largest number of clusters (Figure 48), employment and number of firms at close to one quarter of Spain's total. The most popular industries for clusters are Environment and energy, which accounts for one fifth of total employment in clusters, followed by Tourism and Information and communication, with well over 400 thousand jobs each. More distantly, they are followed by Motor vehicles, Agrifood and Logistics around 200 thousand each.

Figure 48. Distribution of Spain's clusters by region and industry

Distribution by autonomous region



Distribution by industry



Note: It has not been possible to verify whether the reported numbers of firms and employment levels may have been assigned to more than one category.
Source: OECD, based on Ministry of Industry, Innovation cluster statistics, https://clusters.ipyme.org/es-es/Identificar/Paginas/Estadisticas.aspx

Other coordinating agents and platforms - a new perspective

Furthermore, many other entities, associations and professional service providers such as specialised consultancies and financial intermediaries often complement the role of TTOs and other intermediaries in the transfer and application of research results originating from public universities and research organisations. Such entities are also an important part of the intermediation ecosystem for science-business engagement in Spain even if they are not formally recognised and regulated by the authorities.

A tentative assessment of the landscape for knowledge intermediaries in Spain indicates that there is much to be gained by raising the profile of individuals with explicit or implicit boundary-spanning roles (Box 12) as well as improving the coordination across these many different actors in order to avoid possible overlaps in the provision of services by different entities and help identify possible gaps in the response to transfer needs.

Having a greater overarching view of the technology transfer eco-system of a territory, including both public and private institutions could help improve the efficiency and effectiveness of the knowledge exchange process. This can be especially valuable from the perspective of the business sector, sometimes overwhelmed and confused by the multiplicity of players in the eco-system.

Box 12. The case for greater recognition of boundary spanners in Spain's innovation system

Successful innovation collaboration requires deliberate attention to the end-users' goals and constraints, helping define which problems to address and how best to go about it with the resources available to the partners and capacity to bear risks. Individuals with boundary spanning roles are critical actors in facilitating the efficiency of knowledge transfer and collaboration in an innovation system by effectively focusing on the connection between goals and potential solutions. Boundary spanning roles include:

- Connecting producers and users of knowledge by enabling and organising their interaction, including providing logistical, mediation, facilitation, and financial support;
- Reconciling and protecting interests, different motivations, and cultures at the boundary and attending to issues of equity and trust building;
- Acting as 'honest brokers' by specifically focusing on integrating scientific knowledge with stakeholder input and offering alternative approaches;
- Co-producing and disseminating decision support materials, tools, and objects that help bridge users and producers of knowledge, suitable customised to different decision contexts;
- Providing services, training, and complementary expertise to enhance the production of actionable knowledge; and
- Supporting and fostering the creation and maintenance of knowledge networks and communities of practice that sustain knowledge exchange.

Boundary spanners can be found in all sectors in Spain's innovation system, yet their margin for specialisation and operation is rather limited for a number of reasons. The diversity of skills associated with all functions described above are often not explicitly taught in most mainstream pre-career academic or professional training and may be *ad hoc* or emergent for professionals (e.g. a knowledge producer/scientist). In addition, they are often not formally codified as a main component of their job responsibilities.

First, as detailed above, boundary spanners may be asked to play a number of roles, some of which may fall outside their area of expertise, requiring access to a broader network of expertise and training.

A related set of challenges stem from a lack of recognition of boundary-spanning as a discrete function and/or profession. For example, often, boundary spanning is seen as something that certain actors, such as researchers and planners, choose to do in addition to their regular duties. This is also a function that is hard to assess, and in which it is important to be able to develop a good reputation as efficient and honest knowledge broker.

In recognition of the importance of this type of role and the specific challenges associated with it, the Spanish Chamber of commerce has been working with an international consortium to develop a custom profile description, training programme and expert network for boundary spanners.

Source: OECD, drawing in part on CYD (2020[52]) and www.spanning-boundaries.eu.

A notable example of such an over-arching coordination platform is TECNIO, set-up by the Business Competitiveness Agency (ACCIÓ) the regional government of Catalonia, which is

specifically designed to facilitate the orientation and accessibility of technology and innovation to Catalonia-based businesses (see Box 13).

Box 13. Catalonia's TECNIO technology facilitator and developer platform for businesses

The Business Competitiveness Agency (ACCIÓ) of the Generalitat de Catalunya (Regional Public Administration in Catalonia) has set up the TECNIO Platform as a one stop shop for companies that want to gain market competitiveness by applying new technologies to their products, process or services, but that do not necessarily have the required technological knowledge. TECNIO acts as a platform of all technology facilitators and developers operating in Catalonia and beyond.

The **TECNIO certification** identifies differential applied technology providers and facilitators. The certification:

- Supports the most qualified agents involved in technology transfer processes.
- Allows companies to access advanced R&D and develop new products and services.
- Increases the scope of technology projects by finding the most suitable technology partners and suppliers.
- Helps raise company competitiveness and technological innovation capacities.

Two kinds of organisations are accredited with the TECNIO certification:

- **TECNIO developers** generate new technology and transfer it to companies, either through tailor-made R&D projects, or through direct sale of the developed technology. The list of certified TECNIO include transversal (e.g. ICT, nanotechnology, advanced materials, photonics, biotechnology, advanced manufacturing) and sector-based (e.g. agri-food, design, culture, sustainable mobility, health and life-sciences) technology development centres and developers. They are not only certified research and development providers active in Catalonia but are also accessible to external businesses.
- The **TECNIO facilitators** are the technology transfer offices located at the main Catalan universities that help companies discover the technology being generated in their scientific and technological domains, and offer the access to a portfolio of market-ready, developed technologies. Their main role is to provide companies with a point of contact with the corresponding university; know-how on the most innovative technologies; and access to technology in a licencing phase (sales).

TECNIO technologies are a list of advanced technologies developed by certified TECNIO facilitators and developers that are at the disposal of external companies either through tailor-made R&D adaptation projects, or through direct sale of the developed technology.

The **TECNIO association**, composed of the 59 research groups with a TECNIO certification, was created in November 2021 to pool resources and increase the visibility of those research groups, enhance their collaboration with businesses and increase their impact on business innovation.

Source: OECD, adapted from http://catalonia.com/innovate-in-catalonia/rd-in-catalonia/tecnio.jsp

3.4.5. Private philanthropy as a catalyser of knowledge transfer and collaboration

While several stakeholders have noted significant difficulties in securing philanthropic engagement in support of knowledge transfer and collaboration and achieving its full potential, there is some evidence of a growing sector with noteworthy experiences (Box 14) (Rey-García and Alvarez-González, 2015[70]). The Spain country report of the EUFORI Study conducted principally in 2014 showed Spanish Research and Innovation foundations constituted a relatively young, dynamic and diverse foundation sector. Despite being supported to a considerable extent by public policies, the sector also builds upon the decisive and growing involvement of medium and large enterprises. Spanish R&I foundations participating in that study held at the time over EUR 4 690 million in assets, adding up to over EUR 980 million in income, and devoted over EUR 773 million to R&I expenditures (2012). The EUFORI study identified significant weaknesses, particularly in terms of:

- relative lack of scale and specialisation in research and innovation;
- high share of operational costs and small share actually devoted to transfers to third parties;
- insufficient internationalisation;
- limited public incentives to philanthropy, esp. concerning the tax regime;
- limited commitment to supporting public and private actors beyond the specific actors they are instrumental to, e.g. an insufficient degree of general duty to society

The report highlighted a shift towards newly emergent models of philanthropic support with considerable relevance to knowledge transfer and collaboration activities (KTC) (Box 14).

Box 14. Emerging models of philanthropic support for knowledge transfer and collaboration

Among the cases highlighted in that report of direct relevance to KTC, the following stand out:

Endowed foundations support for knowledge transfer and commercialisation

Endowed foundations have supported the transfer of technology by public universities, research groups and research centres through a mix of grants and equity investing in spin-offs originating from their activities, according to program-related investment and venture philanthropy trends. The Botín Foundation has pioneered this approach in Spain since 2005 with its State-wide Technology Transfer Program, with a major focus on the biomedical area. For researchers, this programme combines long-term research grants for selected IPs, with management, marketing and legal support for the valorisation (idea evaluation and protection) and commercialisation stages, as well as investments in the equity of the eventually resulting spin-off companies. The 'Mind the Gap' programme supports biotechnology business R&D projects with commercial potential to the validation phase, also taking mature technologies to more commercially attractive stages of development. In 2019, Mind the Gap invested over EUR 200 000, adding to a total of EUR 2.6 since its commencement.[51] The Barrié Foundation launched a training program on the transfer of technology for Galician public researchers and knowledge transfer managers in collaboration with Oxentia, a subsidiary of the University of

[51] See 2019 annual report. https://fundacionbotin.org/89dguuytdfr276ed_uploads/FUNDACION/MEMORIAS%20ANUALES/Memoria%202019%20EN.pdf

Oxford that manages the transfer of technology and academic consulting for its owner and also for external clients. In 2019, the Barrié Foundation transferred to GAIN the methodology developed with support from Oxentia and started a programme for the accreditation of technology transfer professionals.[52] The methodology was later transferred to FEDIT.

Foundations working on the interface between R&I and entrepreneurship

The meeting point between R&I and entrepreneurship has attracted a significant portion of innovative programmes, such as those by the Celera and INLEA foundations. The Celera programme, founded by Javier García, a university professor with a PhD in Chemistry, founder of Rive Technology, develops and trains talented Spaniards in the field of science, innovation, technology and entrepreneurship. The programme hosts a maximum of ten participants, includes a broad set of networking and training opportunities, and lasts for three years, and receives support from the Rafael del Pino, Sabadell and Soria-Melguizo foundations. The INLEA Foundation, which focuses on promoting entrepreneurship among research and technology experts, particularly in the field of ICT, is the CSR vehicle for its parent company, INLEA, a provider of technological solutions and other professional business services. In 2008 it launched linktoStart, a nine-month comprehensive training and mentoring program that supports the development of new ideas and provides business training for entrepreneurs in Spain's ICT sector in order to transform their technology-based projects into a business model worthy of the attention of investors.

Source: OECD and Rey-García and Alvarez-González (2015[70])

Interviewees with connections to the business world referred to the OECD team that the Spanish universities and research base, in comparison with other countries, do not currently represent by and large a sufficiently attractive "image projection" proposition for public philanthropy outside a number of highly prominent areas, principally connected to health, an area that has been the subject of public-private partnerships for R&D and its direct application.

Two cases indeed stand out, namely those of the structures hosting and lending support to CNIO[53] and CNIC (Box 15). The examples mentioned with some of their translational R&D successes generate economic and social value, which even if not necessarily monetised, are of a sufficiently large scale to offset and justify the investments made by private and public parties. Governments therefore have an important role in putting in place the legal framework to facilitate the formation of organisations like the Pro CNIC Foundation or "CNIO Friends", which tie private money—mainly on a not-for-profit basis—into long-term social commitments of universal benefit. In this landscape, it is crucial for all actors in Spain's innovation system to coordinate with each other to raise its level of philanthropic support towards research and innovation up to the level of its European peers, making use of new opportunities such as crowdfunding, while extending the scope of such an enhanced support to other major social challenges.

[52] See https://fundacionbarrie.org/sharing-knowledge

[53] In the case of CNIO, Spain's National Centre of Oncological Research, the annual reports do not provide a complete picture of funding sources but clearly outline the value of philanthropic donations via sponsorships and partnerships on the one hand and the CNIO Friends, having raised over EUR 800 million in 2020, a figure that is on the same order of magnitude as that raised by Cancer Research UK. https://www.cnio.es/downloads/annual-report/2020/00/cnio-annual-report-2020-portrait-lq.pdf

Box 15. CNIC: an example of private public partnership in cardiovascular research

Cardiovascular disease is the principal cause of death in Spain. Research in this field is therefore considered a priority by health professionals and government authorities. ISCIII created Spain's national centre for cardiovascular research (CNIC) as a public foundation, whose main objective was to create a centre of excellence as the nexus of an expanded Spanish contribution to cardiovascular research and play a leading role in the application of research results in clinical practice, nationally and internationally. The organisation, combining departments devoted to basic research and those with a more directly clinical orientation, reflects the priority of translational research as well as the discovery and professional training of new researchers.

The funding of the CNIC is based on a PPP of the broader, socially committed model through the Pro CNIC Foundation (http://www.fundacionprocnic.es). CNIC appealed to the sense of social obligation of the largest businesses in the country by inviting these major players in Spanish civil society to make an active and long-term funding commitment. The outcome was an agreement, signed in December 2005, between the Ministry of Health and a group of some of the most important Spanish businesses, the terms of which initially committed these businesses to funding the CNIC until 2012. Shortly afterwards, this grouping of companies was formally constituted as the Pro CNIC Foundation. Since then, new companies have joined the group, and the Pro CNIC Foundation currently has 13 members: Acciona, Banco Santander, BBVA, Endesa, Fundación Abertis, Fundación Ramón Areces, Gas Natural, Grupo Prisa, Inditex, La Caixa, Repsol YPF, Fundación de Investigación Mutua Madrileña, and Telefónica. In this innovative PPP, the Spanish government has committed nearly half EUR 1 billion over the next 10 years and the Pro CNIC Foundation close to half of that amount.

The Pro CNIC Foundation not only provides CNIC with funds, but also contributes its accumulated managerial and business expertise. Representatives of the Pro CNIC Foundation sit on the CNIC's Board of Trustees and participate in its management, planning and decision making. In addition to this know-how, a major strength of this PPP model is that it provides for a more solid base than traditional forms of charitable financing, giving the CNIC a more stable financial support than if it relied on sporadic donations from benefactors. This stability gives the CNIC greater freedom to commit itself to long-term, high-return research strategies in collaboration with public and private institutions and allows for a more effective use of its own resources generated through competitive projects and the exploitation of intellectual property rights.

The Pro CNIC Foundation is an example of a new model of patronage in biomedical research and is an example of collaboration between the public and private sectors. CNIC has also entered into product-development partnerships, a prime example of which is the collaboration with FERRER, a Spanish pharmaceutical company, which resulted in the first fixed-dose combination drug («polypill») approved in Europe. This particular PPP brought together skills, knowledge and resources from a private for-profit pharmaceutical company and a PRO to create a new approach to solving a key global health problem. The collaboration agreement between CNIC and Philips allowed CNIC to have the most advanced cardiovascular imaging technology in the entire spectrum and resulted in a joint patent that allows reducing imaginge examination times from 30 minutes to less than one.

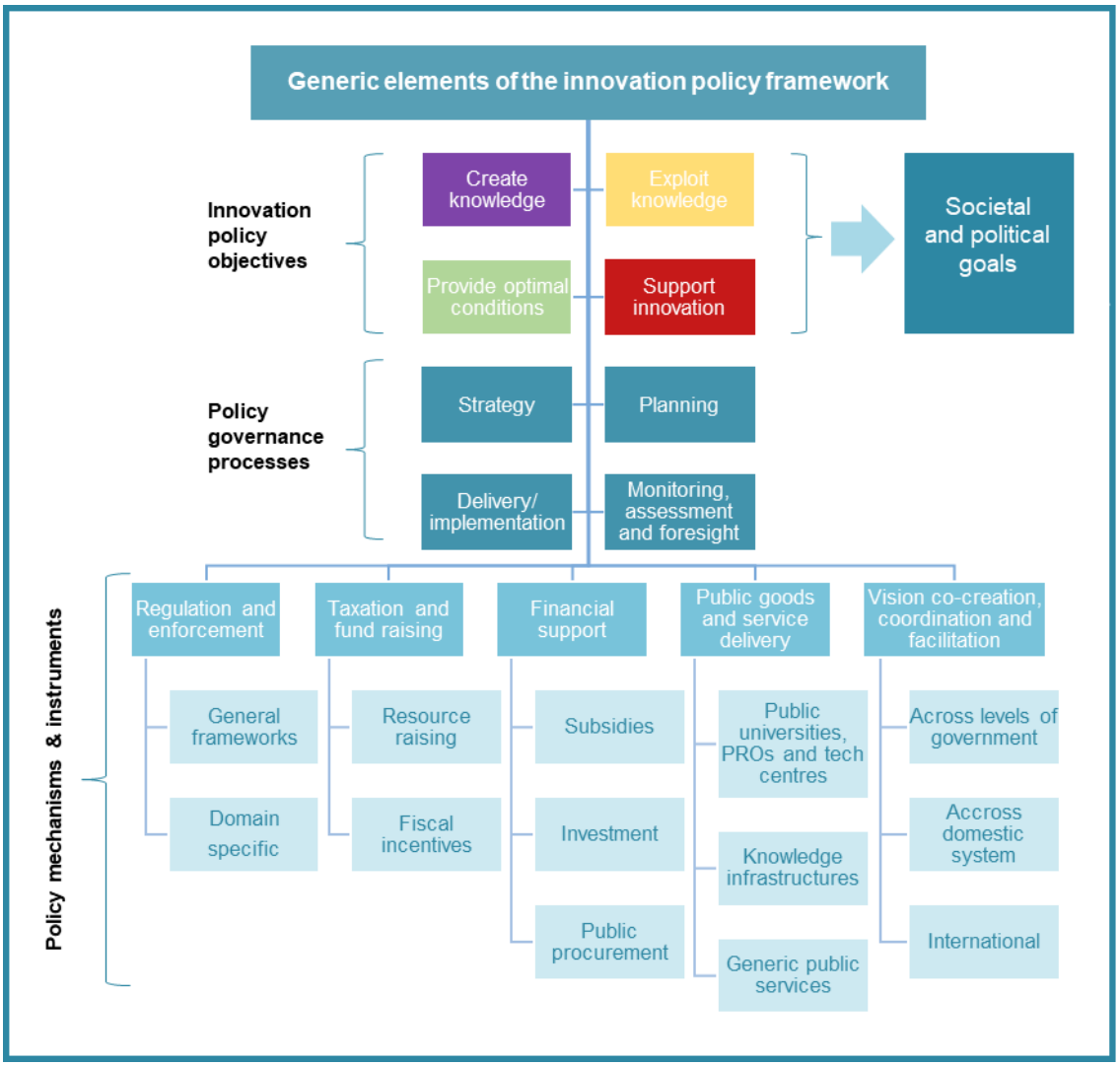
Source: CNIC, https://www.cnic.es/sites/default/files/Spanish.pdf and https://www.cnic.es/en/noticias/otri-or-how-capitalize-investment-talent-and-resources-academic-centers

4. Public policies for science-business knowledge transfer and collaboration: the role of Spain's central government

4.1. A reference innovation policy framework for science-business knowledge transfer and collaboration

As highlighted in previous sections, the promotion of science-business collaboration around the exchange and use of knowledge is an integral part of innovation policy. The general procedures and tools of policy making can and should be mobilised towards such an objective in the framework of a coherent innovation policy, as indicated in Figure 49. The figure, which sums up this conceptual framework, separates between a) the innovation policy objectives; b) the governance processes which go from science and innovation strategy definition to policy delivery; and c) the policy mechanisms and instruments across the entire policy toolbox.

Figure 49. Elements of the innovation policy framework for science-business knowledge transfer



Source: OECD own elaboration.

Innovation policy in advanced economies pursues multiple objectives that span the array of functions of an innovation system, namely the creation of new knowledge, particularly fundamental knowledge that while it may not have direct applications, will represent the basis for future technical advances; the exploitation of available knowledge; the support to innovation across the entire economy and society; and the provision of optimal framework conditions for the actors in the innovation system to fulfil their functions. These objectives are oriented towards the pursuit of societal goals as broadly defined through the political participative process. The recent OECD/EU STI Policy Compass toolkit for knowledge transfer[54] identifies more specifically a list of thematic output areas for knowledge transfer policy initiatives (OECD/European Commission, 2021[71]). These typically fit more than one element of the combined set of create/exploit/conditions/support innovation objectives:

- Collaborative research and innovation ((co-)create and exploit knowledge, support innovation)
- Commercialisation of public research results (exploit)
- Transfer and sharing strategies (exploit)
- Intellectual property rights in public research (conditions, exploit)
- Enablers of third-party funding (conditions)
- Cluster policies (conditions, support innovation)
- Inter-sectoral mobility (create, conditions, exploit, support innovation)
- Entrepreneurship capabilities and culture (exploit, support innovation)

The policy governance processes encompass the procedures of setting strategy, planning for implementation, policy delivery and assessment through the entire policy cycle. A wide range of policy instruments can be used for innovation policy purposes and for promoting knowledge transfer and collaboration more specifically. This section will discuss each one of them in the same order.

4.2. Policy governance for science-business knowledge transfer and collaboration: from strategy to implementation

4.2.1. Evolution of Spain's STI policy strategies and regulatory frameworks to enhance science-business knowledge transfer and collaboration

The objective of addressing deficiencies in the extent and nature of science-business engagement has been a long-standing consideration in Spanish strategies for science and innovation, and has also been persistently raised within EU and OECD policy recommendations for Spain. For instance, in 2005, an OECD evaluation of Spanish state-level practices in support for public-private partnerships for research and innovation (OECD, 2005[72]) highlighted the existence of a wide gap between stated goals and actual implementation, calling in particular for improved incentives and institutional frameworks for the co-operation between the private and public R&D sectors. Already at the time, what had been a rather remarkable growth in scientific output had not been matched by a comparable increase in business demand for scientific inputs to innovation processes, leading to a large amount of human and knowledge resources underutilised from an economic and social standpoint. The study concluded then that the Spanish system of research and innovation had reached "a sufficient level of sophistication for a new approach to the

[54] https://stip.oecd.org/stip/knowledge-transfer

promotion of PSR-industry relationships to be successfully experimented […] adapting the model implemented in diverse OECD countries to the Spanish conditions" (OECD, 2005[72]). This OECD evaluation contributed to the development by Spanish authorities of new initiatives such as a programme of support towards strategic private-public partnerships for technological innovation.

However, the experience of limited stability of programmes and initiatives, not necessarily linked to the implementation of conclusions from evaluation studies but most often the result of budgetary priorities and availability of resources, appears to be a dominant but not the sole factor in the implementation of STI initiatives in Spain. The rapid succession of laws and strategies outlined below also highlight the pre-eminence of regulatory approaches to the innovation and knowledge transfer challenges that have contributed to building a complex web of rules that are not optimally suited for knowledge creation and exploitation activities and cannot possibly foresee all potential circumstances and needs amidst a rapidly changing economic and social context. In the past, this has called in turn for additional legislative developments and extension initiatives that feed onto each other, drawing considerably on limited policy making resources.

Knowledge transfer and collaboration in Spain's STI strategies

Up until the dawn of the global financial crisis, Spain's government continued to make sizeable investments in research capacity that were reflected in several scientific output indicators, while a series of strategies continued to place knowledge transfer and exchange as a continuing structural weakness worthy of policy prioritisation. For example, the **2007 Spanish national Strategy for Science, Technology and Innovation (STI)** alluded to the imperative of transitioning to a model of innovative universities where knowledge transfer and other similar specialised units serve as effective mechanisms of knowledge exchange towards market-based applications (Gobierno de España, 2007[73]). The employment of qualified research personnel in firms, and the promotion of patenting and the creation of spin offs were explicitly identified as core elements of this strategy for HEIs. The Strategy also called on the institutional integration of different types of entities within the PSR, including PROs, towards a greater facilitation of increased engagement with business.

The **2007 amendment to the 2001 Law of Universities** developed further the knowledge transfer objective of universities already present in the law, affirming it as a key social function (Gobierno de España, 2007[42]). It required universities –autonomous entities under the Spanish Constitution and regulated by regional governments– to determine and establish means to facilitate such engagement by teaching and research personnel, including the recognition of such activities as part of their professional evaluation. In addition to this, the legislation provided for HE permanent staff to request the authorisation to join enterprises based on technologies or results resulting from their projects, under a special leave of absence mechanism of up to 5 years' duration. This measure sought to provide a framework and additional incentives beyond those already allowing for the delivery of scientific and technical services to third parties.

The policy response to the financial crisis

Facing a marked reduction in private and public resources available for R&D in Spain throughout a protracted fiscal consolidation period, the **2011 Law of Sustainable Economy (LES in Spanish)** implemented a series of structural reforms on public contracts, research and innovation with significant implications for the social engagement of PSR institutions and their staff. In particular, the law laid out the use of contractual private law as the framework for contractual engagement in relation to the management and transfer of results from research, development and innovation (Gobierno de España, 2011[74]).

The **2011 Law of Science, Technology and Innovation** (LSTI) established that knowledge exchange and transfer activities were to be promoted in the framework of future "State Plans"[55] for S&T Research and innovation across the entire PSR (Gobierno de España, 2011[75]). It also included the measures to facilitate collaboration agreements between private actors and PSR entities for R&D, innovation, creation or financing of centres, project financing, personnel development, knowledge dissemination and shared used of facilities. This law recognised how the research and intermediation activity of Technology Centres, Scientific and Technology Parks, Technology Platforms and Associations of Innovative Enterprises in the translation and dissemination of research-based knowledge in the innovation system, including an explicit promotion of "inverse" knowledge transfer from business to the PSR.

The confluence of two major pieces of legislation in 2011, one domain specific and another more general but with domain specific provisions, highlights the legislative coordination challenge for science and innovation as a policy area.

Intellectual property rights (IPRs) were also the object of a number of provisions in the new legislation. The LSTI established the right of research staff to have a share in the proceeds of undertakings arising from the exploitation of knowledge to which they have contributed, separately from their salary remuneration. The LSTI also modified the **Patent Law (2015)** to extend such rights to staff in public research institutes under the responsibility of regional administrations[5657]. Responsibility for setting the terms of such participation was vested on the relevant administrations in charge of each research entity. The LSTI foresaw a series of knowledge transfer contracts, including equity participation in undertakings, contracts for collaboration and contracts for the delivery of services or assignment of IP rights.

Still facing major budgetary challenges, Spain's **Science, Technology and Innovation Strategy for 2013-20**[58] was the first one to bring together the previously separate strategies for Innovation (EEI) and Science and Technology (ENCYT) under a common strategy. It identified as major systemic weaknesses the barriers to mobility between the PSR and business, the rigidity of governance models for the PSR, the inefficiency of instruments for knowledge exchange, and the low absorptive capacity among SMEs (Gobierno de España, 2013[76]). Based on this diagnosis, the Strategy established the transfer and management of knowledge as one of the priority axis of action to be further developed in the **2013-2016 State Plan** (Gobierno de España, 2013[77]). That plan foresaw (a) the implementation of inter-sectoral collaborative R&D and innovation projects with the aim to develop new products, services and technologies; (b) the development of exchange and communication infrastructures: and (c) the promotion and commercialisation of their outputs. The 2013 Strategy also pointed to the need to adopt regulatory, administrative and financial measures to endow the PSR with greater flexibility and efficiency.

[55] The term "state" as literal translation of "*estatal*" refers effectively to the central level of government. State plans, approved by the Council of ministers, are foreseen in the LCTI of 2011 comprise the programmes envisaged by the central government to implement the national strategy (ECTI) through different instruments under its responsibility. The autonomous regions define their own plans.

[56] Previously in 2008, the European Commission had published a recommendation on the management of intellectual property (IP) in knowledge transfer activities and good practices at universities and PROs, encouraging countries to adopt a series of policy principles leading to coherent normative frameworks and institutional practices within the public research institutions for IP and knowledge transfer, as well as for collaborative research and subcontracting (European Commission, 2008[151]).

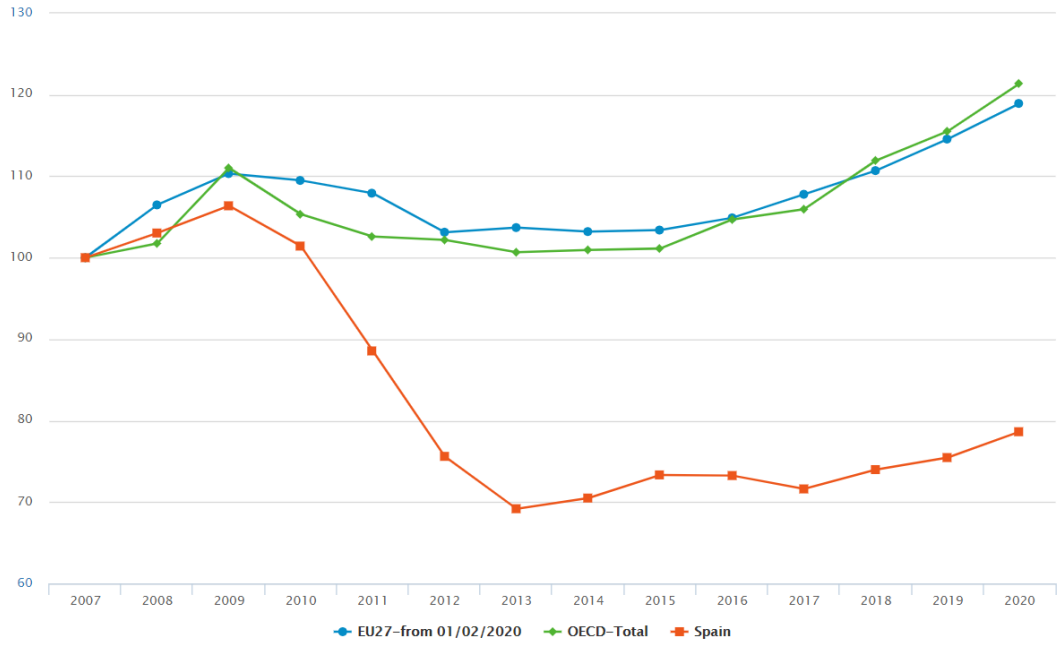
[57] See article 21 of the 24/2015 Patent Law.

[58] The strategy set as major objectives the promotion of talent development and use, the pursuit of S&T excellence, the promotion of innovation business leadership and the orientation of research towards priority societal goals.

Further reforms under a constrained budgetary environment

The continuing economic and financial challenges compelled the government to continue restrictions to public spending in this area (Figure 50). Additional spending control mechanisms for research organisations were introduced in 2014, which compounded to the high bureaucratic burdens already identified in the ERAC review (European Commission). While some of those controls were formally lifted in 2019, several observers continue to consider that the legal and administrative regimes applicable for the hiring and promotion of staff, purchases and sales of goods and services are still particularly detrimental to the existence and fluidity of knowledge-based exchanges between PSRs and the private sector. While these challenges are not strictly unique to Spain, the Spanish system appears to face structural difficulties towards defining, implementing and combining effective institutional autonomy principles with both established and reformed rules-based compliance frameworks.

Figure 50. Trends in government R&D budgets, 2007=100



Note: R&D budget figures do not include funding for R&D tax incentives nor repayable financial incentives.
Source: OECD STI.Scoreboard. https://stip.oecd.org/stats/SB-StatTrends.html?i=C_INDEX&v=3&t=2007,2020&s=EU27_2020,OECD,ESP

The **2017-2020 State Plan for Scientific and Technical Research and Innovation** had as a key objective addressing the 2016 EU Council's recommendations to increase cooperation between businesses, universities and the broad research sector (Gobierno de España, 2017[78]). Echoing the ERAC Peer Review findings, the Council had also pointed at the need to raise performance-based financing at PROs and universities (a dimension not covered by the plan), adopting as well measures to stimulate research and innovation in the private sector.

Policies for the PSR and its engagement with business have continued to be an important focus of external policy recommendations, while noting developments such as the above and the programmes like the Cervera Programme for Technology Centres and the Science and Innovation Missions Programme, both managed by the Centre for Industrial Technological Development (CDTI) (see section 4.4 below). The EU Council Recommendation on the 2019 National Reform Programme of Spain recommended Spain to take action in 2020 to enhance

the effectiveness of policies supporting research and innovation. The **2020 European Semester country report for Spain** noted that Spain had taken action to improve coordination and synergies in research and innovation policies, referring to the design of the post-2020 strategic framework for innovation in coordination with other relevant national and regional bodies. The report also noted low business participation in innovation projects (especially among SMEs), arguing that the low level of utilisation of available knowledge and public research base resources by Spanish firms prevents them from innovating on a larger and broader scale. The EU has also pointed out the imperative of a strengthened governance of research and innovation policy across government levels, as well as a closer alignment of R&D infrastructure and projects to regional and national innovation strategies (European Commission, 2020[79]).

4.2.2. Strategy, planning, delivery and monitoring for science-business knowledge transfer and collaboration today

Strategy and planning

The **Strategy for Science, Technology and Innovation 2021-27**, approved in September 2020, sets out the ambition that by 2027 Spain should become a country based on knowledge and innovation, capable of meeting its social, economic and environmental challenges and achieving sustainable welfare and inclusive growth (Gobierno de España, 2020[80]). The strategy sets out seven strategic objectives[59]. The 2021-27 strategy identifies science-business knowledge transfer as:

- One of its key objectives (Objective 6. Promote knowledge transfer), under the overarching aim to Promote innovation and business leadership.
- One of its key axis of action (Axis 11 on furthering relationships among agents through channels of engagement between public and private actors).

The strategy also includes a number of indicators to monitor and evaluate its implementation, including two indicators related to knowledge transfer activities out of 29:

- Number of licensed patents from universities and public research organisations per million inhabitants (2018 baseline: 24.9): 50 by 2027
- Number of spin-offs created by universities, public research organisations and technology centres in the last 5 years (2018 baseline: 549): 800 by 202

[59] 1) Make science, technology and innovation a key pillar to achieve the Sustainable Development Goals of the 2030 Agenda; 2) Contribute to the EU's political priorities by aligning with its R&D and innovation programs and support all actors responsible for the Spanish Science, Technology and Innovation Strategy to achieve this objective; 3) Prioritize and provide responses to the challenges of the national strategic sectors through R&D and innovation, with the aim of promoting the social, economic, industrial and environmental development of the country; 4) Create scientific knowledge and leadership, improving the position of research staff and institutions, and the quality of their infrastructures and equipment. Promote scientific excellence, ensuring that this has systemic effects and its impacts benefit a wider range of groups. Apply scientific knowledge to develop new technologies that can be used by companies and improve the communication with society; 5) Boost Spain's ability to attract, recover and retain talent, by **facilitating professional progress and mobility of scientific personnel between the public and private sectors**; 6) **Encourage the transfer of knowledge and develop two-way links between science and business (including SMEs)**, by strengthening mutual understanding of needs and objectives; 7) Promote research and innovation in Spanish business sector, increasing its commitment to research, development and innovation and expanding the number of innovative companies to make them more competitive.

The latest "State Plan" and first corresponding to the 2021-27 ECTI, the State Plan **for Scientific and Technical Research and Innovation 2021-23**[60] (*Plan Estatal de Investigación Científica, Técnica y de Innovación, PEICTI*) was approved in June 2021, including two specific Sub-programmes that target knowledge transfer and collaboration:

- Sub-programme for knowledge transfer, with an annual budget of EUR 51 million in annual subsidies and EUR 300 million in repayable loans. This is complemented by EUR 450 million from the National Recovery, Transformation and Resilience Plan (RTRP) for 2021-23.
- Sub-programme for public-private collaboration, with an annual budget of EUR 465 million in annual subsidies. This is complemented by EUR 706 million from the RTRP for 2021-23.

Other Sub-programmes closely linked to the area of knowledge transfer and collaboration include those that support talent recruitment and talent mobility, and that aim at enhancing the research and innovation capacity of businesses.

A number of additional developments in the central government policy landscape have direct implications for knowledge transfer and collaboration. Section 6 explores these in detail.

Implementation and delivery

Section 2 described the governance structures and the role of government in implementing STI policies at a national level. Their programmes in support for knowledge transfer and collaboration will be analysed in more detail in section 4.4. From a governance perspective, it is worth noting the differences in structural arrangements for different **delivery agencies**.

As previously shown in Figure 25, CDTI is legally set up as a "Public business entity" which allows it to be governed by private law in its relations with third parties, allowing it to offer companies relatively user-friendly and flexible support services and finance.[61] The more recently constituted State Agency of Research (AEI) is in contrast set up as a state agency operating with a multi-year contract agreement with its sponsoring ministry and subject to public law. In both cases, most of their resources are devoted to the management of programme funding calls, provision of related advice and the technical appraisal of proposals[62], with a significant emphasis on internationalisation and support towards the participation of Spanish actors in EU and international programmes.

Traditionally, both agencies have served different types of potential beneficiaries, with CDTI having a key expertise on state aid for undertakings, a subject of strict EU regulation. While each agency counts with representation of the counterpart's leadership in its governing board, it is still noteworthy, from the perspective of implementing policies in support for knowledge transfer and collaboration, that the major reporting or planning published documents for each of these two agencies do not include references to mutual coordination with each other.

[60] See https://www.ciencia.gob.es/site-web/Noticias/2021/Junio/Aprobado-el-Plan-Estatal-de-Investigacion-Cientifica-Tecnica-y-de-Innovacion-2021-2023.html

[61] The study by Listeri, Sanz-Menéndez and Curbelo (2017[152]) concludes that CDTI's key strengths as an innovation agency are based on its financial (including own capital) and organisational stability, professionalisation with scarce room for political interference, procedural rigor, instrument portfolio breadth, internal analytical and assessment capabilities. The main reported weakness in this study relate to limited scope for external advisory influences and evaluations, coordination with other institutions and challenges retaining and attracting professionals, problems with common features to other Spanish government agencies.

[62] In the case of the AEI, according to its 2021 Action Plan, the management of the peer review system is the largest single activity in terms of staff workload, followed closely by the auditing effort and by the issuance of accounting documents to beneficiaries.

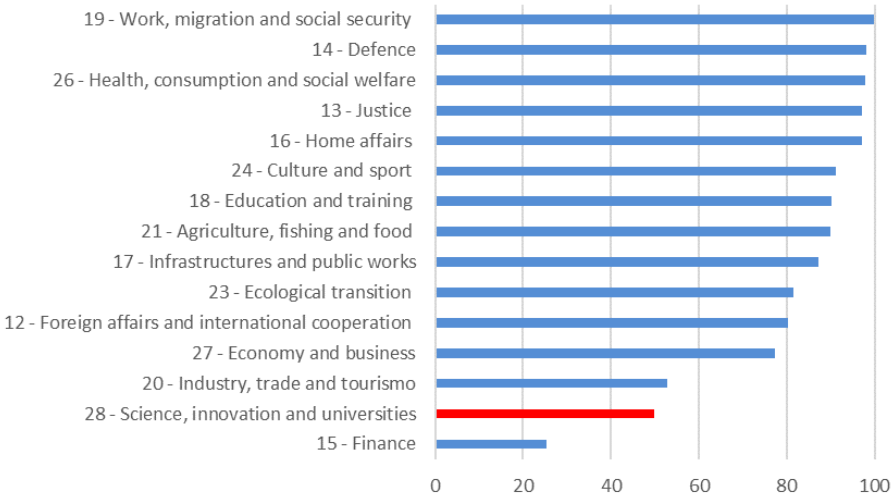
Another interesting dimension is the use of collaborative agreements in the case of CDTI between the central government agencies and the regional governments and their own agencies in order to ensure optimal coordination in particular in the allocation of financial support to businesses and organisations, avoiding unintended overlaps. References to coordination with regional governments and their agencies are absent from the latest AEI annual planning document.

In light of the extensive strategy setting and planning procedures in Spain's science and innovation policies, stakeholders interviewed coincided in flagging policy implementation as one of the major challenges in Spain. This difficulty is invariably associated in interview after interview to **regulatory and budgetary challenges**.

Indeed, one of the key points of concern for policy implementation and delivery in Spain is the extent to which resources allocated through the budgetary process end up being used for their intended purposes. Data for 2019 indicate that the expenditure area for Science and innovation exhibited one of the very lowest shares of recognised obligations out of total budgetary credits in the entire government, an indicator of underspend, at less than 50% (Figure 51), without including in this calculation the tax incentives for R&D and innovation in business, which appear to be attributed to the Finance area and have also generally undershot expenditure plans.

Figure 51. Recognised spending obligations as a share of final budgetary credits, 2019

By selected expenditure areas



Source: OECD analysis of IGAE data, https://www.igae.pap.hacienda.gob.es/cigae/EjecucionAGE.aspx

According to several analyses, this is in both due to the choice of support instruments for which demand is particularly difficult to predict (particularly extensive use of loans) and the operational approval procedures that are in place and that contribute *de facto* to supressing demand while generating considerable uncertainty, reducing the actual planning capability of the actors in charge of both running programmes and undertaking the types of projects and activities that the budgetary process ultimately expects. While this is a generic concern for science and innovation policy in Spain which is not exclusive to the specific subject of this study, discrepancies between plans and reality for resources can have a particularly more detrimental effect on knowledge transfer and collaboration activities in the system since it is sufficient for uncertainty to be perceived by one single actor for the planned engagement among two or more to fail to materialise.

Beyond its effect on restraining public expenditure on science and innovation, **regulatory challenges** are the recurrent target of comments by interviewed stakeholders. Section 4.3 focuses on the different legislation items and the way they are perceived to impact on knowledge transfer and collaboration. At a more general level, the OECD team has observed that regulatory compliance in Spain's innovation system is particularly complex not only for the "performers" that need to comply with the rules and benefit from public support and sponsorship, but also for the authorities and agencies in charge of implementing policies. In a rules-based rather than a principles-based legal system, there is a perception that all forms of relationships and transactions need to be explicitly regulated for each type of actor, and in the absence of such specific legislation, the applicable rules tend to be those of the government sector for its core administration. As noted in the description of different actors and knowledge intermediaries in section 3, this landscape leads to a self-reinforcing need to define and maintain registers of actors to accredit their entitlement to a particular policy treatment, making horizontal approaches more challenging to consider. New legislation often begets new legislation to implement any novel approaches introduced by the former.

Overall, this type of governance results in a system that consumes a considerable amount of resources in terms being devoted to administration, legal advice and compliance, leaving little room for investing in actual implementation and intelligence capacity to assess whether policies are having the intended effect and how procedures may need adapting.

Monitoring, assessment and evaluation (MAE)

The MAE function is particularly challenging in the sphere of science-business knowledge transfer and collaboration policy because of the multiplicity of actors, relationships and policy objectives. This task can be more easily accomplished when the MAE of individual types of agents across the system has reached some maturity and the systems in place are sufficiently interoperable.

The **STI data infrastructure** plays an important role in Spain's STI policy governance, a point that is well understood within the Ministry of Science and Innovation, which is putting in place an advanced information system building on different constituent parts under the framework and mandate laid out in the 2011 Law of Science, Technology and Innovation, the System of STI information, (*Sistema de Información de Ciencia, Tecnología e Innovación, SICTI).* SICTI is conceived in the law as the main tool for providing the necessary indicators for monitoring and evaluating public R&D and innovation policies, their results and impact, as well as their efficiency and effectiveness[63]. SICTI comprises inter alia a set of Knowledge Transfer and Innovation Indicators based on the KT survey (*Encuesta de Transferencia del Conocimiento e Innovación, ETCI*) covering Spain's universities, PROs and related organisations, described in Section 3.

SICTI is a joint information system of the central government and the regions. For its development, a working group was set up in 2017 comprising representatives from different administrations and funding bodies. The criteria governing the exchange of information were approved by the Science, Technology and Innovation Policy Council, as provided for in the STI Law. SICTI contains information on all the actions financed by public bodies, both at the central and regional levels, and on the aid granted for projects, human resources, centres, infrastructures and equipment. It includes information on the beneficiary entities and researchers, as well as the projects financed with European funds. It also provides information on publications, intellectual property rights, licensing agreements, R&D contracts and spin-off companies, as well as on budget appropriations at the central and

63 https://www.ciencia.gob.es/site-web/Estrategias-y-Planes/Gobernanza-estrategica/Sistema-de-Informacion-de-Ciencia-Tecnologia-e-Innovacion-SICTI.html

regional level used to finance R&D and innovation activities. It also makes it possible to identify the different agents of the Spanish Science, Technology and Innovation System, both funders and executors of R&D and innovation, as well as intermediate entities for the management and promotion of innovation. SICTI aims to be an ambitious, well-resourced and sustained information system that integrates available information, data and analysis.

In addition to helping map knowledge flows in a more comprehensive fashion, SICTI also provides an opportunity to strengthen coordination across different bodies and support initiatives launched in recent years that serve different policy purposes. For example, the National Statistical Institute (INE) which is dependent from the Ministry of the Economy is responsible for official statistics on R&D as well as on business innovation. These represent a major source of survey-based indicators of knowledge-based interactions, most of which cannot be at present easily replaced by administrative or other commercial sources but need to be used in a complementary fashion. There is therefore scope for different data sources to reinforce each other even though information exchange is already at a good level between ministries and INE. Actors like the Spanish Foundation for Science and Technology (FECYT) not only contribute data from its surveys on population attitudes towards science and technology but also engage in providing data resources and services such as those around repositories, the classification of journals, the tools for using normalised curriculum vitae (NCV)[64] and others in support of research-related administrative processes and the promotion of concrete policy objectives such as open science[65]. There is some significant discontent within the scientific community with the way some indicators computed at the level of individual researchers and the journals they publish in are used for research assessment purposes, a point we will examine in some detail when we look at researcher incentives.

Data analysis and linkage tools that use natural language processing techniques are being developed to facilitate the identification of relevant expertise and collaboration opportunities. As reported to the OECD team, the authorities' intention is to make them available to all the agents in the system although from past experience, there is a significant lag between announcements and data resources becoming effectively available to the public. These examples highlight the breadth of potential sources and uses of data and data-based systems within and around SICTI, which can range from the purely statistical to administrative and evaluative applications.

Ensuring the integrity and appropriate normalisation of the data is a key and time intensive task, which could be supported by more proactive use by the different agencies of common data standards and procedures for individuals, entities and interrelationships between them, which is of particular importance for tracking knowledge transfer and collaboration. Essential elements of an MAE system for SICTI's further development to take into account include the following:

- Ensuring long term sustainability of investments in data resources as well as data integrity, taking into account the incentives of different actors to provide and curate truthful, accurate and timely information.
- Adopting procedures for monitoring, auditing and accountability that are less compliance and more outcome oriented and do not generate perverse incentives, such

[64] More information about the CVN can be found at: https://cvn.fecyt.es/editor/index.html?locale=eng#INDEX

[65] The Infrastructures and Standards for Open Science (INEOS) project initiated in 2018 is a collaboration between FECYT, CSIC, ISCIII and INIA. The objective of this initiative was to interconnect the results of research financed with public funds with the data used in this research; to improve the quality of the existing data in the repositories and to increase the visibility of researchers in different institutional applications. https://recolecta.fecyt.es/ineos-en?language=en

as some types of outsources auditing arrangements paid with contingent recovery fees.

- Developing capabilities and procedures for outcome oriented ex-ante assessment of programmes and policies, in order for them to inform forward looking policy decisions, anticipating ex post evaluation requirements.
- In connection to the above, have comparable capabilities and procedures for ex-post evaluation and analysis, drawing on best domestic and international practice, and are sufficiently well integrated into decision making and policy learning processes.

This implies that the data infrastructure component of SICTI is not a sufficient condition for an effectively functioning system that promotes policy learning.

Evaluation challenges act as major impediments to the design and implementation of STI policies in Spain. It is important to clarify that in the context of this governance section we refer to the evaluation (ex-ante or ex-post) of programmes and policies, not to the technical appraisal of individual researchers or teams' merits or those of the projects they propose, which will be discussed later on in relation to knowledge transfer activities among others; nor the key performance indicators used in support of MAE activities. There is a substantial focus in Spain on assessing R&D performers but less so on assessing, against counterfactuals or alternative options the strategies, programmes and policies that shape the functioning of the system.[66] The concept of evaluation is also often misunderstood with the concept of tracking key performance indicators.

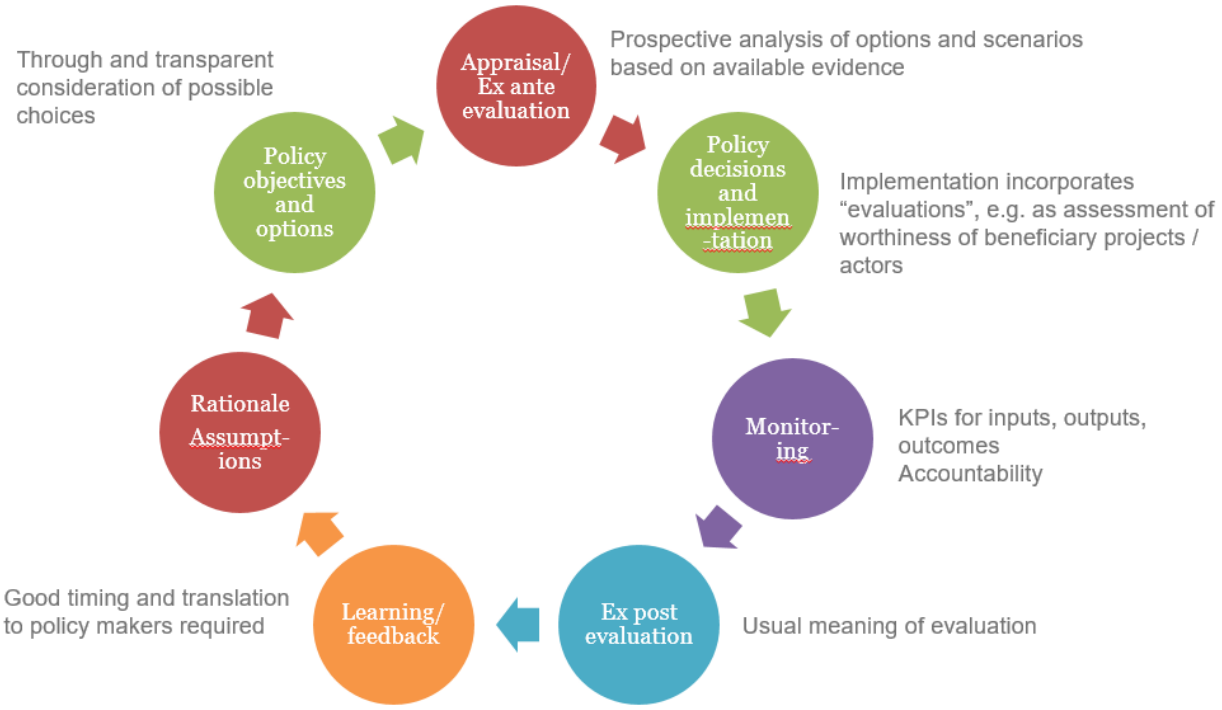
In comparison with other countries, the evaluation of STI public policies has not been sufficiently institutionalised in Spain (Garde Roca, 2004[81]). Borrás and Laatsit (2019[82]) have recently explored four key attributes (coverage, perspective, temporality and expertise) of innovation policy evaluation systems across the EU member countries and found Spain to be among the third quartile of countries, jointly with Latvia, Hungary, the Czech Republic and Portugal. The authors state that *"*these are countries with an uneven regularity of evaluation activities and uneven variation of the expertise. Their [evaluation] coverage is rather limited, and so is their systemic perspective. But these countries have made clear attempts to engage with the available expertise and tap into the available knowledge, typically from international expertise, and to comply with conditions slightly above the minimum required by external funders. These are countries which have taken the first steps towards creating some basic structures of what could in the future become a system oriented approach".

A key institution working towards the implementation of a culture of policy and public institutional evaluation in Spain is the Independent Authority for Fiscal Responsibility (*Autoridad Independiente de Responsabilidad Fiscal,* AIReF), created in 2014 with the aim

[66] As observed by Cruz-Castro and Sanz-Menéndez (2008[153]), the Spanish research evaluation system has been characterised by increasing political decentralisation and growing importance of individual evaluations compared to organisational ones, given "the limited financial resources for research of Spanish universities and their dependence on the success of individual researchers in obtaining research grants through competitive bidding". At the national level, the National Agency for Evaluation and Foresight (*Agencia Nacional de Evaluación y Prospectiva*, ANEP), created in 2004, was in charge for many years of project evaluation, but its role was assumed by the AEI, which since 2015 (following the 2011 Law of Science) oversees the whole project funding process, from ex-ante evaluation, to funding to ex-post monitoring. At the regional level, evaluation units to grant competitive regional funding are often connected to accreditation and quality assurance regional agencies, created with the aim to evaluate teaching quality at universities (following the 2001 University Law). The National Agency for Accreditation and Quality Assurance (ANECA) has now counterparts in most regions with increasing responsibilities.

"to oversee the sustainability of public finances as a means for ensuring economic growth and the wellbeing of Spanish society in the medium and long-term". AIReF evaluations and studies deal with all areas of public policies, and as a result also include, eventually, instruments related to R&D and innovation policies. These have been analysed recently in reports covering the programmes Torres Quevedo Program and Ramon y Cajal (as part of the Spending Review of 2018) (AIReF, 2019[83])and the R&D tax credits (published in 2020) (AIReF, 2020[84]). These external evaluation capabilities should stimulate and provide a model for developing specialist policy analysis capabilities within the ministries in charge of Universities and Science and innovation.

Figure 52. Various concepts of evaluation in the policy-evidence cycle



Source: OECD adaptation of the ROAMEF cycle
https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/938046/The_Green_Book_2020.pdf

Overall governance assessment

Based on the previous discussion and anticipating a number of points that will be expanded on in the following subsections, Table 5 presents an indicative assessment of the comparative strengths and weakness of Spain's STI policy governance along the four dimensions of the strategy-planning-implementation-MAE schema.

Table 5. Overall assessment of Spain's STI policy governance at central government level

Elements impacting on knowledge transfer and collaboration policies and potential opportunities

	Strengths	Weaknesses and challenges	Opportunities / recommendations
Strategy	Established strategy setting process and governance; Definition of strategic priority lines and connection to EU-level priorities; Integration of S&T with innovation under a common strategy; Visibility of underpinning analysis;	High level discursive document disconnected with resources Complex set of layers – axes – objective; Coordination with regional strategy setting process; Superficial consensus on science and innovation as priority, not carried through to long term budgetary commitments	Provide greater clarity about strategic choices in connection with resources and actual strengths and opportunities; Secure effective reciprocity in other national strategy processes with regards to STI strategic issues; Incorporate external "independent" influences in the strategy setting and monitoring process; Design a sustainable social compact on science and innovation
Planning	Established procedures for central government STI plans	Regional coordination challenges Consultation procedures Planning resources and capacities Lack of effective multiyear budgeting systems	Secure effective reciprocity in other national strategy processes with regards to STI policy programming; Improve alignment of budgetary decisions with realistic spending plans
Implementation	Considerable expertise on defined administrative tasks within established agencies	Highly dependent on annual budgetary approval process Dependence on multiple accreditation mechanisms and formal registers Regional coordination challenges Several control steps leading to systematic underspend and delays Requirements for additional implementing legislation diverting effort and increasing uncertainty	Undertake independent assessment of effectiveness and value for money of administrative procedures in the public system of research, commencing with major bottlenecks; Secure relevant independent expertise for specific implementation initiatives, esp. from business
Monitoring and evaluation	Abundance of well curated data resources; wealth of administrative data on STI; High profile of measurement / monitoring agenda	Insufficient degree of connectivity and interoperability of data resources. Lack of institutionalised ex-ante and ex-post evaluation capacities and practices, connected to decision making in the STI domain. Excessive emphasis on evaluation of individuals to the detriment of evaluation for policies and programmes (and institutions) Disconnect with auditing function, which is not sufficiently outcome focused.	Potential for reinforcing coordination among data collectors and processors, better tuning of indicators to purposes Develop an STI strategic intelligence networked function that connects data, analysis, evaluation and foresight

While these are not strictly speaking focused on knowledge transfer and result from the diagnosis in previous sections, these represent foundational elements for improving the effectiveness and efficiency of knowledge transfer and collaboration policies. This indicative assessment also includes a number of recommendations for consideration as they bring about reform opportunities. Across all of them, a number of common points emerge for enhancing the policy governance of the system and putting in place a sound basis for achieving greater research-business collaboration:

- Articulate and effective, multi-partisan long-term commitment to a stable public funding model for science and innovation with an equal commitment by the system to deliver concrete societal benefits that sustain a new "innovation consensus" across different phases in the budgetary cycle.
- Ensure greater openness to external independent influences in the way the system is assessed, strategies defined, public organisations governed, and opportunities for improvement identified.

- Reduce the need to regulate every single aspect of the system and place more emphasis on building expert intelligence and implementation capabilities, bringing policy assessment and evaluation to the standards of leading countries and policy areas with greater evaluation embedding inside decision making.
- Raise outcome-oriented accountability to be on a par with existing high levels of autonomy in parts of the system, particularly within the university system, whilst allowing institutional reform to enable universities and different types of PROs to enjoy similar levels of effective autonomy under governance and funding arrangements that are consistent with their declared missions.

4.3. The regulatory framework for science-business knowledge transfer and collaboration

Based on interviews held with stakeholders and practitioners, the Spanish national legal framework affecting knowledge transfer comprises a series of legal instruments with variable seniority that can be broadly grouped according to broadly defined features, based on whom they apply to and the range of activities that they cover:

- Domain specific legislative framework for science and innovation policies, already alluded to at the outset of this section.
  - The **2011 Law of Science, Technology and Innovation** (*Ley 14/2011, de 1 de junio, de la Ciencia, la Tecnología y la Innovación*)
  - The **2011 Sustainable Economy Law** (*Ley 2/2011, de 4 de marzo, de Economía Sostenible*)
- Organic legislation on the status and functioning of universities.
  - The **2001 Organic Law of Universities** (*Ley Orgánica 6/2001, de 21 de diciembre, de Universidades, LOU*)
  - The **2007 Organic Law of Modification of the Organic Law of Universities** (*Ley Orgánica 4/2007, de 12 de abril, de Universidades, LOMLOU*)
- Public sector status and procedural legislation, covering transactions and exchanges involving public sector organisations and their personnel.
  - The **1984 Law of Incompatibilities of Personnel at the Service of Public Administration 1984** (*Ley 53/1984, de 26 de diciembre, de Incompatibilidades del Personal al Servicio de las Administraciones Públicas*)
  - The **2003 Law on Subsidies** (*Ley 38/2003, de 17 de noviembre, General de Subvenciones*)
  - The **2015 Law on Common Administrative Procedures for the Public Administration** (*Ley 39/2015, de 1 de octubre, de Procedimiento Administrativo Común de las Administraciones Públicas*)
  - The **2015 Law on the Legal Regime of the Public Sector** (*Ley 40/2015, de 1 de octubre, de Régimen Jurídico del Sector Público*)
  - The **2017 Law of Public Contracts** (*Ley 9/2017, de 8 de noviembre, de Contratos del Sector Público*)
- Urgent measures introduced by Royal Law Decree, including the following:

- The **2019 Royal Law Decree on urgent measures in the field of science, technology, innovation and universities** (*Real Decreto-Ley 3/2019, de medidas urgentes en el ámbito de la ciencia, la tecnología, la innovación y la universidad*)
- The **2020 Royal Law Decree on urgent measures to modernise the public administration and implement the RTRP** (*Real Decreto-Ley 36/2020, de 30 de diciembre, por el que se aprueban medidas urgentes para la modernización de la Administración Pública y para la ejecución del Plan de Recuperación, Transformación y Resiliencia*)

Other relevant legislation affecting researchers and knowledge transfer include additional national norms related to public employee status as well as regional regulations affecting universities, regional public research centres, foundations, technology centres, etc. in addition to internal regulations pertaining to each public research institution.

While references are made throughout this report to the public system of research as a general category, there are important differences across specific types of institutions, such as OPIs and public universities, as to how the legal framework affects their research activity. These formal differences, the main features of which have been laid out in section 2.3, are important determinants of an organisation and their staff's incentives and ability to engage in knowledge transfer and collaboration activities.

In addition to those specificities, several national regulations, such as the 2003 Law on subsidies or the 2017 Law of public contracts[67] affect all public sector institutions equally, including public research organisations and public universities. These laws establish a series of administrative requirements for the management of publicly-funded collaborative research projects, which in the words of interviewees and observers constitutes a drain of human and financial resources for those organisations, well in excess of those experienced in other comparable OECD countries. This has also contributed to the "bureaucratisation" of PROs, which need to devote a significant part of their efforts to manage such procedures to the detriment of promoting knowledge transfer. The Royal Law Decree 36/2020 on urgent measures to modernise the public administration and implement the RTRP, establishes some modifications to these laws in order to streamline the procedures in case of grants financed by European funds (Bolaños, 2021[85]).

The remainder of this subsection provides an overview of the main regulatory asymmetries and obstacles for science-industry knowledge transfer and collaboration highlighted by stakeholders during interviews. These are classified in five KTC facets, namely those connected with the formalisation of public-private collaboration agreements; the mobility of public research personnel; personal entitlement to proceeds from R&D services and outputs; the creation of academic spin-offs; and the management of IP rights obtained through collaborative activities.

[67] The 2017 law of public contracts sets thresholds to classify contracts as minor or not, and is modeled in the Directive 2004/18/EC of the European Parliament and of the Council of 31 March 2004 on the coordination of procedures for the award of public works contracts, public supply contracts and public service contracts. As stated in the text of 2017 law of public contracts, its goal is to increase transparency in public contracts and obtain better value for money.

4.3.1. Public-private collaboration agreements and contracts

Collaboration agreements

Research agreements involving institutions in the public sector are governed by Law 40/2015 on the **Legal Regime of the Public Sector**[68] which rules the internal functioning of the public administration and the relations between its different units. Article 47, defines collaboration agreements (*convenios*) adopted by public sector organisations as distinct from contractual agreements, focusing on those binding government institutions (public administrations), their public-law bodies ("organismos" and linked or dependent public law entities) and public universities. Articles 48 and 49 define validity and content requirements. Article 50 prescribes the administrative procedures to be followed, focusing on the central government administration and its public law dependent bodies. Regional bodies and public universities, in the exercise of their autonomy, although within scope of its broader rules, are as mentioned in article 2.2.a governed by their specific legislation in this particular regard.

The general principles of *equality and objectivity* prevail for any activity involving the central government's public sector, requiring publicity and competition with a number of steps to be taken before concluding any agreement. The implementation of such principles in Spain contributes to a very substantial slowing down of collaboration processes. The case of 'collaboration agreements' is particularly salient. For instance, research collaboration agreements involving OPIs can take between 4 to 6 months between the end of negotiation between the parties about the terms of the agreement and their signature. Interviewed stakeholders that public-public agreements can be more bureaucratically demanding than agreements with private sector organisations. For instance, in the case of an agreement between a central government administration research body (OPI) and a public university or regional research and technology organisation, four different approvals are required on the part of the OPI, namely those from:

- The government's legal service (*Abogacía del Estado*), unless the agreement follows a pre-approved model by the corresponding legal service;
- Ministry of Territorial Policy;
- Ministry of Finance approval of public expenditure;
- Ministry of Finance authorisation.

Each of these reports on average can take 2-4 weeks to be issued, adding up to a total between 4 to 6 months. Moreover, any amendment to an agreement formally needs to follow the same steps as an original agreement, thus again partners need to wait the same amount of time. For example, if close to the end of the collaboration they decide to extend its duration, they would have to initiate the procedures well in advance to have them ready on time. This brings a lot of legal uncertainty to the system which discourages the establishment of agreements, although it is not possible to pin down an estimate of the true effect.[69]

While these naturally seek to protect the public interest and the central government which is ultimately bound by such agreements, this accumulation of checkpoints represent a considerable burden and can prove to be discouraging for potential partners outside government. These burdens have not yet been subject to detailed analysis and quantification

[68] The origin of the Law 40/2015 lies in a report prepared by the Commission for the Reform of the Public Administration (CORA), which received the mandate to propose measures to modernise the Spanish public sector, make it more efficient, eliminate duplications and simplify procedures.

[69] See FAQ of the Law 40/2015 at https://administracion.gob.es/dam/jcr:1ac9bb92-4e15-4510-bdae-0974809089a9/faq_Convenios.pdf

in the case of Spain. The Royal Decree 36/2020 modified Article 50 aiming to accelerate these procedures by adding a deadline of a maximum of 7 days for each report to be issued by the corresponding body. However, it remains too unclear whether there is sufficient capacity to fulfil the obligation given the amount of reports needed (Bolaños, 2021[85]).

It is indeed important however to bear in mind that the legislation on collaborative agreements in the public sector addresses concerns raised by Spain's Audit Tribunal in 2010 about the potential widespread abuse of this instrument *in lieu* of contractual agreements, explicit subsidies or other mechanisms requiring greater degree of transparency and competition[70]. From this viewpoint, the 2015 legislation remedies a prior situation of potential legal uncertainty but its asymmetric categorisation of entities and the effective implementation bureaucracy, results in a disproportionate impact on knowledge transfer activities of the most constrained organisations. The experience of the PSR response to COVID-19, a regulatory sandbox in its own right, highlights that it is possible to accelerate partnering procedures when there is effective strategic interest. This demonstrates that it is the implementation of the legislation that particularly matters and the way in which public sector gatekeepers interact with the institutions in the PSR through the various processes.

There are also important differences in how this legal framework affects the knowledge exchange activities of public research organisations directly dependent from the central public administration, such as CSIC (which comprises a total of over 120 centres, several of them jointly managed with universities), and other public research sector institutions, such as public universities and regional PROs. Furthermore, article 50 leaves outside the scope of its provisions on collaborations the foundations or business entities under control of central government institutions which are also part of the institutional public sector. OPIs are ultimately treated as any other unit of the central government administration, without taking the specificity of its knowledge providing service activity into account, in all aspects of their functioning. As noted in Section 3, this begs the question as to whether central government research institutions fulfilling similar mandates and consistently constituted with a legal structure that is appropriate for and conducive to a successful acquittal of knowledge generation and dissemination functions.

Another potential approach worth considering is the streamlining of simpler, lower risk procedures. For instance, agreements to set up consortia among beneficiaries of public grants are currently not excluded from these procedures, which may prevent speculative submissions of joint applications to domestic or international funding calls. Furthermore, in this context of joined-up application for support, the **2003 Law on Subsidies**, in its article 40, includes a principle of solidarity that applies in specific cases where authorities may request the reimbursement of a grant. This clause intended to protect to public purse has been noted to act as a potential deterrent for organisations to apply for grants supporting collaborative research and innovation activities with new partners, since each entity may be obliged to meet the obligations of third parties without having the capacity to influence the events that trigger the obligation to reimburse.

Contracts

The **2017 Law of public contracts** sets the limit for minor contracts (those where the buyer can choose directly the seller without public tender) at EUR 15 000 per year, institution and provider, a threshold that was very rapidly reached at research institutions requiring frequent acquisitions of materials, equipment and services to implement projects. The Royal Decree 3/2019 relaxed such conditions, increasing the limit to EUR 50 000 for contracts held by public entities of the science, technology and innovation system (provided they were not

[70] See http://www.tcu.es/uploads/I878.pdf

related to general services or infrastructure of the institution). The functioning of this legislative framework needs to be assessed from the perspective of university and PRO requirements for specialised equipment and services, since it impacts not only on the ability of the PSR to fulfil its role but also represents a fundamental challenge for the growth of a knowledge intensive specialist industry in Spain.

4.3.2. Mobility of public research personnel

In comparison with other forms of mobility, the baseline legislation for public sector employees dedicates little attention to mobility with institutions in the business or non-profit sectors, or mixed consortia. In fact, the term "private" is not mentioned at all in the Public sector employee statute law. Leave for private reasons does not entitle the public sector employee to a number of seniority benefits, while, at present, special forms of leave do not contemplate socially desirable activities around knowledge commercialisation. Its regulation effectively left to domain and body-specific legislation. The **2011 Law of Science, Technology and Innovation** establishes, in its article 17, that research personnel that would like to carry out activities in private companies need to request a temporary non-extendable leave of absence (up to a maximum of 5 years). This prevents the establishment of longer-term collaboration relationships between firms and public researchers and the development of temporary experiences which may provide the basis for better informed decisions as to what professional research career is more appropriate from an individual standpoint. Furthermore, the temporary mobility of researchers to the business sector is perceived as very risky, as it paralyses their career progression in the public sector since this type of mobility is not currently acknowledged in the ANECA accreditation system.

In the laws relating to knowledge transfer there are no specific provisions or indicative guidelines on the ownership and revenues of intellectual property rights obtained from the results of the research carried out by the researcher during the period in which he/she carries out activities outside the PSR institution. This could be a source of legal uncertainty for researchers when considering mobility options. The current complexity particularly affects SMEs, generally with less resources and capacities to plan for all possible contingencies.

4.3.3. Entitlement to proceeds from R&D services and outputs

There are also significant institutional differences in potential personal entitlement to proceeds from research outputs. According to Article 83 of the 2001 Law of Universities, researchers from public universities are allowed to perceive a share of revenues they contribute to generate through research contracts signed by their institution provided they are duly authorised and operate in the terms agreed set out by the institution in its Statutes. This share can represent up to 80 to 90% of the revenues perceived by the institution in some universities, as the share depends on the indirect costs retained by the institution.

This does not apply to researchers working at public research bodies dependent from the Central Administration (OPIs), such as CSIC, for whom the conditions to perceive a share of revenues from research contracts as additional personal income are more stringent. For example, a CSIC researcher may only be able to perceive 15-20% of her salary as a personal productivity bonus. This is explained by general rules of the central government public administration and are justified to some extent for researchers whose compensation is connected to the R&D services they provide to the employing institutions and its formal users.

4.3.4. Incentives for the creation of academic spin-offs

The **Law of Incompatibilities of Personnel at the Service of Public Administration 1984**, in its article 12, allows only the participation of research staff in the capital of firms that are created or participated by the public research entity to which the researcher is affiliated. This requirement acts as an important barrier to the entrepreneurial activity of researchers, which does not apply to university professors who were exempted by the 2007 Organic Law of Universities.

4.3.5. Management of IP rights

The **Spanish Law 11/1986 of Patents and Utility Models** mirrored the European Patent Convention in many respects, but had one important difference: the lack of substantive examination at the Spanish Office for Patents and Trademarks (OEPM). Until 2001 all patent applications filed at OEPM were granted without substantive examination, based only on formal requirements, but that year a Royal Decree introduced the option for applicants to request substantive examination of the patentability requirements (novelty, non-obviousness and inventive step) to have their patents granted.[71] Another change was introduced in 2001: the exemption for all Spanish public universities from paying fees at OEPM. This exemption also covered searching fees for PCT international filings when OEPM acted as receiving office.

The **1986 Spanish Patent Law**, in Article 20.4., also stated that the statutes of each public research organisation determine the terms and the amount of participation of the scientists in the earnings obtained by the institution from exploitation or transfer of rights over inventions (González-Albo Manglano and Zulueta García, 2007[86]; Arqué-Castells et al., 2016[87]; Martinez and Bares, 2018[88]). Thus, the share of patent royalties from licensing was to be determined at each institution and the distribution is very heterogeneous.

The **2015 Spanish patent law** entered into force in April 2017 introducing very substantial changes in the system. Firstly, it requires all Spanish patent filings to go through substantive examination. Second, public universities are no longer fully exempted from paying patent fees at OEPM. Third, public universities can be reimbursed for the cost of OEPM fees if they can provide evidence of patent exploitation or commercialisation not later than four years. Public research centres do not benefit from this possibility of reimbursement, in the same way as they were not exempted from paying patent fees under the previous patent law.

Significant challenges remain in terms of IP legislation provision, in particular regarding IPR rights other than patents, for instance in relation to rights about computer software, as well as the extent to which university and PRO researchers are entitled to a share in the economic benefits of the IPRs they have contributed to develop as public sector employees or under government sponsored projects. However, the IPR legislation in this area is probably not the most appropriate venue within which to regulate sectoral specific aspects.

Many of the challenges that were referred to the OECD team had to do with limited functional knowledge of the IPR system and its implications for PSR activity around knowledge transfer and collaboration. The OEPM operates a number of programmes and activities to help improve this aspect of the system, something which also requires the effective use of specialised legal firms.

[71] Substantive examination was optional, and applicants were charged an additional fee. Only a small fraction of patent applicants requested substantive examination between 2001 and 2017, when the new law entered into force and substantive examination became compulsory.

4.3.6. Classification-based regulatory uncertainty and "institutional sandboxes"

Several interviews raised questions to the OECD team about the degree of uncertainty or at least coherence in the overall classification procedures of entities connected to the PSR as part of the public sector and its applicable regimes.

Public sector accounting regulations that derive from European directives that implement the System of European Accounts (SEC2010) clarify the definition of the General government sector from the different public administrations to the non-market-based (i.e. non-profit) entities that operate under its control. This system pursues a coherent accounting of government deficit and debt, and is entrusted to the IGAE at the Finance Ministry to implement the monitoring of different indicators that indicate whether control exists for institutions such as foundations or universities, and whether as a result they are subject to the financing and accounting controls that pertain to the general government sector. Under this classification system, the extent to which an institution is majority financed by the government is not the sole applicable criterion and can be overridden by other considerations that may represent a better indicator of effective control.

This classification system stands in contrast with the regime that defines which institutions are subject to the public sector contract legislation and transparency requirements, which is entirely based on financing contribution criteria or majority board designation criteria. This gives rise to potential classification misalignments that are an additional driver of regulatory uncertainty for the PSR.

While Spain's PSR has witnessed a progressive move towards public institutions creating or adopting non-profit private law foundational regimes, acting as de facto "**institutional sandboxes**" for the conduct of R&D and KTC activities in the PSR. This reflects the previously alluded pursuit of flexibilities around contracting, procurement, collaboration agreements, competing for subsidies, as well as auditing and reporting, these may ultimately fall under similar constraints through implementing regulations and practices that evolve over time and are often communicated at short notice. Several interviewees from universities and PROs alluded to these regime shifts and expressed concerns about the uncertainty associated with these changes and the impact of future court decisions that may remove the space for the application of a proportionality principle where that is still possible.

Regulatory reform proposals that touch upon these different aspects will be discussed in section 6. The analysis of the state of play on knowledge transfer policies continues with the study of existing support instruments.

4.4. Policy support instruments at the central government level

Spain's public funding for its research base in universities and a majority of PROs is principally based on **institutional funding** to universities and research organisations. A number of central government policies modulate this institutional funding landscape within the very tight constraints that permanent employment payroll commitments and other upkeep costs allow. These have to be taken into account in the budgeting procedures for central and regional governments and transfers across them, as discussed in the previous section. This lack of a margin for manoeuvre is indeed one of the main reasons for the relative lack of implementation of institutional funding mechanisms linked to outcomes on a wide scale.

Discretionary government funding for activity and project-oriented support programmes, while smaller in overall size, plays a critical role in shaping the direction of R&D efforts in the system, allowing additional hiring and overheads that institutional funding cannot cover. Programmes become institutions in their own right that agents in the system come to rely upon but shape complex dynamics particularly when regulatory requirements are layered on top or budgetary restrictions become tighter.

Another overarching consideration is the importance of **EU policies** for the design and implementation of policy support instruments. In addition to state aid rules that shape programme design, EU programmes complement domestic funding, indirectly inducing domestic programmes to align to them, especially when match funding is required. Their rules of operation can be used as valuable quality assurance signals.

Several policy instruments are implemented at the central government level **to encourage science-business knowledge exchange and collaboration** in Spain. Most of these initiatives are managed by two funding agencies under the responsibility of the Ministry for Science and Innovation: the Spanish State Agency for Research (AEI), in charge of scientific research funding programmes principally oriented towards the PSR; and the Centre for Industrial Technological Development (CDTI), in charge of business R&D and a number of innovation support programmes. The Health Institute Carlos III (ISCIII) has also deployed a number of programmes to enhance collaborations in the fields of biomedicine and public health[72]. Table 6 provides an overall overview of the main financial policy support programmes and instruments that impact directly or indirectly on KTC activities in Spain.

Financial support mechanisms (in the form of grants or loans) to promote collaborative research or innovation projects are the most common (section 4.4.1), followed by instruments to promote the mobility of PhD students and post-docs (section 4.4.2). Other instruments include financial rewards for academics and researchers that collaborate with industry (section 4.4.3); support for the creation of collaborative platforms or networks, building on the territorial, sectoral or technological proximity among actors (section 4.4.4); support for intermediary organisations and investments in unique scientific and innovative infrastructures, open to competitive access by users in the entire research community (section 4.4.5); and support for the creation of spin-offs and science-based start-ups (section 4.4.6). Section 4.4.7 presents two other important innovation policy instruments that, while not directly targeting science-industry engagement, have the potential of indirectly promote such linkages: R&D tax incentives and public procurement of innovative solutions.

[72] While instruments implemented by the ISCIII are included in the mapping of instruments, they are not the focus of the analysis presented in this section.

Table 6. Overview of policy instruments implemented in Spain (central government level) to support science-business knowledge transfer and collaboration

Support mechanisms in Spain (Central government level)	Promotion objective	Targets / barriers addressed	Direct beneficiaries	Type of support instrument	Annual financial commitments
Grants and loans for collaborative R&D projects					
Challenges - collaboration RDI projects *Proyectos I+D+I Retos-Colaboración* (AEI) Since 2014	PRO-business collaborative R&D in priority areas	Collaboration, finance for high risk applied R&D	Consortia of PROs and business. Projects with budget over EUR 500k	Competitive-allocated (CA) grants (PROs), loans (business)	EUR 260m (2019)
Funding for projects in strategic areas *Proyectos en líneas estratégicas* (AEI) Launched in 2021	PRO-business collaborative R&D in priority areas	Collaboration, finance for high risk applied R&D	PROs (grants) and business (loans)	CA mix of grants and loans	EUR86m (2021-23, RTRP funds)
Funding for proof of concept projects *Proyectos de prueba de concepto* (AEI) Launched in 2021	Valorisation of knowledge generated by PROs	Finance for R&D projects in more advanced TRLs	PROs (grants)	CA grants	EUR40m (2021-23, RTRP funds)
Science and innovation missions' programme *Misiones Ciencia e Innovación* (CDTI) Since 2020	Business collaborative R&D in priority areas, with engagement of PROs+	Collaboration, finance for high risk applied R&D	Business consortia (3+), with min. SME participation, and minimum outsourcing requirement to knowledge generation centres (20 or 15%)	CA mix of grants and loans, business size dependent (<65% for large firms, <80% small firms)	EUR 95m (2020)
Cervera R&D transfer projects *Proyectos I+D transferencia Cervera* (CDTI) Since 2019	Business-technology centre collaborative R&D projects in priority areas	Collaboration, finance for high risk applied R&D	Business and technology centres, for projects with budget >EUR175k, and >10% allocated to technology centres	CA mix of grants (<33%) and loans, up to 85% project budget.	EUR 500m (2020
CIEN Strategic projects. *Proyectos estratégicos CIEN* (CDTI) Since 2014	Business collaborative R&D and innovation projects in priority areas, with outsourcing engagement of PROs+	Collaboration, finance for high risk applied R&D and innovation	Business consortia (3+), with min. SME participation, and minimum outsourcing requirement to PROs+ (15%), for projects with budget EUR 5-20m	CA mix of grants (<33%) and loans, up to 85% project budget.	N.A.
Health technology development projects *Proyectos de desarrollo tecnológico en salud* (ISCIII)	Health R&D and demonstration projects, in collaboration with pharma industry	Finance for applied R&D in health, transfer of innovative solutions	Accredited health research institutes (IIS), non-profit health entities, PROs+ (Indirect beneficiary: pharma industry interested in project results)	CA grants to direct beneficiaries	N.A.
Support for the mobility and industry engagement of PhDs and post-docs					
Industrial doctorates *Ayudas para Doctorados industriales* (AEI), Since 2014	Engagement of young researchers in industrial R&D projects	Mobility of PhD students between university and industry	Firms interested in recruiting PhD students to participate in their R&D activities (annual salary <EUR 23.7k)	CA grants to co-finance employment contract of PhD student for 4 years, and cover tuition fees	EUR 4 million (2019)

Support mechanisms in Spain (Central government level)	Promotion objective	Targets / barriers addressed	Direct beneficiaries	Type of support instrument	Annual financial commitments
Industrial PhDs in health sciences and technology, *Contratos i-PFIS Doctorados IIS-Empresa en Ciencias y Tecnologías de la Salud* (ISCIII), Since 2014	Engagement of young researchers in public-private R&D projects	Mobility of PhD students between university and industry	Accredited health research institutes, that collaborate with firm where PhD student will participate in their R&D activities	CA grants to finance gross salary of PhD student for up to 4 years (annual salary <EUR 20.6k)	N.A.
Torres Quevedo Grants, *Ayudas para contratos Torres Quevedo* (AEI), Since 2008	Recruitment of doctors by industry	Mobility of doctors between univ. and industry	Firms, technology centres, business associations, science and technology parks	CA grants to co-finance salary for up to 3 years (<EUR 55k)	EUR 15 million (2019)
Financial rewards for public researchers that engage in knowledge transfer activities					
Knowledge transfer sexennium *Sexenio de transferencia* (ANECA)	Reward knowledge transfer/third mission activities by individuals	Incentives of academic staff	Academic staff at PROs and universities accredited to meet requirements.	Permanent wage bonus for awarded researchers (~145 EUR per month per sexennium, up to 6 sexennia)	N.A.
Collaborative platforms and networks					
Technology and innovation platforms *Plataformas tecnológicas y de innovación* (AEI) Since 2005	Public-private collaborations in priority areas	Collaboration, exchange and communication, strategic planning	Entities in charge of the platform's technical secretariat	CA grants to fund platform's annual assembly and cooperation activities	EUR 4 million (2020)
Networks for cooperative research oriented to health solutions, *RICORS* (ISCIII), Since 2013	Public-private collaborations in priority areas	Collaboration, finance for high risk applied R&D	Research centres or groups in >10 autonomous regions.	CA grants	EUR 5.8 million
Intermediaries and key infrastructures					
Cervera programme for technology centres *Ayudas Cervera para CT* (CDTI), Since 2019	Technology centre collaborative R&D and inno. in priority areas	Collaboration, finance for high risk applied R&D	Technology centres consortia, for projects with budget EUR2-4m	CA grants	EUR 20m (2019)
Innovative business clusters programme, *Programa apoyo a las agrupaciones empresariales innovadoras* (MINCOTUR), Since 2017	Business collaboration in innovation activities	Business collaboration	Clusters ("Innovative business groups"). Knowledge generation centres (specially technology centres) often participate in innovation activities	CA grants	EUR 8 million (2020)
Innovation Platform in Medical and Healthcare Technologies, *Plataforma ITEMAS* (ISCIII)	Valorisation of innovations generated in hospitals	Support market entry of innovative solutions	Hospitals / healthcare professionals	Creation of innovation support units in hospitals to help turn ideas into solutions that can enter the market	N.A.
Unique scientific and technical infrastructures *Infraestructuras Científicas y Técnicas Singulares* (MICINN)	Frontier research infrastructures open to competitive access by entire research community	Access to frontier research infrastructures and related services	Public and private R&D actors	Competitive access by public and private R&D actors	N.A.

Support mechanisms in Spain (Central government level)	Promotion objective	Targets / barriers addressed	Direct beneficiaries	Type of support instrument	Annual financial commitments
Creation of science- or technology-based spin-offs					
NEOTEC programme (CDTI) Since 2002	Innovative start up activity (including PRO spin-offs)	Finance, start-up innovative activity, SMEs.	Technology-based projects in innovative start-ups drawing on research activity results. Spin-offs from PROs can benefit.	CA grants, for up to 70% of project, up to EUR 250k.	EUR 25m (2020)
INNVIERTE programme (CDTI) Since 2012	Venture capital investment in technology-based small firms	Finance, start-up innovative activity, SMEs	Small technology-based companies. Spin-offs from PROs can benefit.	Co-investment, for up to EUR15 m per company.	N.A.
R&D tax incentives					
Tax deductions for R&D and innovation projects, withholding tax credits on social security contributions for R&D and inno. personnel. Business investment in R&D and innovation	Finance, R&D capability building	Individual businesses subject to corporation tax. Other businesses & PROs+ can be subcontractors	Tax credit for projects allocated on qualifying demand basis, and tax benefits on employer's social security contributions for R&D and innovation personnel. In the Basque Country, more generous provisions apply for R&D activities in collaboration with PROs.	No defined budget, on demand.	

Source: OECD elaboration based on EU/OECD STIP Compass database (https://stip.oecd.org/), CDTI website (https://www.cdti.es/), AEI website (http://www.aei.gob.es/) and ISCIII website (https://www.isciii.es/).

The presentation of these instruments is accompanied by the identification of their main strengths and some potential areas of improvement, based on the insights gathered through 47 stakeholder interviews carried out in the context of this study and information collected through the OECD STIP Compass database. Section 4.4.8 presents a brief assessment of the policy mix at the central government level.

In 2021, a number of additional instruments have been announced as part of the Recovery, Transformation and Resilience Plan. These are explored in section 6.1.1 as part of the broader discussion on reforms and new investments that can provide the basis for a roadmap for greater public-private collaboration in research and innovation.

4.4.1. Grants and loans for collaborative R&D and innovation projects

This section presents six policy instruments currently implemented at the central government level to promote collaborative research and innovation projects through the provision grants and loans. It includes one programme managed by the AEI (challenges-collaboration RDI projects), four managed by CDTI (science and innovation missions' programme, Cervera R&D transfer projects, Cervera programme for technology centres, CIEN Strategic projects), and one managed by the ISCIII (Health technology development projects). It also outlines a number two new instruments introduced in 2021.

The **challenges - collaboration RDI projects** initiative (*Proyectos I+D+I Retos-Colaboración*), launched in 2014 and managed by the AEI, supports experimental development projects carried out jointly by companies and public and private research organisations, and led by companies. Such projects aim at solving societal challenges (as identified in the 2017-2020 State Plan for Scientific and Technical Research and Innovation) through the development of new technologies, products and services. Support for public sector entities and research organisations is provided in the form of grants, while support for companies and business associations is provided in the form of soft loans. Each project should have a minimum budget of EUR 500,000, and be implemented in between 2 to 4 years. Resources allocated to this initiative decreased over time, from EUR 548 million in the 2014 to EUR 260 million in 2019. In 2019, only EUR 135 million were awarded – around half of the funds available. Calls for proposals were launched annually between 2014 and 2017, and are currently launched biennially.

The first call for proposals for the **science and innovation missions' programme** (*Misiones ciencia e innovación*) was launched in February 2020. Managed by CDTI, the programme supports large strategic R&D projects developed by business consortia with an important participation of knowledge generation centres (universities, research organisations and technology centres) that aim to solve major challenges in specific areas[73]. Support is provided in the form of grants of two types:

- Grants for "large enterprise missions" are allocated to projects that have a budget of between EUR 5-10 million, carried out over a period of 3 to 4 years by business consortia composed of between 3 and 8 partners, including at least 1 SME. At least 20% of the budget must be devoted to subcontracting activities from knowledge generation centres.

[73] The five missions identified by CDTI through an extensive process of consultation with experts, business associations and the scientific advisory council of the State Agency of Research are the following: 1) Safe, efficient and clean energy; 2) Sustainable and intelligent mobility, 3) Sustainable and healthy agri-food sector, 4) Spanish industry in the industrial revolution of the 21st century; and 5) Sustainable responses to diseases and ageing societies. These missions do not correspond to the 5 missions identified in Horizon Europe (Adaptation to climate change including societal transformation; cancer; climate-neutral and smart cities; healthy oceans, seas, coastal and inland waters; soil health and food).

- Grants for "SME missions" are allocated to projects that have a budget of between EUR 1.5-3 million, carried out over a period of 2 to 3 years by a business consortium composed of between 3 and 6 SMEs. At least 15% of the budget must be devoted to subcontracting activities from knowledge generation centres.

The budget for the initiative was of EUR 70 million in 2020 (that could be increased by up to EUR 25 million), of which a minimum of EUR 10 million are reserved for SME missions. Grants can cover up to 65% of the project costs for large firms, 75% for medium-sized firms and 80% for small firms (CDTI, 2020[89]). In December 2020, 24 projects were approved: 16 correspond to large enterprise missions (integrated by 105 entities) and 8 are SME missions (39 entities). These have a total budget of 117.7 million, of which EUR 82.86 million will be provided by CDTI (Ministerio de Ciencia e Innovación, 2021[90]).

The **Cervera R&D transfer projects** (*Proyectos I+D transferencia Cervera*), launched in 2019 and managed by the CDTI, support applied R&D and innovation projects conducted jointly by businesses and technology centres and addressing one of the so-called "11 Cervera priority technology areas". The R&D or innovation project should have a budget of more than EUR 175 000, and a duration of between 12-36 months. Support is provided in the form of partly repayable loans covering up to 85% of the project budget, with a no-repayable tranche of up to 33% of the support provided. At least 10% of the project budget must be allocated to technology centres. The programme had a budget of EUR 500 million in 2020 (CDTI, 2020[91]).

The **CIEN Strategic Projects** (*Proyectos estratégicos CIEN*), launched in 2014 by the CDTI, is a programme that aims to support large industrial R&D projects conducted by business consortia (gathering between 3 and 8 firms, at least one of which an SME) in areas of strategic interest and with international potential. Enhancing public-private collaboration is also one of its main objectives, as the programme requires that part of the project activities (at least 15% of the total project budget) are conducted by research centres (of which at least 1 should be a public entity). Projects should have a budget of between EUR 5 million and EUR 20 million, of which more than 50% should be devoted to business R&D activities, and should have a duration of between 3 and 4 years. Support is provided in the form of partly repayable loans covering up to 85% of the project budget, with a non-repayable tranche of up to 33% of the support provided. The budget of the programme was close to EUR 100 million in 2018.[74]

The **Health technology development projects** programme *(Proyectos de desarrollo tecnológico en Salud*), managed by ISCIII, finances projects of an applied nature whose objective is to promote innovation in NHS healthcare centres and the transfer of innovative solutions, as well as the generation of benefits for the community, while promoting the establishment of alliances between research entities and companies in the pharmaceutical, biotechnology and health technology sectors. Beneficiaries include accredited health research institutes (IIS), public and private non-for-profit health entities and institutions, universities, public research organisations and other public entities. Awarded projects must involve the engagement of companies or other public or private entities interested in the development and results of the project (while these cannot be the beneficiaries of the grants awarded).

[74] www.cdti.es/recursos/doc/Programas/Financiacion_CDTI/ProgramaCIEN/21392_2442442018171917.pdf

New instruments introduced in 2021

Two new instruments to support science-industry collaborations have been introduced by the AEI in 2021, as planned in the schedule for calls for proposals published in January 2021[75]. These programmes will be launched annually between 2021 and 2023 and funded by the EU Recovery and Resilience Fund:

- **Funding for projects in strategic areas** (*Proyectos en líneas estratégicas)*. This instrument supports 3-year public-private and interdisciplinary collaboration projects in specific strategic areas, defined annually by the Ministry of Science and Innovation in line with the strategic areas set up in the 2021-27 Science and Innovation Strategy. Financial support will be provided for the three years in the form of grants for public researchers (EUR 43 million in 2021) and loans for companies (EUR 43 million), and is expected to fund around 40-50 projects per year, with a minimum of about EUR 500,000 per project. In contrast with other calls, projects can be led by public institutions. The minimum participation of partners is of 10%, and the partnership should include at least a firm and a public research institution[76] (AEI, 2021[92]).
- **Funding for proof of concept projects** *(Proyectos de prueba de concepto)*. This instrument aims to fund proof of concept projects of ideas or results generated in recently completed or soon-to-be-completed RDI projects previously funded by the AEI (under the 2017 or 2018 calls of the knowledge generation programmes or the research challenges programme). Financial support is provided in the form of grants of up to EUR 140,000 per project for a duration of two years[77]. The budget for the programme is of EUR 40 million in 2021 (AEI, 2021[93]).

Assessment

Programmes currently supporting collaborative R&D and innovation projects involving both the PSR and business primarily target large firms, SMEs and technology centres, with the exception of the "challenges-collaboration" RDI programme, which also targets the research community and public sector entities. The other programmes can also involve universities and public research centres, albeit as subcontractors rather than equal partners.

[75] https://www.ciencia.gob.es/stfls/MICINN/AEI/ficheros/Planificacion_AEI_2021-firmado.pdf

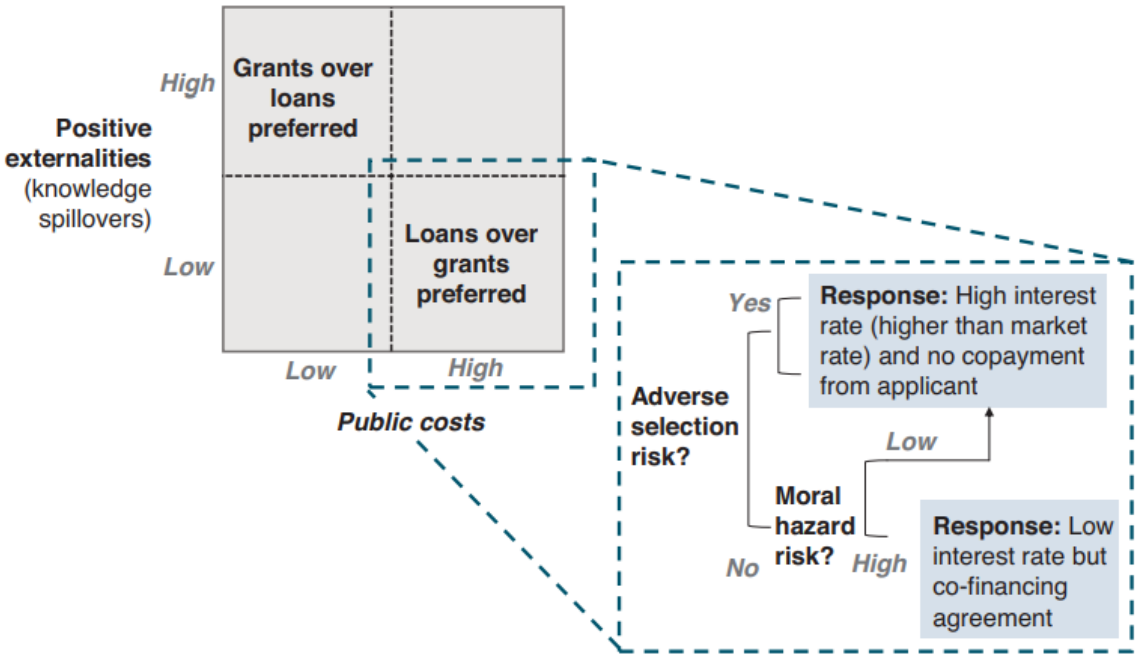
[76] Find more information at: http://www.aei.gob.es/portal/site/MICINN/menuitem.dbc68b34d11ccbd5d52ffeb801432ea0/?vgnextoid=7b3e211217048710VgnVCM1000001d04140aRCRD

[77] Activities that are eligible for funding include the following: Technology development activities for the conversion of research results into a value-creating process with innovation potential; Analysis of the technical, commercial or social feasibility of the results; Obtaining technological prototypes, demonstration at pilot scale, tests with end users, or other activities that allow the validation of the result, process or product ; Collaboration with companies or other social entities that participate in the validation of the results and full-scale testing; Collaboration with public administrations, institutions or foundations for the development of plans, programmes and public policies, as well as with museums, libraries, archives and foundations for the development of models, prototypes, products and conservation, exploitation and visibility programmes; Knowledge protection and strategic management of industrial and intellectual property rights, knowledge transfer or exploitation of research results; Actions aimed at the exploitation of results, elaboration of business models; Initial actions for the creation of a company (spin off, technology-based company); Training, mentoring or consultancy activities that contribute to developing and strengthening the innovation and entrepreneurial capacities of the research team. http://www.aei.gob.es/portal/site/MICINN/menuitem.dbc68b34d11ccbd5d52ffeb801432ea0/?vgnextoid=e41db42bcfd68710VgnVCM1000001d04140aRCRD&vgnextchannel=b24e067c468a4610VgnVCM1000001d04140aRCRD

These programmes are also characterised by their directionality or strategic orientation component. They encourage collaborations oriented towards responding to societal, technological or industrial needs and demands. The "challenges-collaboration" RDI initiative supports projects dealing with societal challenges in line with the 2017-2020 State Plan for Scientific and Technical Research and Innovation. Projects supported by the science and innovation missions' programme address challenges in one of 5 specific areas; and the two Cervera programmes focus on 11 priority technology domains[78].

The CDTI programmes providing partly-refundable loans to companies are regulated by private commercial law. Within Spain's regulations, this allows operating a system of rolling admissions (instead of specific application deadlines), which provides higher flexibility to applicants, as they can develop their proposals and build solid collaboration plans with all partners without fear of missing an application deadline. Another specificity of these programmes is that applicants can benefit from advice and support from CDTI during the application process[79]. To ensure that allocation is based on merit and the process is transparent, there is a clear division within CDTI of responsibilities between those in charge of providing advice for proposal development, those tasked with reviewing and selecting projects, and those monitoring their implementation and impacts.

Figure 53. Considerations in the use of loans vis-à-vis grants for R&D



Source: Cirera et al (2020[94]), based on Lach, Neeman and Schankerman (2017[95])

Some of the challenges and weaknesses of current financial support instruments, as highlighted by stakeholders, are the following:

[78] Advanced materials; Circular economy; Energy transition; Smart manufacturing; Technologies for health; Safe and healthy food chain; Deep learning and Artificial Intelligence; Advanced mobile networks; Intelligent transport; Information protection; Quantum computing.

[79] http://perspectivacdti.es/guia-facil-ayudas-cdti-cdtioficial/si-ya-conoces-las-ayudascdti-y-quieres-asesoramiento/

- **Public researchers are often subcontractors and not collaborators in projects:** The direct beneficiaries of CDTI programmes (Science and Innovation Missions, Cervera R&D transfer projects, CIEN Strategic projects) are firms, which are obliged to devote a share of the funding received to subcontracting activities provided by knowledge generation centres. Consequently, public researchers and academics often join those projects once the project scope and development plan have been set and approved, and their activities specifically defined. The difference in status between the actors engaged in such projects often limits the establishment of truly collaborative relationships among them.

  The "challenges-collaboration" RDI programme addresses this aspect by encouraging the creation of consortia with a mix of actors. Support for public sector entities and research organisations is provided in the form of grants, while support for companies and business associations is provided in the form of soft loans. From the perspective of the funding agency, this approach is more demanding in terms of human resources needed to assess project proposals and monitor their implementation. Before adopting such an approach, it is therefore critical to ensure that the agency has the sufficient internal capacities to perform appropriately all the necessary supervision tasks without slowing down the support allocation process.

- **Financial support mechanisms are not sufficiently attractive to firms to justify the application efforts, especially SMEs**, owing to a range of factors. First, support provided to firms is often in the form of partly-repayable loans, covering up to 85% of the project budget, with a non-repayable tranche of up to 33% of the support provided. In order to benefit from such support, it is necessary to have a pay-back guarantee, normally from a bank, which is not always easy to obtain, especially for SMEs. Arrangements do not fully align with economic theory consierations, shown in Figure 53. An important exception is the science and innovation missions' programme, which provides support in the form of grants. Second, bureaucratic processes involved in the preparation and submission of project proposals also discourage some potential applicants. Large companies aiming to apply to these and other policy instruments often solicit the advice of specialised consultancy firms, which help them navigate the bureaucratic processes and comply with all the requirements set in the calls for proposals. SMEs interested in occasionally applying to a specific programme would often not be able to incur the costs associated with such services or may not have sufficient information to consider it worthwhile. Overall, as highlighted by several interviewees, the critical mass of firms with interest in engaging in such collaborative R&D projects and with the capacity to navigate the administrative processes to do so is limited. As a result, non-negligible shares of the budget allocations for business R&D programmes are often not disbursed, as documented earlier in section 4.2.[80]

- **Delays in the awarding of financial support and its effective disbursement**: One of the common complaints raised by programme beneficiaries are the long processing times between the deadline for submission of project proposals, the final resolution of the call, and the disbursement of financial support. For instance, the provisional resolution of the 2019 "challenges-collaboration" call for projects was published eight months after the application deadline, and it took several additional months for the disbursement of financial support. Such delays can be particularly

[80] In the case of the "challenges-collaboration" RDI projects, support has two parts with separate budgets: grants for public sector entities and research organisations, and loans for firms and business associations. As soon as one of these budgets runs out, financial support is no longer granted, even if there are still funds in the other section. These conditions should be revised to ensure that all funds available can be disbursed.

disruptive for collaborative projects, where a diversity of actors need to coordinate their respective work plans to be able to deliver their contributions as part of the joint project while complying with other work commitments. Between the moment when the resolution is published and the support is received, the beneficiaries of those programmes finance their R&D and innovation activities with their own funds in order to meet the deadline for presentation of results. Such delays can also discourage firms from applying for support: firms' experimental development and innovation activities aim, in general, at providing rapid responses to their existing challenges (e.g. improving their processes or products). The specific interests of firms at the moment of developing their project proposal may evolve quickly and be different by the time they are awarded the financial support.

The COVID-19 pandemic illustrates that it is possible to accelerate the process of submission and revision of proposals and allocation of funds for collaborative research and innovation activities. For instance, CDTI adopted exceptional measures such as fast-tracking the process of submission of applications, the use of digital signatures for contracts, and the online monitoring of projects. The impacts of such processes should be assessed in the coming months, and provide opportunities to identify lessons learned that can help make process more agile in the future, while ensuring that funds are allocated to the best proposals.

- **Low stability of programmes over time and insufficient long-term visibility about upcoming open calls.** Many stakeholders highlighted the lack of stability of support programmes, and in particular the reduction in budgets devoted to them in the aftermath of the 2008 financial crisis. The unreliability of programmes from the viewpoint of long term planning of business R&D and innovation within businesses is reflected in the fact that several of the programmes described above are very recent (with the exceptions of "challenges - collaboration" RDI projects and the CIEN programme), while others that were implemented in the past were effectively abandoned (e.g. CENIT, PETRI) principally owing to budgetary considerations. This makes it harder for businesses (in particular SMEs) to be fully aware of existing support programmes and their functioning when it is relevant in their planning horizon. This regular change in programmes also impedes evaluating their impacts. The decrease in resources allocated to such programmes is reflected, for instance, in the case of the "challenges - collaboration" RDI projects, which saw its budget reduced from EUR 548 million in the 2014 to EUR 260 million in 2019. This is also observed in other long-standing programmes described in sections below, such as the Torres Quevedo grants.

  Another challenge faced by potential beneficiaries of programmes is that they are often not aware about upcoming open calls sufficiently in advance to plan their collaborative activities. For instance, in early 2021 bureaucratic processes resulted in delays in the publication of the annual calendar of calls for proposals by the AEI, which started to be published annually in 2019. Deadlines for applications once the calls are open are relatively short. As a result, it may be difficult to develop sufficiently strong proposals in short notice, especially when these involve establishing collaborations arrangements between actors.

- **Insufficient support to move forward in advance technology readiness levels (TRLs)**. The creation of a new instrument by the AEI to support the development of proofs of concept is a very positive step ahead, and responds to long-standing demands of many stakeholders. Such funds can accelerate the market entry of technologies or technical advances developed in research centres and universities, by targeting the early phases of the so-called technological "valley of death".

International practices, and experiences of initiatives sponsored by regional governments or private foundations in Spain (e.g. CaixaImpulse) should be leveraged to inform this program. Efforts should also be devoted to increasing the visibility of marketable technologies, so that these can be easily identified by potentially interested businesses.

- **Low awareness by firms.** The existence of policy instruments with similar objectives implemented at different levels of government (European, national, regional, local), while positive and illustrative of the importance of providing support in this area, could also be a source of confusion for companies, especially SMEs with limited knowledge about existing opportunities and their functioning. The discontinuity of programmes over time, and the regular change in names and eligibility criteria, can also reduce awareness by potential beneficiaries. More efforts are needed to streamline information available on the agencies' official websites, so that it is easily accessible by all actors, including those that have never benefited from public funding support. The PI+D+I Network (*Red PIDI*), an information and advice service for firms interested in public support programmes for R&D and innovation activities, can play a key role in that regard and their actions could be further publicised among SMEs (CDTI, 2021[96]). As mentioned above, CDTI also offers advice to firms applying to most of its programmes[81].Those services are offered free of charge.

4.4.2. Supporting the mobility and industry engagement of PhDs and post-docs

Three programmes are currently in place across the entire Spanish territory to encourage the recruitment of doctoral students and post-docs by private companies. Such programmes have several objectives: creating and reinforcing the links between universities and business, facilitating the professional insertion of young researchers in the labour market, strengthening the R&D and innovation capacities of firms by incorporating talent, and promoting research oriented to solving industrial challenges.

The **Industrial Doctorates** programme (*Doctorados industriales*), launched in 2014 and managed by the AEI, promotes the engagement of doctoral students in industrial research or experimental development projects carried out in companies, based on which they will develop their doctoral thesis. The programme targets firms aiming to recruit doctoral students to participate in their industrial R&D activities conducted internally or in collaboration with other organisations. The student is simultaneously employed by the company and enrolled at a university. Support is provided for a period of up to 4 years, and covers the following: 1) co-financing of the employment contract for PhD students; 2) financing of temporary stays of the student at other R&D institutions (up to EUR 2 400 per student); and 3) financing of tuition fees for doctoral studies (up to EUR 1 500 per student). The maximum annual eligible recruitment cost is ca EUR 24 000. The programme has an annual budget of EUR 4 million. A total of 61 contracts were awarded under the 2019 call, a relatively small number of a country of Spain's size.

Several autonomous regions have launched their own industrial doctorate programmes, including Andalusia, the Basque Country, Catalonia, Madrid, Murcia, Navarre and Valencia. In the same vein, in 2014 the ISCIII launched an **industrial doctorate programme for doctoral students in health sciences and technology** (*Contratos i-PFIS Doctorados IIS-Empresa en Ciencias y Tecnologías de la Salud*). The beneficiaries of the programme are health research institutes accredited by the Ministry of Science and Innovation – these have to sign a collaboration agreement with a firm that specifies the

[81] Programmes that provide partly-repayable loans, managed under commercial law.

activities to be carried out in the context of the industrial doctorate programme. Support provided covers the gross salary of the hired student for up to 4 years (ca EUR 20 000 per year). Over that period, the student will complete a PhD thesis in public-private collaboration. From the third year of the contract, the student has a mandatory stay in the company to carry out research activities directly linked to the candidate's doctoral thesis.

The **Torres Quevedo Grants** programme (*Ayudas para contratos Torres Quevedo*) was launched in 2006 and is managed by the AEI. It promotes the employment of doctorate holders in companies by co-financing their salary and their employer's social security contributions for up to 3 years. Doctorate holders should be engaged in industrial research projects, experimental development or feasibility studies. Programme beneficiaries can be firms (including spin-offs and young innovative firms), recognised state-wide technology centres and technological innovation support centres, business associations and science and technology parks. The amount of financial support provided varies depending on the type of company (large company, medium or small) and the type of project to in which the doctorate holder will be involved (industrial research, experimental development or technical feasibility studies). The annual eligible recruitment cost is of between EUR 18 000 and EUR 55 000, although the gross remuneration in the contract may be higher. The programme has an annual budget of EUR 15 million (2020), significantly below the budget of EUR 54 million in its 2008 call. A total of 176 contracts were awarded under the 2019 call.

Other programmes are implemented at national and regional level to support the recruitment of doctors in research organisations and universities, and to attract and retain international talent. Examples of state-wide programmes are the Ramon y Cajal, Juan de la Cierva, and Beatriz Galindo contracts. These are complementary to the three programmes presented above in that they promote the mobility of talent, indirectly supporting linkages across different research institutions. Yet those programmes are based on research excellence criteria and do not specifically target science-industry linkages nor recognise these as part of the recognised merits. The Ministry of Universities has a programme aimed at supporting the upskilling of academic and research staff at universities through subsidised mobility experiences, which is the only one under its jurisdiction with explicit references knowledge transfer.[82] It is unclear how many individuals benefit from this programme from a specific KTC perspective.

Assessment

In general, stakeholders consulted in the context of this study consider the programmes supporting the mobility of doctoral students and post-docs and their engagement with industry as highly necessary and reasonably successful to date. Ex-post evaluations of those programmes should be conducted in the coming years to better understand their long-term impacts on researchers' careers and engagement with industry[83].

The Spanish Independent Fiscal Accountability Authority (AIReF) already conducted an evaluation in 2018 of the programmes implemented by the Ministry of Science, Innovation

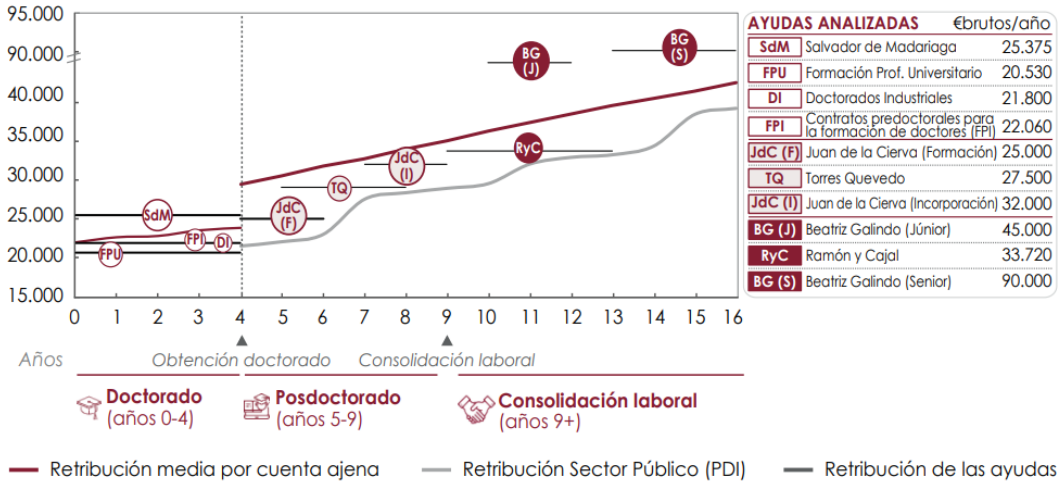
[82] See Strategic Objective 2.1 in https://www.universidades.gob.es/stfls/universidades/ministerio/ficheros/Plan_Estrategico_Subvenciones_2021_M_Uni.pdf

[83] Impact assessments of industrial PhD programmes implemented in other countries a positive impact of programmes on employment and income. A study of the Danish programme finds that nearly 80% of industrial PhDs are employed in the private sector, where they occupy highly specialised jobs with high salaries, while for conventional PhDs the share is below 50% (Danish Agency of Science, 2012[147]).

and Universities to support the employability of talent. While the analysis focused on two programmes not explored here[84], it also provides a valuable assessment of some aspects that are relevant to all programmes supporting talent, including the industrial doctorate programme and the Torres Quevedo contracts (AIReF, 2019[83]). Two of them are of specific relevance: first, surveys of doctoral students and postdoc researchers reflect that the lack of predictability (call dates and award criteria, long processing times), the high level of bureaucracy (excessive documentation to be submitted and time required to collect it), and lack of clarity regarding the characteristics of the different support mechanisms available, are the main barriers they face when applying to these programmes. Second, the salary of the industrial doctorates covers the opportunity cost of market entry; in the case of the Torres Quevedo contracts, the average salary is slightly above the average salary of researchers in the public sector (*personal docente investigador*), but below that of postdocs in the private sector (Figure 54). This, however, varies significantly across beneficiaries.

Figure 54. Overview of research career salaries

Average annual gross salary (EUR)



Note: The average employee contribution since the completion of the doctorate onwards is taken into account. The length of the line indicates the period of duration of the support (in years). Before obtaining the doctorate, the comparison is based on the earnings of individuals with a master's degree. After obtaining the doctorate, the comparison is based on the salaries of doctorate holders.
Source: AIReF (2019[83]).

Some stakeholders pointed out that the industrial doctorate programme is too small (EUR 4 million budget in 2019, resulting in only 61 industrial PhDs awarded that year) and more resources should be devoted to it – yet it is important to recall as previously noted that several regional governments have similar programmes in place. While the Torres Quevedo programme has a significantly larger budget (EUR 15 million in 2020), resources devoted to it have significantly decreased over time (from EUR 54 million in its 2008 call). Actions aimed at increasing awareness about these programmes, especially among small firms, could also be envisaged, based on a clearer understanding of the factors that enable a match to be made. It is unclear for example what can be the main motivations for a firm to engage a doctoral student or recent graduate, and overall international experience suggests that

[84] The AIReF assessment focuses on the *Formación de Personal Investigador* programme (pre-doctoral contracts) and *Ramon y Cajal* Contrats (post-doctoral contracts) at research organisations and universities.

these matches, in order to be mutually beneficial, have to be based on trust between the research institution and the company.

The Torres Quevedo programme could also be revised to ensure that the necessary support is provided to ensure a successful transition of doctorate holders from university to industry. Firms interested in contracting a doctor often expect these to be able to autonomously manage a research project and even supervise other team members from the moment they join the company. However, newly graduated doctors with no previous experience in business are not necessarily at ease in performing such tasks, which would require a transition period to familiarise themselves with tasks and acquire the necessary skills before becoming sufficiently autonomous. The Torres Quevedo programme could introduce some flexibilities during the first year of the programme, allowing a progressive integration into the world of business while pursuing some training activities and still engaging with university activities.

The AIReF study also points out that, while in both programmes the impact and quality of the research project undertaken and the candidate's curricular merit are considered, the track record of the funded company is not directly assessed. The study raises the question as to whether or not a first filter should be established to identify the companies that would have the appropriate capabilities to host the research activities of PhD students and doctors (AIReF, 2019[83]).

In addition to those programmes, the system would benefit from expanding e**ntrepreneurship education** at all levels of university education (from undergraduate to PhD studies) and across all academic fields (including those considered "basic" science fields and traditionally more inclined to pursue their careers in public research institutions). Furthermore, the figure of the **Adjunct Professor** (*Profesor Asociado*), created by the Organic Law 11/1983, was originally conceived as a means of allowing students to acquire knowledge from and establish contact with highly qualified professionals outside academia. These professors would occasionally engage in teaching activities on a part-time basis to transfer their experience to students, but would pursue their main professional career outside university. The system, however, has been perverted over the past years, as many universities have been using such contracts for recruiting full-time essentially academic lecturers at lower cost, contributing to the precarisation of research careers (OECD, 2021[97]) and preventing the type of knowledge exchange foreseen for such roles. Indeed, when students enrol on a degree or subject may not necessarily know in advance whether the subject will be taught by a full time academic or an external professional. The Ministry of Universities is currently working on a new Statute for Teaching and Research Staff (*Estatuto del Personal Docente e Investigador*) that aims, among others, at reversing this situation. It is particularly important that the figure of Adjunct Professor recovers its original purpose, as it offers students broader perspectives about their possible career paths and helps develop more practical skills and competences in university curricula to meet business demands. In addition, these lecturers would serve to stimulate the development of industrial doctorates, as well as internships and degree/master theses. It would be advisable to include within the scope of their contracts this kind of thesis supervision activities, a mission that is currently neglected.

The system would also benefit from encouraging further the **interaction and mobility of students with business during their studies**, beyond existing internship programs, for instance by encouraging masters' students to write their masters' thesis in collaboration with a company or setting up dual education arrangements from an earlier stage in their educational trajectory, leveraging lessons learned from experiences in other countries as well as within Spain (as mentioned for example in the case of Tecnalia in Box 10), with a broader based view that also takes into account the potential contribution of the PSR to the

formation of not only researchers and engineers capable of overseeing R&D projects but also scientific and technical support and implementation personnel.

Box 16. Knowledge Transfer Partnerships, United Kingdom

The United Kingdom's Knowledge Transfer Partnerships (KTP) programme is one of the most remarkable international examples of policy programmes promoting knowledge transfer through the mobility of skilled human capital. The programme's aim is to facilitate the transfer of knowledge and the spread of technical and business skills through projects undertaken by highly skilled, recently qualified, graduates under the joint supervision of personnel from business and the knowledge base. Each KTP is a 3-way partnership between a UK-based business of any size or a not-for-profit organisation; an academic or research organisation, which can be a university, college or research and technology organisation in the UK; and a suitably-qualified graduate with the capability to lead a strategic business project. The academic or research organisation partner will help to recruit a suitable graduate, known as an Associate. They will act as the employer of the graduate, who then works at the company between 12 and 36 months, depending on what the project is and the needs of the business. Average project length has increased from 24 months in 2017-18 to 28 months in 2018-19.

A KTP is part-funded by a grant. The company contributes to the salary of the Associate who will implement the project, plus the cost of a supervisor who will oversee the scheme. The amount to be invested by the company depends on the scale and length of the project. It also depends on the size of the company. Most academic and research organisations have a dedicated KTP office. These offices work with the business and academic partners who intend to collaborate together to scope out the project and help with the application process. KTP is one of the UK's largest graduate recruitment programmes, offering over 300 job opportunities each year.

Source: Guimón (2019[98])

Measures to support the mobility of recently qualified graduates under the joint supervision of personnel from business and university could also be explored (Box 16). Other actions that have been undertaken by some countries to promote inter-sectoral mobility of researchers include the following (OECD, 2021[27]):

- *Preparing PhD students for diverse careers* by changing the objectives and content of doctoral training, including providing more opportunities for institutional placements during the phase of doctoral education.
- *Providing professional development advice to PhD students and doctors* through career advice and mentoring, decoupling research and career advice.
- *Publication of data on labour-market outcomes of recent cohorts of doctorate holders* so that young researchers can build realistic perspectives about their future. In Spain there is no equivalent to the Belgian Observatory of Research and Scientific Careers, the detailed information conveyed by the NSF in the United States, or HESA and Vitae in the United Kingdom.
- *Ensuring the portability of acquired benefits*: The European Union has developed RESAVER, a multi-employer occupational pension solution for research organisations that enables researchers to stay with the same pension plan when moving between countries or employers.

The Spanish Recovery, Transformation and Resilience Plan envisages the coordination of the industrial PhD and the Torres Quevedo programmes with the Cervera and the NEOTEC Programmes (see section 6.1.1). Building stronger connections between different policy programmes is a useful way of creating synergies that, in this case, promises to contribute to a much-needed increase in the employability of PhD holders in the private sector.

4.4.3. Incentives and rewards for public sector researchers that engage in knowledge transfer and collaboration activities

The Spanish law mandates the general government to "put in place systems that allow the assessment of public sector employees" and foresees the use of pay enhancement mechanisms according to results and achievements.[85] This default system for performance related pay (PRP)/merit award schemes within a given grade is fairly complex to describe within the scope of this report and project, having no clear equivalent in public administrations in other countries. In essence, and at the risk of gross oversimplification, the Spanish system for public sector employees:

- allows to accredit "merits" only after a given time period or with certain periodicity (3 years –*trienios*, 5 –*quinquenios*, 6 – *sexenios*), in which case they entitle them to relatively small but cumulative pay enhancements that become substantive over time regardless of future performance;
- traditionally placed a relatively law bar on the accreditation of merit, although this has been evolving for a number of types of "merits";
- the accrediting of the merit is not generally governed by the same authority that funds the pay enhancement, therefore requiring the employing institution to anticipate and absorb its impact on its budget;[86]
- excludes period of leave of absence unless in cases foreseen by law, for example related to becoming an elected official.

These features contributed to making the system more akin to an enhanced tenured-based system. Since 1989, a system to reward the research performance of tenured professors and researchers has been in place in Spain. Following an assessment process, those granted with a so-called research "sexennium" receive a monthly salary increase of around 145 euro[1] in recognition of good research performance over a 6-year period, with the possibility of accumulating up to six *sexennia* over a researcher's career. The system has evolved into a standardised CV-based evaluation procedure that primes scientific publication prestige as indicator of excellence and rates a researcher's five most significant outputs over each 6-year period. The introduction of this research excellence incentive has been accompanied by reforms of regulations and accreditation systems affecting the selection and promotion of university professors, as well as by new regulations that allow those professors holding sexennia to teach less hours than those who do not (albeit most university departments have still not fully applied this system). [87]

[85] See https://www.boe.es/buscar/act.php?id=BOE-A-2015-11719

[86] However, the reform of the merit award schemes does need to seek in principle the approval of budget authorities if the budgetary impact is not neutral.

[87] The Sexenio also has implications for the amount of teaching hours that academic staff are expected to devote. The achievement of a research sexennium allows academics to devote a larger share of their time to research, although many university departments are still not applying this system.

In 2010, a specific field called knowledge transfer ("Campo 0"), was included in the research sexennium, in addition to the standard fields for each scientific area, for those candidates that wished to be assessed for knowledge transfer outputs such as patents and spin-offs, rather than for scientific publications. This represented a first recognition of KTC activities, although rather limited in scope.

The Knowledge Transfer sexennium

In November 2018, the Spanish authorities introduced, on a pilot basis, a new Knowledge Transfer and Innovation sexennium (KTS)[88] in parallel to the traditional research sexennium pay enhancement mechanism. This new system is overseen by the National Commission in charge of the Evaluation of Research Activity (CNEAI in Spanish), which is since 2014 part of the National Agency for the Evaluation and Accreditation of Quality (ANECA in Spanish), an autonomous body dependent of the ministry with responsibilities for higher education (now the Ministry of Universities).

The application and evaluation processes of the KTS match those of the research sexennium, and the salary increase (as well other privileges) if positively assessed is the same: a permanent monthly salary increase of around 145 euro,[89] in recognition of satisfactory performance over a 6-year period, with the possibility of accumulating up to six sexennia over a researcher's career. However, the types of targeted outputs are different: they include research or consulting contracts financed by industry, participation in spin-off companies, patent licensing, and other forms of knowledge transfer such as supervision of industrial doctorate theses, participating in policy-making bodies, or mobility to the private sector, among others. Both contributions with an economic impact and those with a social value are considered, meaning that the transfer of knowledge is not necessarily to industry but could also comprise NGOs, public agencies or civil society more broadly. This deliberately broad conceptualisation of knowledge transfer and diffusion activities makes it distinctive from Campo 0 (which disappeared in 2018 with the introduction of the KTS) and aims at integrating the different KTC practices across scientific disciplines.

With this broader scope, the number of submissions (close to 17 000) in the first pilot call exceeded official expectations and average submissions to the research sexennium (around 8 000). The large number of applications received, together with the high complexity of assessing KTC activities for the first time, resulted in substantial delays, which were aggravated by the outbreak of the Covid-19 pandemic. As a result of those delays, it took 18 rather than 6 months (i.e. June 2020 instead of 2019) to conclude the process. A second call is expected to take place in 2021.

The KTS compounds with other incentives in place such as the possibility for university professors and researchers from public research institutes to gain additional personal income, despite their civil service status, from contract research with private entities; from patent licensing; and from the participation in spin-off companies[90]. Significant differences, however, exist across institutions (i.e. in terms of income that can be perceived by

[88] Boletín Oficial del Estado (BOE), Número 285, Disposición 16138, del 26 de noviembre de 2018. https://www.boe.es/boe/dias/2018/11/26/pdfs/BOE-A-2018-16138.pdf.

[89] The exact amount ranges from 130 to 160 euro depending on the position held by the professor or researcher (e.g. a full professor receives a slightly higher salary increase than an associate professor).

[90] Knowledge transfer activities are also taken into consideration by ANECA within the accreditation process of university professors, albeit with a lower importance than teaching and research. The internal selection and promotion processes at universities and public research institutes also consider the candidate's accomplishments in knowledge transfer, although this varies by institution and, again, the importance attached to knowledge transfer activities is lower than teaching, research or administrative activities.

university researchers and those in other public research institutions for engaging in knowledge transfer and collaboration activities). The ability of the latter to financially benefit financially from the KTS has to this point not yet been established.

Assessment

The experience of the pilot KTS provides a useful perspective from which to judge the initiative and its future. As results from the pilot got published, many unsuccessful applicants in the first call raised complaints about the **transparency and consistency of the assessment system**. For example, in several instances it was noticed that two applicants presenting exactly the same merit as part of a team were evaluated very differently (e.g. with one rated with a 2 and the other a 6). Part of the problem concerns the subjectivity of the merits and the lack of a common, thoroughly defined assessment framework and criteria, something which the pilot was intended to develop.

Despite the aforementioned operational implementation issues[91], the large number of applications submitted, and the high interest that it has raised among the Spanish scientific community can be interpreted as signs of what could be highly promising initiative. The information collected suggests that the knowledge transfer and innovation activities of Spanish universities and public research institutes are broader and more intense than previously thought, since traditional indicators used were failing to capture many forms of cooperation between public research and business (Mato, 2020[99]). According to the interviews held within this project, over the medium to long term, the KTS could lead to a new culture more prone to knowledge transfer among Spanish researchers, similar to the effect that the research sexennium had on scientific publications. While it is still too early to evaluate the impact of the KTS on the propensity of Spanish professors and researchers to engage in knowledge transfer activities, one can expect that such impact will ultimately derive both from the economic incentive itself and from a **cultural/institutional effect**.

Based on anecdotal evidence, a possible major effect of the KTS and its evaluation system is that it could help "**formalise**" current engagements with industry of university professors (such as consultancies, part-time employment, or equity holdings in companies), which have been often conducted informally without the institutions being formally aware of them. In the KTS, only those contributions supported by a contract with the university's technology transfer office (or similar organisation) are taken into account in the assessment process.

Following the first pilot call of the KTS, the Spanish government and ANECA have committed to institutionalising the incentive as a stable element in the Spanish system to assess and reward the performance of tenured professors and researchers, complementing the research sexennium. For this to be successful, it will be necessary to fine-tune the evaluation process in order to make it more agile and transparent. Indeed, in 2020, ANECA commissioned an internal and external evaluation of the pilot call. Based on these inputs, a set of guidelines will be published to accompany the next call of the KTS. In particular, three sets of guidelines will be published, addressed to applicants, institutions and evaluators. The first will aim at setting more transparent principles that help applicants select which contributions to submit and reduce scope and merit uncertainty. The second

[91] For instance, there were problems with the online tool used to handle the submission of applications and the evaluation process. Initially, the system collapsed due to the large number of applications and to the heavy size of the documents uploaded by applicants to justify each contribution. This was one additional factor behind the delays mentioned above. Moreover, the form included an additional space to provide a 6th potential contribution to be considered as an alternative to some of the other contributions if awarded a lower grade. However, this option was not practical because the space provided was very short and it was not possible to upload an attachment.

will be addressed to universities and public research institutes, indicating the proper way of documenting and certifying the knowledge transfer activities of their employees towards applying for the KTS. Both of them will be made public, in contrast with the third, which will be provided only to evaluators in order to guide the evaluation process.

According to our interviews, a key challenge ahead consists in **elaborating sufficiently clear and acceptable guidelines** regarding the eligibility and non-eligibility of different types of activities and the scoring system. One of the core difficulties, which often led to misunderstandings, was drawing a clear line of separation between knowledge transfer activities and other kinds of research and teaching activities. A systematic analysis of the data obtained from the pilot call would lead to some sort of catalogue with an inventory of examples of potential contributions and their rating across different scientific fields (Mato, 2020[99]). The KTS adopted a wide definition of knowledge transfer, including not only those activities generating economic value but also those generating a social impact and the dissemination of knowledge to a wider audience. For some, this is positive since it recognises the multifaceted nature of knowledge transfer and caters to all academic disciplines. For others, this opening of the concept has gone too far, to the extent that the most important activities generating economic value (e.g. spin-offs, patent licensing, etc.) are being valued relatively low compared to other more minor contributions. Some of our interviewees have recommended to include business representatives (and not only academics) in the evaluation panels, to ensure that the more impactful activities are given the appropriate recognition. Others have suggested to organise evaluation panels around type of activities (e.g. patents, spin-offs, technical assistance and consulting, knowledge diffusion through the media, etc.) rather than by scientific areas, or to use a combination of both.

As a follow-up of the first pilot call of the KTS, besides the evaluation reports and guidelines outlined above, ANECA has also been working on a report to analyse gender differences. Consistently with what has been found in other countries and international studies, across all fields, men were more likely to apply and they also achieved a higher award success rate. These gender differences are a cause for concern that should be analysed further in light of the distribution by gender of the population that can potentially apply. A clear diagnosis of the gender and other possible biases in KTC is therefore necessary in order to propose appropriate and inclusive assessment and incentive frameworks.

Another range of issues to be addressed is **how the KTS relates to other activity incentive mechanisms and activity domains**. With respect to teaching merits, some commentators have criticised that the current system of incentives is focusing only on the second and third missions of universities (research and knowledge transfer sexennia), leaving aside the teaching mission. To address this, the Ministry of Universities has announced that it plans to launch a new "teaching sexennium" in the near future and ANECA is already working on defining the corresponding system. The connection with the research incentives is at this point more challenging, on a number of different dimensions:

- Relative size of merit, i.e. is the KTS going to be given equal recognition as the research sexennium, not only in terms of the financial incentive itself, but also with respect to its use as credential when it comes to the selection and internal promotion processes of professors and researchers, as well as the assessment of project applications (researcher merit) for national research funding programmes?
- Substitutability or complementarity of research and KTS sexennia. In other words, does the attainment of one impinge on the eligibility to obtain accreditation and a result financial award for the other, as it would be the case if there were a maximum

limit of sexennia over a researcher's career, as it currently is the case (6)? That would indeed represent a quasi-budget neutral position, but may have implications on incentives. Alternatively, the authorities may not limit the number of possible sexennia of either type, but constrain the number of that can be effectively paid out and accumulated.

The authorities should address more explicitly the **question of who pays for the KTS and its opportunity cost**. Greater transparency on this particular point and the actual possibilities of take up and eligibility in different institutions would be very important for the future of the KTS as a financial incentive, over and above its signalling/credential role. The budgetary implications of the incentive schemes have to be assessed in a rather clearer fashion from the perspective of all the parties implied. In the case of universities, the cost of the sexennium is borne by the regional budgets for their universities, while in the case of central government institutions this represents a pressure on their resources which principally come from the central government budget, which also includes transfers to the autonomous regions that contribute to the funding of universities and regional research and technology organisations potentially covered by the sexennium arrangements. The sexennia are additional elements in an already complex system in which different regions and institutions make variable use of their autonomy to set salaries and work-related salary complements

The implementation of the KTS represents another example of **institutional asymmetry**[92] that appears to result from the decoupling of accreditation and budgeting. At the time of writing this report in 2021, university professors who were awarded the KTS from the 2018 call had started receiving the financial incentive in their payrolls. In contrast, the Ministry of Finance had blocked payments to researchers from PROs within central government attached bodies (e.g. CSIC), having interpreted that this incentive overlaps with a separate pre-existing incentive, the so-called "*quinquenio*", which also rewards researchers for their accomplishments in various activities other than research, such as teaching and knowledge transfer[93] (CCOO-CSIC, 2021[100]). These contradictions and delays are unfortunate because they could have been foreseen and create uncertainty among the scientific community about the credibility of these initiatives. If the KTS is to have the expected effects on promoting knowledge transfer, the Government should commit more strongly to its sustainability and the calendar of future calls should be more predictable.

Predictability and stability are additional important matters that are insufficiently addressed thus far, as without them it is not possible to speak of a true incentive effect on the behaviour of researchers. There are some elements of concern in this regard. After concluding the evaluation of the 2018 pilot call in June 2020, as of June 2021 the next call of the KTS had still not been issued. This delay can be explained by the operational issues discussed above, in particular the need to develop clear evaluation guidelines to accompany the next call.

To sum up, Table 7 presents a brief overview of the early assessment of the KTS developed above, pointing to some potential areas for reform that should be taken into consideration. It should be stressed out that the KTS is a pioneering initiative that has not been used in any other country, with the qualification already made about the highly idiosyncratic nature of the baseline pay and incentive regime in place in Spain for public sector employees. As such, it is not possible to evaluate its impact based on a comparison with other countries. Given its experimental nature, it is worth reflecting on the extent to which it could be a

[92] Furthermore, the KTS and RS do not apply to all categories of staff.

[93] University professors also receive the "quinquenio", but only as a reward for teaching activities, not for knowledge transfer. This is incentive is effectively awarded in an automatic fashion.

model for other countries to consider and whether there are simpler mechanisms to achieve a similar effect.

Table 7. Strengths, weaknesses and potential reforms of the knowledge transfer sexennium

	Strengths	Weaknesses	Potential reforms
Scope and eligible activities	Broad range of eligible activities recognising the variety of KTC and dissemination channels, catering for all disciplines including social sciences and humanities.	Activities with strong economic and business impact are not being sufficiently valued vis a vis other kinds of knowledge diffusion activities with lower impact.	Reconsider carefully the weight assigned to each type of knowledge transfer activity, taking into account the effort involved and the expected economic and social impact. Introduce necessary adjustments to ensure they are compatible and do not overlap with *quinquenios*
Evaluation process – capacity to assess merit	Serious peer review system relying on panels of independent experts by discipline.	Slow process and lack of transparency and clear criteria.	Clear rating system and guidelines for applicants and evaluators building on pilot experience. Include business representatives in evaluation panels. Organise evaluation panels around type of activities rather than scientific areas.
Fit within policy mix	Complements research sexennium by providing similar incentives to knowledge transfer activities.	Excessive focus on individual-level incentives. Lack of similar incentives for teaching activities. Insufficient recognition of knowledge transfer in selection and promotion processes.	Improve alignment of incentive schemes with areas of activity. Performance-based funding systems for institutions that consider both research and knowledge transfer indicators. Introduce more clear guidelines to ensure that knowledge transfer is considered in selection and promotion processes.
KTC incentive effect	In the long term, if the system is perceived as longstanding, KTC behaviour may change and drive sustained cultural change.	In the short term, the reward is provided for past activity and therefore there is a deadweight cost, although it has a behavioural "formalisation" effect that can be beneficial.	Ensure greater predictability and alignment of activity and reward, and consider a) implications of individual incentives of for teams operations b) institutional level incentives combined with greater institutional capacity to reward individuals
Budgeting	Relatively small impact on public purse in return for the greater formalisation and cultural change.	Misalignment of accreditation and resource allocation by budget holders (incentive acts as a tax on other parts of public sector). Opportunity costs not spelled out.	Secure greater coordination with research funders bound by the centrally adopted scheme and accreditation decisions.

Source: OECD elaboration

The Spanish pilot experience confirms the challenges of assessing knowledge transfer activities and implementing incentives over an already complex layer of rules and institutional funding arrangements. It also raises questions about placing emphasis on individuals, which has a number of pros and cons. This kind of initiative requires to clearly define the type of eligible knowledge transfer activities, to design specific criteria to evaluate each type of contribution and to set up and manage evaluation panels in a consistent way. The organisational and human resources required for an efficient and fair evaluation process should not be underestimated, given the complexity and diversity of knowledge transfer activities and the impossibility (and undesirability) of implementing a fully metrics-based approach to sustain it.

4.4.4. Supporting the creation of collaborative platforms and networks

Enabling coordination is major object of KTC policies as there are major informational gaps and asymmetries in innovation systems that prevent the exchange of knowledge and collaboration among actors. The AEI, following the example of the European Technology Platforms (ETPs), launched in 2005 a programme to support the creation of "technology networks", later called "**technology and innovation platforms**". These are industry-led public-private structures of exchange and communication among research and innovation actors in specific sectors or technology areas. Actors engaged in such platforms include public research organisations, public universities, other research centres dependent of the State and regional administrations, technology centres, technological innovation support centres, public and private non-profit entities that conduct or manage R&D activities, businesses and sectoral business associations.

The support programme is managed by the AEI and in 2018 had a budget of EUR 4 million. It provides grants to create new and consolidate existing technology and innovation platforms, as a way of promoting public-private collaborations, boosting the technological capacity of the productive sector, aligning the strategies of the different research and innovation actors, and jointly identifying new demands in the area of "missions". Activities financed by the grant include: the organisation of the platform's annual assembly, thematic conferences and other dissemination activities; the preparation of prospective and early demand studies; activities to address specific challenges ("*retos*") in collaboration with other platforms; and activities to promote technological cooperation and advice in the preparation of R&D and innovation projects.

As of January 2021 there are 43 technology and innovation platforms in Spain covering a range of areas, from agri-food, to transport, energy, biotechnology, health, and advanced materials. Platforms do not have legal personality, and the beneficiaries of the Ministry's grants are the entities in charge of the platform's technical secretariat.

The **Networks for cooperative research oriented to health solutions** (*Redes de investigación cooperativa orientadas a resultados en salud*, or RICORS), previously known as thematic networks for cooperative research in health (*Redes temáticas de investigación cooperativa en salud*, or RETICS, created in 2002) promote collaborative research across multidisciplinary research centres and groups. The programme is managed by ISCIII and covers research centres or groups that can be publicly or privately funded, and that have to be located in at least 10 different autonomous regions. Funding for research networks is provided for 3 years and covers four main thematic areas[94]. The programme has an annual budget of EUR 5.8 million. Companies and other public or private entities can engage in the networks, but they cannot be beneficiaries of the grants awarded.

Also in the field of health, the **Network for cooperative research in biomedicine** (*Centro de Investigación Biomédica en Red*, or CIBER) is a public research consortium set up in 2013[95] at the initiative of the ISCIII to promote research in biomedicine and health sciences done in the national health system and in the science and technology system. Some calls promote the transfer to the industrial sector of scientific or technological results from the research carried out by specific CIBER groups. Valorisation projects are also launched, with the objective to support technologies with a minimum TRL of 3, so that they can advance the TRL by one degree at the end of the project period. They target groups that

[94] Primary care, chronicity, and health promotion; inflammation and immunopathology of organs and systems; advanced therapies; and cerebral vascular diseases.

[95] Several centres for cooperative research in biomedicine (*Centros de Investigación Biomédica en Red*) were created in 2006, which were grouped together in a consortium in 2013.

have a patent with CIBER co-ownership, or that participate in intramural collaborations or projects.

Assessment

Stakeholders coincided in assessing as positive the creation of technology and innovation platforms. These soft instruments, with a comparatively modest budget, are a valuable instrument to mobilise research and innovation stakeholders around common interests – such as sharing information, jointly developing research and innovation roadmaps or technology foresight studies. Such platforms facilitate networking and contribute to building trust among actors, reducing the search and transaction costs in the establishment of new collaboration partnerships.

It is important to note however that there is significant heterogeneity in terms of scope and impacts of their activities, largely depending on the engagement and commitment of actors within each of these platforms. The Spanish Aerospace Technology Platform (PAE) is an example of very active forum of collaboration. It serves as an aeronautical and space research advisory body in Spain, conducts technology foresight exercises, and regularly updates the Aerospace Strategic Research Agenda. In 2020, the platform published the new Aerospace Strategic Research Agenda, and the R&D priorities in the fields of unmanned aerial systems, additive manufacturing, and advanced manufacturing related to the sector.

This type of programmes, like other types, would benefit from a greater degree of evaluation focused on demonstrating the collaborations enabled and the extent to which they enable the relevant stakeholders to come together to produce, for instance, credible roadmaps for their sector and technology areas, informing and engaging in the co-creation of government policies, etc.

4.4.5. Instruments to support intermediaries and key infrastructures

Other mechanisms used internationally to enhance science-industry collaboration include support for knowledge intermediaries (e.g. technology transfer offices, science and innovation parks, technology centres, clusters) and the financing of key scientific and technological infrastructures with open competitive access to the whole research community. At the Spanish central government level, there are currently no instruments in place to support technology transfer offices and science and innovation parks, although regional governments often have specific programmes to support them.

Central government support for technology centres

The **Cervera programme for technology centres** (*Ayudas Cervera para Centros Tecnológicos*), launched in 2019 by CDTI, provides support in the form of non-repayable grants to implement strategic research, development and innovation programs by consortia of 3 to 5 country-wide technology centres and technological innovation support centres. The programme aims to strengthen the capacity of technology centres of conducting applied research in key technology areas (as identified by the 11 Cervera priority technologies), and collaborating with a diversity of actors in the ecosystem. Technology centres are considered key players in providing services to companies aiming to boost their innovation performance, particularly SMEs with limited internal R&D capabilities. The programme, launched annually, had a budget of EUR 20 million in 2019, allocated to projects that have an eligible budget of between EUR 2-4 million, carried out over a period of 3 years.

The results of this first call were released in August 2020, with a decision to fund 4 strategic projects. The second call granted support to 5 strategic projects, as announced in June

2021[96] (La Moncloa, 2021[101]). Although it is too early to evaluate results, it would be advisable to reflect further on the suitability of existing monitoring systems and ongoing support services that CDTI should provide to these pilot networks in order to enhance their impact. Such impact should not only be measured on the basis of the technological outcomes of the projects themselves, but also on the behavioural additionality effect of the programme in terms of enhancing the propensity of technology centres to collaborate among each beyond the scope of these 3-year projects.

Central government support for science and technology parks

S&T parks host a substantive share of technology centres and facilities. The central government has in place in previous year a series of programmes in support of feasility studies for the creation and improvement of infrastructures within S&T parks and the acquisition of equipment, leveraging additional funding from the European Regional Development Fund (INNPLANTA). As mentioned in section 3, the financial difficulties faced first after the GFC and more recently with the COVID crisis presented a major challenge for the financing of the debt incurred to develop S&T parks. Supported by provisions in the government's general budget, the AEI has been launching a procedure for the annual refinancing of the S&T park debt, thus assisting their promoting entities, in many cases universities. In the AEI's 2020 annual report[97], the subsidy under the INNPLANTA programme is estimated at close to EUR 40 million, one of the main programmes in size and equivalent to close to 10% of the overall subsidy provided on that year.

Central government support for clusters

While clusters are not formally recognised by the Spanish Ministry of Science and Innovation as "innovation actors", the Ministry of Industry, Commerce and Tourism (MINCOTUR) has promoted their development as a way of strengthening innovative business ecosystems building on regional capacities and sectoral specialisation trajectories and is responsible for their state wide sponsorship.[98]

As is the case for other government sponsored intermediaries, Spanish authorities make use of regulatory accreditation mechanisms and registers. Accredited AEIs join the Registry of Innovative Business Groups managed by MINCOTUR. Ministerial order IET/1444/2014 defined Innovative Business Clusters (AEIs) as combinations, in a geographic space or productive sector, of companies and public or private research and training centres, involved in an exchange process collaborative aimed at obtaining advantages and / or benefits derived from the execution of joint projects of an innovative nature. AEIs activity must be organised around a scientific or technological branch or sector and / or a target market or market segment. Furthermore, the AEI must also have a critical mass that ensures the competitiveness and international visibility of its companies, especially SMEs, promoting the practice of innovation and internationalization. The legislation foresees two types of AEIs:

[96] The government announced that, while the initial budget for the 2020 call was of EUR 20 million, an additional amount of EUR 15 million could be added to this support from the EU Recovery and Resilience Fund during 2021.

[97] See page 14 in http://www.aei.gob.es/stfls/MICINN/AEI/ficheros/Informe_General_Actividad_2020-AEI.pdf

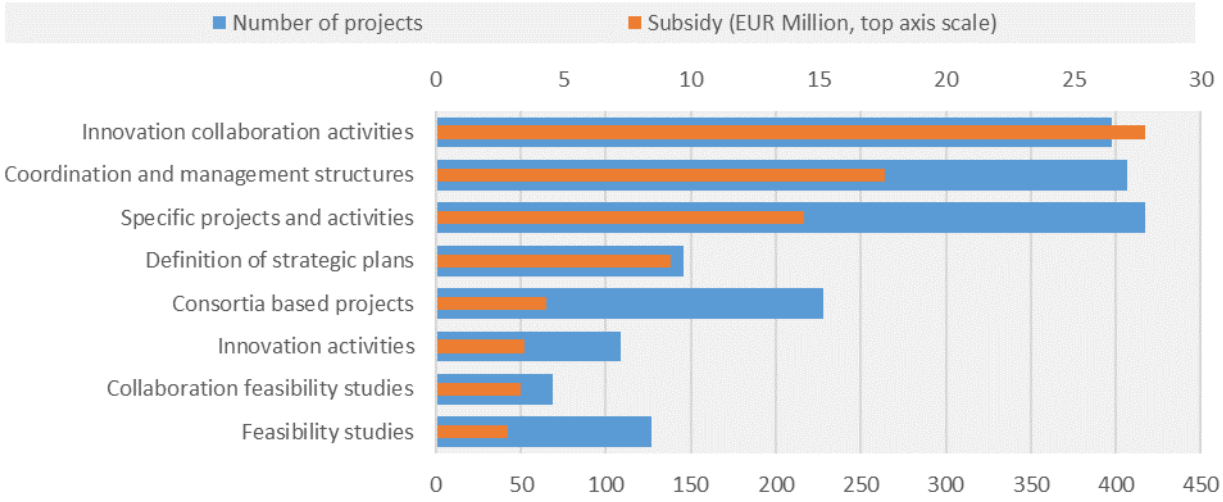
[98] For a description of Spain's central government policy on clusters, see https://clusters.ipyme.org/es-es/PoliticaClusters/NuevaPoliticaClusters/Programa/Paginas/DescripcionGeneral.aspx

- Incipient: AEIs recently constituted, in the process of consolidation, with an age of a maximum of 4 years from the date of incorporation.
- Excellent: AEIs that manage to demonstrate a high degree of performance in the development of projects and services relevant to the improvement of the competitiveness of the associated companies, in the organisation of their own management structure and in the achievement of a sustainable financial structure.

The regulation came in support of the **innovative business clusters support programme** (*Programa de apoyo a las agrupaciones empresariales innovadoras*) launched in 2007, aimed at strengthening "innovative business groups" (AEIs in Spanish, more commonly known as "clusters"). The programme provides grants to clusters for: a) the creation of new and strengthening of existing coordination and management structures of clusters; b) carrying out technical feasibility studies; and c) developing innovative activities, including industrial research, experimental development, and organisational and process innovation activities. Activities b) and c) can be performed by several members belonging to one or several clusters registered in the "Register of Innovative Business Groupings". In 2020, the programme had a budget of ca EUR 8 million, having disbursed close to EUR 83 million since its inception, corresponding to close to two thirds of the value of approved projects. Figure 55 provides a picture of which types of projects have been most subsidised, showing that innovation collaborative activities have attracted the largest share of support. The programme does not currently require the participation of public research organisations, universities or technology centres – yet these, in particular technology centres, are often engaged in such activities.

Figure 55. Distribution of business innovation cluster support, by type of project

Value of subsidy and number of projects subsidised over the programme's lifetime, 2007-20



Source: OECD analysis of AIEs-cluster statistics, Ministry of Industry, Trade and Tourism. https://clusters.ipyme.org/es-es/Identificar/Paginas/Estadisticas.aspx

Support for health platforms

In the field of health, ISCIII has launched some platforms that enhance knowledge transfer and collaboration across actors. The **Innovation Platform in Medical and Healthcare Technologies** (*Plataforma de Innovación en Tecnologías Médicas y Sanitarias*, ITEMAS) promotes innovation in the hospital environment and facilitates the transfer of knowledge

to the productive sector. Its main tool is the creation of Innovation Support Units in hospitals, which provide the necessary resources and support services to healthcare professionals that aim at turning their ideas and discoveries into new technologies that can ultimately the market (ITEMAS, 2021[102]). ISCIII also launched three **support platforms for research in health science and technology** (*Plataformas de apoyo a la investigación en ciencias y tecnologías de la Salud*). One of them[99] specifically aims at enhancing the innovativeness capacity of the NHS sector and promotes the transfer of the research and innovation developed by the NHS to the tech and pharma sectors. The 2020 call had a total budget of EUR 27.4 million.

Infrastructures

Another way of promoting interactions across actors is by creating shared infrastructures, such as research labs or demonstration facilities, which could be partly funded by the private sector. In Spain, the so-called **unique scientific and technical infrastructures** (*Infraestructuras Científicas y Técnicas Singulares*, or ICTS) are leading publicly-owned R&D facilities that, individually or by coordinating several installations, provide services for pioneering research, as well as for the transmission, exchange and preservation of knowledge, transfer of technology, and promotion of innovation. These infrastructures are unique or exceptional in their field, and have a high investment and/or maintenance and operation cost that is justified by their strategic nature for the R&D community. They are open to competitive access by users in the entire research community, both form the public and private sector. There are currently a total of 29 ICTS, made up of 62 infrastructures located across Spain (ICTS, 2019[103]). Infrastructures are often set up as public consortia as they involve different public administrations and benefit from institutional funding contemplated in their annual budgets.

For instance, the Barcelona Supercomputing Centre was established in 2005 and is a public consortium formed by the Spanish government, the Generalitat de Catalunya and the Universitat Politècnica de Catalunya - BarcelonaTech (UPC). Its mission is to conduct research, develop, manage and transfer technology and knowledge from the field of high processing computing with the aim of facilitating progress in different scientific areas, with particular focus on Computer Science, Life and Environmental Sciences and Engineering. The ratio of public institutional to public project funding was in 2018 close to 5 for both transfers from the central government (which accounts for over 50%) and the Catalan regional government. Revenue from external service provision to firms, etc. accounts for close to one fifth of total revenue.

Assessment

At the central government level, programmes-based support for knowledge intermediaries has been limited to the Cervera programme for technology centres, S&T parks and the Innovative business clusters support programme described above. It is more difficult to assess what it is the overall contribution through institutional funding to knowledge intermediaries which also play a role as R&D performers or are located within them (e.g. TTOs). There is a lot to be learned in terms of how the central government supports knowledge intermediation, which does not only entail direct financial support but also in kind assistance, such as training for knowledge transfer professionals, the creation of spaces for intermediaries to exchange and collaborate, or the development of soft guidelines and codes of conduct. Changes in institutional incentives for HEIs and PROs

[99] The platform is called "Revitalisation and innovation of the industrial capacities of the NHS and their effective transfer to the productive sector". The other two are the platform for biobanks and biomodels, and the platform to support clinical research.

(e.g. making part of their funding conditional on knowledge transfer results) could increase the resources and ensure the continuity of support to their knowledge transfer offices (TTOs). Our analysis reveals a somewhat extreme compartmentalisation of sponsors to beneficiaries that gets reflected in the design of programmes, which are probably too customised to the official classification of the targeted beneficiary. Our conclusion is to recommend paying greater attention to what different actors can meaningfully do rather than how they have been officially labelled in the many registers maintained by Spain's central government. It is advisable to allow different types of actors to compete in parity for support opportunities, regardless of which ministry is formally in charge of their sponsorship.

Box 17. Public-private partnerships to finance joint research centres

Research Campus (Germany)

The general objective of the "Research Campus: Public Private Partnership to Foster Innovation" is to support large-scale and long-term cooperation between science and industry. A Research Campus comprises three criteria: it merges private and public research competences at a single location, it has a medium to long-term perspective and builds on a reliable public-private partnership. Yearly budget of around EUR 10-20 million. Each research campus receives up to EUR 2 million of public funding per year for a period of up to 15 years. In addition, the activities of a research campus not funded by the programme must always account for a larger percentage of the total budget. The Research Campus competition was launched in 2011. Following the selection in September 2012, 9 Research Campuses are currently being funded for a period of up to 15 years (up to 2027). The Research Campuses represent a new type of research structure where researchers from universities, research institutes and companies work "under one roof". Several companies should be part of a Research Campus, including SMEs; but large (multinational) companies are drivers in most cases. Each of the 9 Research Campuses currently in place has between 13 and 23 industry partners. Various forms of organisation and contracts are established suiting the specific demand of each Research Campus.

Collaborative Laboratories (CoLABs) (Portugal)

The programme was initiated in 2018 to promote more intense science-industry collaboration through public-private partnerships. CoLABs are private, non-profit foundations or private companies that integrate activities of research units of higher education institutions, public research laboratories, intermediate organizations, companies, and business associations. With a high share of private funding (>50%), they focus on performing market-driven research and on providing professional R&D services to industry. CoLABs must meet the challenge of enhancing the density of knowledge-based activities in the country by fostering the consolidation of collaborative practices between scientific, technological or higher education institutions and the social and economic fabric, namely businesses, the hospital and health care system, cultural institutions, and social organizations. A total of 35 CoLABs have been established to date, mobilizing 120 private firms.

Source: Guimón (2019[98]) and Corado-Simões (2020[104])

Regarding infrastructures, Spain already counts with a rich network of research infrastructures and technology centres that are mostly publicly funded with a mix of

institutional and programme/project based support. More could be done to increase the engagement of the private sector in both funding and using such types of infrastructures. In this regard, experiences from other countries provide useful references from which lessons can be extracted (Box 17). Research Campus in Germany and Collaborative Laboratories (or CoLabs) in Portugal are examples of joint-labs where universities and firms work under one roof over the long term, and a high share of their funding comes from the private sector. This kind of programmes could contribute to stimulating the emergence of joint university-industry research centres, which as discussed in section 3.2.2 have been very scarce to date in Spain.

While research infrastructures are well developed throughout the country, some stakeholders highlighted the need for more demonstration facilities where firms can test how new technologies could best be integrated in their facilities. Such demonstration facilities could be specifically targeted at SMEs. The *Mittelstand* 4.0 Competence Centers in Germany, for instance, help SMEs become aware of, test and adopt Industry 4.0 technologies and sector-specific applications (e.g. 3D printing, sensors). These demonstration facilities are often located at universities and allow simulating business and production processes in a real-world environment (Competence Centres, 2018[105]). Pilot factories have also been set up in several Austrian universities (TU Wien, TU Graz and Johannes Kepler University Linz), where SMEs have the chance to test new technologies and production processes without having to affect production in their facilities (Mattauch, 2017[106]).

Some testing facilities already exist in Spain. For instance, the CLaMber plant is a biorefinery demonstration plant in Castilla-La Mancha that provides services for companies to perform scaling tests, optimization of bioprocesses, development of new bioproducts, studies of technical and economic viability and training in terms of material recovery of biomass. The plant is a public facility created in 2015 by the Castilla-La Mancha Regional Institute for Research and Development in Agrifood and Forestry (IRIAF), and co-founded by the ERDF programme and the Ministry of Economy (Interreg Europe, 2017[107]).

Finally, before developing new infrastructures, it is important to analyse if existing infrastructures are fit for purpose, and invest in them in priority, providing them with more resources for the acquisition of new instruments or technologies and/or contracting more researchers. Before engaging in new infrastructure investments, it is critical to ensure a long term allocation of funding to cover the maintenance, running and human capital costs of such facilities.

4.4.6. Supporting the creation of S&T-based start-ups and spin-offs

Central government programmes can implicitly support the transfer of knowledge from the PSR to business through their support for activities in newly created enterprises, including those originating through different channels from the PSR.

CDTI has deployed two initiatives in this area with a specific focus on technology-based start-ups, which need not necessarily be academic spin-offs: the NEOTEC and the INNVIERTE programmes.

The **NEOTEC programme** supports the creation and consolidation of technology-based start-ups through project-based support for new business projects requiring the development of new technologies based on internal R&D activities. When the programme was created in 2002 it provided repayable loans but after it was significantly reformed in

2014[100] it focused on providing grants. Grants of up to EUR 250 000 are provided to innovative SMEs (Box 7) for a period of 1 or 2 years, to cover up to 70% of project costs. The programme had a budget of EUR 25 million in 2020 (CDTI, 2020[108]), which has increased to EUR 36.4 million in 2021.

The **INNVIERTE programme**, created in 2012, promotes business innovation by supporting venture capital investment in technology-based or innovative companies. In 2019, the programme launched a co-investment initiative open to investors regulated by the Spanish Securities Market Commission (CNMV), such as venture capital firms, investment companies, and other professional investors. This initiative has two pillars:

- Process of approval of professional private investors specialised in technology, which concludes with the signing of a co-investment agreement between them and Innvierte;
- Co-investment (jointly with approved private investors) in technology-based companies that are in line with Innvierte's investment strategy. Innvierte acquires company shares of a value of a minimum of EUR 500 000 and a maximum of EUR 10 million. The total investment in a single company is of EUR 15 million. On average, there are around 10 to 15 co-investments every 3 months, and the average period of permanence in the companies is of between 3 to 5 years.

The programme also aims to support venture capital vehicles specialised in technology transfer with sufficient critical mass to be able to promote the projects in which they invest in the different stages of business development (CDTI, 2020[109]). Since its creation in 2012, Innvierte has invested in 79 companies in direct co-investment, as well as in 14 venture capital entities acting as a fund of funds (as of July 2021).

Enisa, under the responsibility of the Ministry of Industry, Commerce and Tourism, is the main public entity supporting innovative entrepreneurship through risk financing in Spain. Since its creation, Enisa has granted participative loans to more than 6 000 companies and invested more than EUR 1 billion (as of December 2020). In 2020, it supported 506 operations amounting to EUR 83.4 million (Ministerio de Industria, Comercio y Turismo, 2021[110]). Enisa broadly focuses on innovative entrepreneurship, and includes a line of financing for technology-based companies, but its instruments do not specifically target technology- or science-based academic spin-offs and start-ups. The same ministry is also responsible for the Fund in Support of Productive Industrial Investment, a loan, equity participation and hybrid support system for projects up to EUR 60 million aimed at supporting the creation of new industrial establishments and the implementation of new production lines and production processes. The 2021 call foresees an investment of up to EUR 600 million. It is unclear at present the extent to which technology centres are involved in supporting such projects.

In July 2021, the Ministry of Economic Affairs and Digital Transformation launched the Next Tech Fund – a new public-private venture capital fund aimed at mobilising EUR 4 billion (of which EUR 2 billion worth of public funds) to support high-growth technology-based companies (La Moncloa, 2021[111]).

Assessment

These initiatives are significant elements of support for S&T-based entrepreneurship. The public-private co-investment mechanism (Innvierte) is also critically contributing to build

[100] This reform recognised the challenges of newly created firms in generating positive clash flows to repay the loans.

the internal capabilities of the public administration (CDTI) to invest in this field, which is essential if these mechanisms are to be scaled-up, given the high risk involved in their operations.

In spite of these mechanisms and other initiatives implemented by intermediary organisations (e.g. The Collider, Tecnalia Ventures, CaixaImpulse), for early-stage start-ups and spin-offs access to finance (seed capital) remains a major challenge in Spain, although there are differences across sectors: seed and VC capital investments are mainly directed towards the digital and biotech sectors, while there is a significant deficit of funding for deep tech ventures. The establishment of public-private seed capital funds could help address such deficit. The Recovery, Transformation and Resilience Plan for 2021-23 envisages the implementation of measures that go in this direction (see section 6.1.2).

4.4.7. Indirect business financial support measures for knowledge transfer and collaboration

Two other major types of policy instruments are being implemented in Spain to support innovation: R&D tax incentives and public procurement of innovation solutions. While not directly targeting science-industry engagement, they have the potential of indirectly promote such linkages (or even directly, if some adjustments where introduced in their design). This section outlines their main features and implementation challenges that would need to be addressed to effectively encourage science-industry collaboration.

R&D tax incentives

Spain provides R&D tax relief through a hybrid tax credit and a partial exemption on employers' social security contributions (SSC) for qualified research staff (Table 8). Both incentives are mutually exclusive, except for innovative SMEs, as expenditures claimed for researchers under one scheme are not eligible for the other. In the case of insufficient income tax liability, unused tax credits can be carried-forward for 18 years or obtain a refund at a 20% discount one year after the tax credit was generated. Ceilings apply to refunded credits and the amount of R&D tax relief for firms in any profit situation (OECD, 2021[112]).

Table 8. Main design features of R&D tax incentives in Spain, 2020

		Tax deductions for R&D*		Social security exemption**
Tax incentive* **		Tax credit		SSC exemption
Type of instrument		Hybrid (volume-based and incremental)		Volume-based
Eligible expenditures†		Current, Machinery & Equipment (ME), intangibles		Labour
Headline rates (%)		Volume: C: 25, +17 (R&D staff); ME & Intangibles: 8	Increment (on top of volume): C: 17	40 (Full-time research staff)
Refund		One year after the tax credit was generated (optional at 20% discount)		Redeemable against payroll/related taxes
Carry-over (years)		18 (carry-forward)		n.a.
Threshold	Base amount	Average R&D expenditure in the preceding two years		n.a.
Ceilings	R&D tax relief	25% of gross tax liability if the tax relief for R&D and technological innovation equals or is less than 10% of the tax due; else the cap is increased to 50% of the gross tax due		SSC liability
	Refund-specific	EUR 3 million***; raised to EUR 5 million when R&D expenses exceed 10% of turnover		-

Note: * This tax incentive also applies to technological innovation with a tax credit rate of 12%; to qualify for the refundable tax credit, firms need to meet certain requirements (e.g. maintain the average number of R&D&I staff for up to two years from the end of the tax period the credit was generated), see OECD R&D Tax Incentive Compendium. **: SSC: Social Security Contributions for full-time researchers, including temporary staff and interns (minimum tenure of 3 months where staff member is fully dedicated to R&D projects; up to 15% of time may be at most allocated to certain activities like training). *** The ceiling of 3 million applies to R&D and technological innovation deductions. **** Spain also offers an accelerated depreciation of machinery and equipment and intangibles (immediate write-off) as well as buildings (straight-line depreciation over 10 years) used in the process of R&D. In addition, Spain provides an income-based tax incentive for outcomes of R&D activities. This incentive is beyond the scope of this note. For more details, see OECD R&D Tax Incentive Compendium and Eligibility of current and capital expenditure for R&D tax relief
Source: OECD (2021[112]), based on OECD R&D Tax Incentive Database, http://oe.cd/rdtax, March 2021

Despite the implementation challenges discussed below, the tax incentive is one of the most appreciated policy support instruments for business innovation. The special tax regime of the Basque Country has allowed its regional government to introduce an additional tax incentive within its territory, comprising an additional 20% tax deduction for R&D expenditure subcontracted to universities, public research institutes or technology centres. Other regions (Navarra and the Canary Islands) also offer additional R&D tax incentives, but these do not provide additional tax deductions for collaborative activities. Overall, Spain offers one of the most generous tax incentives provisions (i.e. on paper) among OECD countries, despite the decline in the generosity of the R&D tax credit regime over the 2000-19 period. However, businesses (especially SMEs) often find it complex to navigate and insufficiently attractive, which results in a system that is underused by business. AIReF (2020[84]) evaluates the Spanish R&D tax incentive system in more detail and makes a number of proposals consistent with the feedback gathered throughout this study and previous OECD work.

Unlike the 2014 ERAC report, which was rather critical of tax incentives for Spain's innovation system, our assessment does not recommend a reduced emphasis on this instrument, as that would be significantly detrimental to the weakest elements of the innovative system. However, fine tuning reform on its implementation aspects is possible and desirable to make the most of this type of instrument with its opportunities (open to all firms, non-discretionary and theoretically bureaucracy light) and its limitations. An efficient and accessible R&D tax incentive regime would enable Spain's business to have a reliable broad ranging support platform encouraging a more systematic business engagement in R&D and innovation activities, particularly within traditional sectors. This would be the basis for greater demand from graduates with R&D capabilities and outsourced services from the PSR. Such basis would be eventually conducive to the more demanding step of establishing formal collaborative relationships with the PSR.

Introducing additional tax deductions for collaborative R&D activities, following the example of the Basque Country, could also be considered. This could potentially encourage further collaboration with public research institutions but could be at the expense of reducing engagement with commercial knowledge intermediaries that might not be included in such a lists. Given the current complexity of Spain's R&D tax incentive implementation, enhanced deductions targeted towards collaboration could potentially detract from the key objective of simplifying the system in order to help strengthen business knowledge creation, application and absorptive capabilities. Instead of providing an additional financial incentive, one approach could be to streamline the approval and auditing requirements for expenditures subcontracted with universities, PROs and CTs, easing the current system of technical reports ("*informes motivados*") used to verify the compliance of declared internal R&D plans.[101] A more detailed evaluation of the Basque tax incentive could be useful in future debates to redesign the national R&D tax incentive system.

R&D procurement and public procurement of innovative solutions

In November 2018, CDTI created the Office for Innovative Public Procurement (*Oficina de Compra Pública Innovadora*, OCPI) with the main objective of promoting **pre-commercial public procurement** (PCP) of R&D services connected to final demand by government.[102]

Through this initiative, co-financed with ERDF funds, CDTI will acquire R&D services that may result in prototypes of products or services that are technologically innovative and meet public needs. The prototypes developed will be transferred to the Spanish Public Administrations interested in them, for them to validate the proposed technology in a real world environment. As a first step, in 2019 CDTI published a call for expressions of interest for innovative solutions oriented to public demand in order to collect proposals from potential R&D service providers, preferably companies, that could constitute a repository of ideas for future tenders (CDTI, 2021[113]).

Since 1985, the Ministry of Defence runs an R&D procurement programme (COINCIDENTE[103]) that seeks to apply civil technologies to defence related projects. Interestingly, all types of organisations allowed to provide services to the public sector can apply, including universities, business and their associations, private non-profit research centres. The ministry funds from 20 to 80% of the eligible development costs, which creates room for the service provider to retain a significant part of the intellectual property generated through the work without incurring in state aid. COINCIDENTE operates through annual calls, which were interrupted from 2014 until they resumed in 2018 with a greater focus on a reduced number of technologies and applications. The 2021 call focuses for instance in energy storage, decontamination, explosives detection and soldier support robotics.

[101] More information about technical reports for RTDI tax deductions in Spain can be found at: https://www.ciencia.gob.es/portal/site/MICINN/menuitem.7eeac5cd345b4f34f09dfd1001432ea0/?vgnextoid=dc5a12c94d364410VgnVCM1000001d04140aRCRD

[102] Pre-Commercial Procurement (PCP) challenges industry from the demand side to develop innovative solutions for public sector needs and it provides a first customer reference that enables companies to create competitive advantage on the market. PCP enables public procurers to compare alternative potential solution approaches and filter out the best possible solutions that the market can deliver to address the public need.

[103] See https://www.tecnologiaeinnovacion.defensa.gob.es/es-es/Presentacion/ImasD/Paginas/Coincidente.aspx

Other existing instruments include the **INNODEMANDA programme,** launched in 2012 by CDTI to support the supply of innovative technological solutions in public procurement processes (CDTI, 2020[114]); and the **INNOCOMPRA-Linea FID programme**, launched in 2011 by the Ministry of Science and Innovation, to support public bodies of the autonomous regions in the development of innovative projects capable of generating innovative public procurement contracts. As part of this programme, the Ministry of Science and Innovation and the Ministry of Health collaborate in the implementation of the **programme for demand-driven innovation in health** (*FID Salud*).

These instruments have been complemented by the publication of guidelines, innovation public procurement awards, the provision of legal advice in these area, and the organisation of other promotional activities. Spain is also part of the European project **Procure2Innovate**, aimed at improving institutional support for public procurers implementing innovation procurement, and promoting the exchange of good practices and successful experiences among the 10 participating countries (CDTI, 2020[115]).

After several years, the implementation of public procurement for innovative solutions in Spain is still incipient and presents significant challenges, both for the administration and businesses interested in participating in tenders. Public procurement of R&D or goods and services requiring R&D presents a key opportunity for private-public collaboration and engaging relevant expertise from within the PSR in multiple roles, for instance concerning the assessment of technological need, maturity and capability of service providers. OECD (2017[116]) explores good practices in procurement for innovation across OECD countries that can provide useful guidance to inform the Spanish policy and regulatory approaches in this area. In the case of Spain, the implementation of innovation demand policies represents a major opportunity for increasing intra-government coordination and raising the profile of innovation policies in light of its potential to assist the whole of government in fulfilling its role when doing so requires adopting technologies and processes that are relatively novel, disruptive and uncertain. Like for other areas, it is important that this policy is supported by effective evidence and careful analysis since perceived procurement failures can be particularly detrimental to the innovation agenda and induce overly conservative approaches in public procurement. The authorities should pay specific attention to the effective inclusion of this innovation policy area within the SICTI information system.

4.4.8. Assessment of the policy mix for knowledge transfer at the central government level

The policy instruments described in this section jointly constitute the policy mix implemented by the central government level of Spain to support knowledge transfer and collaboration. This section provides a synthesis of its main strengths and weaknesses. The assessment is in line and complements other previous analyses, such as the one conducted by Sanz-Menéndez and Cruz-Castro (2020[117]) (see Box 18). The current direct support instruments for R&D collaboration, principally based on loans (to companies) and grants (to knowledge generating institutions principally in the public sector), have promoted linkages across actors but suffer from some weaknesses that should be addressed in priority and appear to be the focus of recent investments and reforms to be discussed in Section 6, namely a) lack of effective attractiveness to actors, owing to bureaucratic and design barriers; b) excessive segmentation of support instruments to beneficiaries under ministerial and agency sponsoring arrangements; c) limited use of institutional funding for advancing consortia; d) limited support options for mobility and critical phases for transition to higher technological readiness levels; e) excessive focus on individuals versus institutional financial incentives

Box 18. An assessment of the policy mix for knowledge transfer in the case of Spain: a recent analysis based on OECD STIP Compass database

A recent study by Sanz-Menéndez and Cruz-Castro (2020[117]) draws on the OECD-EU STIP Compass database and stakeholder interviews to analyse the policy mix used to enhance knowledge transfer and science-industry relationships (KT in short) in Spain and other seven countries. Key messages cover three areas:

Strategy and priorities: The authors argue that the overall KT strategy is not well defined within the overall STI policy, and despite having a more prominent position in general innovation policy after gaining momentum in the last decade, the concept of KT is somewhat vague and relatively a low priority for many stakeholders, for example compared with boosting low levels of private R&D investment. Policies have historically focused on intermediary KT organisations. Recently, mobility and engagement at personal level have become more salient topics, with the consideration of additional performance incentives to public sector researchers to orient their production towards the market. Challenges identified refer to the need to address low motivation of public sector researchers to engage in KT, improving the functioning of TTOs at universities, and engaging SMEs in KT activities.

KT policy instruments: Spain reports 20 single-instrument KT initiatives in the STIP Compass, pointing to a possible situation of policy fragmentation. The focus of instruments may be limited since only 20% are targeted to a single group, and 50% to two or three. Firms are the most prominent target group, present in 60% of the initiatives, followed by research institutions in 40% and researchers and intermediaries both in 35% of cases. Stakeholders interviewed by Sanz-Menéndez and Cruz-Castro tend to view that large firms benefit the most from policy initiatives and programmes aiming at collaborative research. On the business demand side, they also point that administrative burdens prevent SME from making effective use of theoretically generous R&D tax incentives, which in the majority of the territory do not include additional provisions to encourage engagement with the public system of research. Sanz-Menéndez and Cruz-Castro point out that while financial instruments are deemed most effective, Spain is an outlier in citing guidance and regulatory instruments as significantly more prominent (63%) than direct financial supports instruments (21%), owing to the adverse budgetary landscape of the last decade. Instruments to support collaborative public-private R&D, such as the CENIT projects, were abolished and have since not been replaced with fully comparable programmes. The CIEN programme, targeted to financing large private R&D projects through business-led consortia, has been smaller in scale and places lower requirements for contracting with public research entities.

Responsibilities for strategy and implementation: Sanz-Menéndez and Cruz-Castro argue that lack of coordination and possible saturation are likely consequences of a long tail of executive agencies in charge of instruments. They also highlight the implications of a decentralized political structure and the overlapping competences between central and regional administrations, which may result in loss of coherence and fragmentation. In their view, policy targeting can be increased and reliance on regulatory measures diminished, given widespread perception that the general regulatory framework for R&D is ill-suited for enabling KT and stakeholders calls for greater policy stability and predictability. Policy evaluation would also have to become better embedded.

Source: Adapted from Sanz-Menéndez and Cruz-Castro (2020[117])

The lack of attractiveness of several support instruments for enterprises is illustrated by the fact that a significant part of the budgets earmarked for support in the form of loans are not disbursed. The national budgeting exercise should provide a much better approximation to the actual outturn than it has been in the past. Complex application procedures and long processing contribute to reducing the effectiveness of the support system.

With the exception of the challenges - collaboration RDI projects and the new projects in strategic areas, the direct beneficiaries of such instruments are companies or technology centres, while universities and public research centres can participate only as subcontractors and not as equal partners. This hampers the establishment of closer partnerships and the generation of long-term linkages. The discontinuity of support over time and changes of name, focus or eligibility criteria, together with the existence of programmes with similar objectives at different levels of government (European[104], national, regional), can be a source of confusion for potential beneficiaries, especially SMEs, which calls for greater efforts in communicating these programmes.

Moreover, the Spanish authorities should look beyond consortia projects of limited duration and consider the potential establishment of joint research and technology centres, with long-term research agendas, well defined knowledge transfer mandates and adequate institutional funding and legal frameworks, particularly in light of how these have they gained in importance in other European countries (e.g. the CoLabs programme in Portugal or Research Campus in Germany). Such approaches should clearly consider how best to leverage on existing institutes and facilities, while considering which institutional arrangements would be most appropriate for central government controlled PROs given current asymmetries. An in-depth independent review of the OPI framework and broader state-controlled PRO system, should provide a range of options for the government to decide on a long-term strategy for "centres".

Another stakeholder demand concerns the request support instruments to support the advancement of the technology readiness levels (TRLs) of technologies developed in universities and public research centres. The launch of proof-of-concept projects by the AEI in 2021 responds to this perceived gap. This new instrument can benefit from lessons learned from the implementation of similar programmes in other countries; initiatives implemented at regional level or driven by private foundations can also provide lessons. These efforts should be accompanied by measures to increase the visibility of each institution's technological capabilities, so that they can be easily identified by potentially interested companies.

Policy instruments to promote research staff mobility, in particular the industrial doctorates and the Torres Quevedo contracts for doctorate holders, are highly appreciated by all actors in the system. However, the industrial doctorate programme is relatively small (although similar programmes exist at regional level) and resources for Torres Quevedo contracts have decreased significantly in recent years. The in-depth evaluation of these programmes is a priority in order to better understand the conditions for their success (e.g. what types of prior linkages needs to be in place) as well as their long-term impact on researchers' careers and their links with companies, identifying specific areas for improving their implementation. Moreover, the introduction of entrepreneurship education courses at all levels of university education (from undergraduate to doctoral studies) and in all academic disciplines (including the "basic" sciences), as well as the possibility for students to spend

[104] An important role for central government support policies is to facilitate Spanish participation in EU and internationally funded programmes.

time in industry during their studies (e.g. dual education programmes) would also contribute to fostering mobility and long-term university-business linkages.

The knowledge transfer and innovation *sexennium*, introduced as a pilot in 2018, recognises and encourages knowledge transfer activities among teaching and research staff at universities and public research centres. The first pilot presented a number of conceptual design challenges and operational implementation problems (e.g. lack of clarity in the criteria for the evaluation of applications, long processing times) which ANECA is seeking to address as a priority in the next call. This instrument, which has no equivalent at international level, can contribute to progressively promote a greater transfer culture among researchers in Spain, as the research *sexennium* did in the past. It is worth asking whether the basic concept applied to both research and knowledge transfer could be structured in a different way to have a greater incentive effect per unit of public expenditure, for example, by considering for how long the bonus is received once past merits have been accredited, and not artificially limiting the number of six-year periods that can be achieved. This analysis coincides with previous external recommendations about the importance of considering incentive mechanisms at the institutional level, as focusing exclusively on individual incentives may have some undesirable effects (Box 19).

Box 19. Individual versus institutional incentives for knowledge transfer and collaboration

A possible undesirable effect of individual-level incentives such as the knowledge transfer *sexennium* is that they result in KT activities that are uncoordinated, developed at sub-optimal scale and unsupported by the institutions in which researchers work, accentuating the current conflicts over the sharing of the burdens and benefits of knowledge transfer. In line with the 2014 recommendations by the expert panel of the European Research Area, a priority for reforms is to consider the introduction of institutional funding mechanisms. These should be partly linked to the achievement of results that are consistent with the missions and strategic objectives of such institutions. Institutions could then use the leeway provided by KT funding to strengthen their transfer capacities and provide them with the necessary resources to carry out their functions, as well as to reward researchers and other staff internally who contribute to transfer results, not only in terms of salaries, but also providing them with better support services, or with the possibility to hire assistants and purchase equipment.

While the availability of a broader set of knowledge transfer indicators such as those developed by the Ministry of Science and Innovation can greatly facilitate this vision, it is also important to consider the importance of introducing complementary qualitative evaluation components to avoid falling into reductionist approaches that distort incentives towards what can be measured quantitatively. This could also encourage experimentation in the generation of evidence to support evaluation processes. The experiences documented in research and technology centres in Catalonia and the Basque Country provide relevant examples within Spain (see next section).

5. Regional policy and institutional models for knowledge transfer and collaboration

5.1. Diversity and experimentation

Although scientific research policy in Spain is an exclusive competence of the central government according to the Spanish Constitution of 1978, over the years many autonomous regions have adopted a more active role in this policy domain based on their own budgets, capacities and strategies (OECD, 2011[118]). Regional governments have followed a "subsidiarity" logic to policy intervention by complementing national initiatives or undertaking new policies and investments that they considered fundamental to their regional development strategies (Borrás and Jordana, 2016[36]), making up for perceived shortcomings at the national level as well as attending to their specific regional needs and preferences. While innovation policy was initially considered mainly a responsibility of the regions within their local development agendas, the central government is particularly active in this policy area but in a somewhat scattered fashion, for instance through the funding provided to innovative projects by national agencies like CDTI and ENISA as well as several other industrial and sectorial policy programmes.

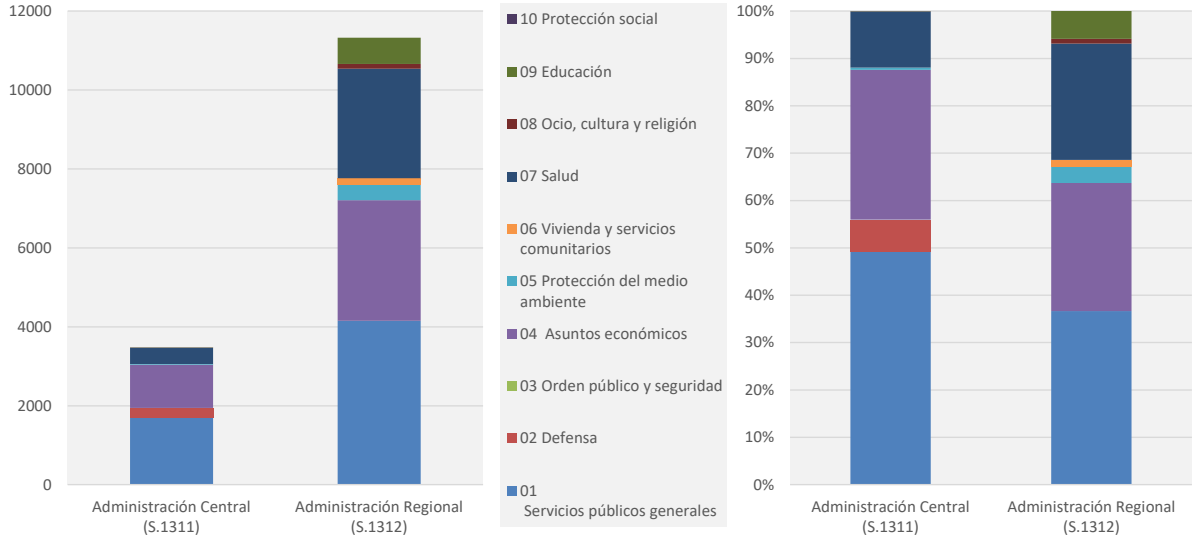
In fact, in recent history the division of competences in science and innovation policies has been a recurrent subject of debate, with continuous claims for further decentralisation by some regions, within a broader context of highly politicised and even confrontational central-regional relations (OECD, 2010[38]). Science and innovation policies in Spain are a shared responsibility between central and regional levels, which creates synergies and complementarities but also leads to duplication, fragmentation and coordination challenges. Therefore, any policy analysis of science-industry cooperation in Spain needs to carefully consider the regional dimension and the national-regional policy interfaces. This also applies to a very large part of the recommendations in this report, which require the concourse of the regions for the effective implementation.

It is beyond the scope of this study to give an accurate portray of the different regional systems, something that would require 17 additional reports, which would contain highly relevant examples that could be considered as best practices but most importantly would characterise the diversity of policy choices made with regards to priorities. Our emphasis is therefore on a few key core elements.

While not entirely consistent with official R&D statistics of budget support for R&D previously reported (Figure 23), data from Spain's national accounts provide useful insights about the relative role of central and regional administrations in connection to different objectives as implied by the Classification of Functions of Government (COFOG). Figure 56 shows that institutions at regional level account for three quarters of total final general government expenditure on R&D. The profile of central government expenditure is more geared towards general public services (which includes basic research as a sub-objective) and defence, whereas regional governments dedicate proportionally a higher level of final R&D expenditure to health and education (absolute and relative) and economic affairs (in relative terms only), reflecting their devolved competences.

Figure 56. National accounts estimates of government expenditure on R&D, by level and function of government, 2019

Totals (EUR) and shares within level of government category



Note: Final government expenditure in the R&D sub-items of the top level government functions has been separately identified and reported. These figures do not coincide with published domestic official R&D budget statistics (GBARD) for a number of reasons driving potential misalignment between reporting systems such as the treatment of European funds which are excluded from GBARD. The local level has been excluded since values are negligible in comparison (EUR 82 million).
Source: OECD analysis based on Spain's National Accounts data, extracted from: https://www.igae.pap.hacienda.gob.es/cigae/Cofog.aspx

Although differences in the intensity and scope of regional innovation policies prevail (Box 20), a certain degree of convergence can also be observed in terms of policy instruments used when experiences in some regions or even abroad are perceived to be successful or at least promising. This can be interpreted as a process of policy diffusion, peer-learning and imitation, not only amongst Spanish regions, but also *vis-à-vis* other European regions (Knill, 2005[119]). Some of the regional policy initiatives to promote science-industry cooperation are similar to national policies, leading to fragmentation and duplication, while others are clearly complementary. The remainder of this section discusses some of the most relevant interface points of regional and central innovation policy for knowledge transfer and collaboration.

Box 20. The diversity of regional innovation systems in Spain

Despite the general trend towards a greater involvement of regional governments in science and innovation policies, there are large differences in the scale and scope of such policies driven by income inequalities across autonomous regions, by the heterogeneity of regional industrial specialization patterns, and by their different institutional profiles and political aspirations. Some regions such as Catalonia and the Basque Country have a stronger industrial base, while in others such as Madrid and Andalusia the share of services is much higher. As discussed in Borrás and Jordana (2016[36]), different typologies of regional innovation systems co-exist in Spain, including some old industrial regions lacking knowledge diversity (e.g. Basque Country), metropolitan regions with problems of fragmentation in their capabilities (e.g. Catalonia and Madrid), and peripheral regions with problems of organizational thinness (e.g. Andalusia and Galicia). More from a political perspective, some regions such as Catalonia and the Basque Country have pushed for a more decentralized approach and have gained increasing responsibilities in this policy area, while others have focused on complementing (rather than replacing) national policies.

With regard to regional innovation policy approaches, Sanz-Menéndez and Cruz-Castro (2005[120]) differentiate between those following an "academic approach" (i.e. focusing on funding universities and public research centres) and those following a "business approach" (i.e. focusing on funding innovative firms and technology centres). They find that most Spanish regions have traditionally followed an academic approach, with the exception of the Basque Country that implemented a business-oriented approach from the outset relying strongly on technology centres, following an acute industrial crisis in the 1970s. However, they also document attempts to shift towards a more business-oriented policy in some regions (Catalonia in the 1980s, Andalusia and Galicia in the 1990s), which was nevertheless limited due to path-dependence and the dominant influence of well-established academic communities (Sanz-Menéndez and Cruz-Castro, 2005[120]). More recently, the shift towards the business approach has accelerated across all regions under the influence of European cohesion policies that require the adoption of smart specialization strategies to receive regional development funds (González-López, 2020[121]). As part of this shift, Regional Development Agencies across Spain, which act as the implementation body for smart specialization strategies, have become increasingly active in promoting business innovation, typically through the development of R&D grants, innovation vouchers, start-up support schemes, technology centres and science and technology parks (EURADA, 2020[122]).

5.2. Sponsorship of technology centres

The development of and support for technology centres by regional governments represents one of the main instruments of regional innovation policy in Spain, complementing their support for and oversight of public universities. As previously explained, as formally characterised in the Spanish legislation, technology centres recognised in the entire territory are non-for-profit organisations (typically private associations or foundations) that conduct applied research and provide technological services to firms.[105] They often have strong

[105] As previously indicated, it is this latter feature of primarily serving businesses that results in them being classified as part of the Business sector despite their legal form or lack of direct profit motive.

relationships with universities, mainly from their regions, to complement their applied research and technological activities with the more basic research conducted at universities. Some technology centres exhibit a marked degree of industrial specialisation connected to their territory while others have a more "generalist" profile.

Typically, 60% of their budget comes from private sources (membership fees and sales of services); 30% competitive public funding (from European, national and regional R&D funding programmes); while 10% originates from non-competitive public funding (this contrasts with the "ideal" 30/30/30 model adopted in other European countries). The latter comes mainly from regional governments that have decided to provide core institutional funding to their region's technology centres, but this is not the case in all regions. Between 2000 and 2008 the central government provided funding to foster the development of technology centres, but this was interrupted in 2008, with the advent of the financial crisis, and centres' programme-based sponsorship was left at the discretion of regional governments. As noted in the previous section, in 2019, the central government, through CDTI, launched the Cervera programme, with two lines of funding support: one addressed to firms that develop innovative projects in collaboration with technology centres, and another addressed to fund new strategic R&D.

The case of Tecnalia, originating in the Basque Country, was described in some detail in section 3.4 as part of the description of Spain's science and innovation system and its KTC performance. Similarly to Tecnalia, Eurecat originates from the merger of the most important technology centres in Catalonia, a process that started in 2015 and is still underway. However, its relevance in the regional innovation system is not as important as Tecnalia's.[106] Other Spanish regions such as Andalusia, Castile and Leon, Galicia, Navarra and Valencia have also developed well recognised technology centres, albeit characterised by a smaller size and external recognition beyond Spain's borders.

Most of these smaller technology centres are sector-oriented, specialising in specific industries of strategic importance in their territories, with a particular focus on SMEs and interacting almost exclusively with regional actors. In addition to this rather vital role, they also play an important function linking territories with large firms and foreign-owned multinationals.[107] There are also some regions that have not followed this model and currently lack technology centres or their presence is rather minimal, among which the case of Madrid is particularly noteworthy. Table 9 shows the disparate distribution of technology centres across the Spanish territory. It is also worth noting that some hybrid models at the crossroads of business driven innovation promotion agencies and technology centres have emerged in recent years with a focus on developing science-industry links, such as Andalusia's CTA (Box 21).

[106] Tecnalia's budget represents over 10% of business sector R&D in the Basque Country, while Eurecat's stands below 2.5% of Catalonia's equivalent (Salazar-Elena et al., 2020[65]).

[107] For example, the Automotive Technology Centre of Galicia (CTAG) has collaborated closely with PSA group in the development of new technologies, coordinating the upgrading of capabilities across regional universities and supplier firms, which has contributed to the continuation and expansion of PSA's plant in the region.

Table 9. Technology centres by autonomous regions

Technology centre participating in the ETCI study

Autonomous region	Technology centres
Andalusia (3)	Fundación para las Tecnologías Auxiliares de la Agricultura; Fundación Centro Tecnológico Acuicultura de Andalucía ;Fundación I+D del Software Libre
Aragon (2)	Fundación CIRCE Centro de Investigación de Recursos y Consumos Energéticos; Fundación AITIIP
Asturias (4)	Fundación CTIC Centro Tecnológico para el Desarrollo en Asturias de Tecnologías Informac. y Comunic.; Asociación de Investigación de Industrias Cárnicas del Principado de Asturias; Fundación ITMA - Instituto Tecnológico de Materiales; Fundación PRODINTEC
Basque Country (7)	Asociación Centro Tecnológico CEIT-IK4; Fundación TECNALIA RESEARCH & INNOVATION; IKERLAN S.COOP.; Fundación Centro de Tecnologías Aeronáuticas; Fundación AZTERLAN; Asociación de Empresas Tecnológicas INNOVALIA; LORTEK, S.COOP.
Cantabria	Fundación Centro Tecnológico de Componentes
Castile-La Mancha	Asociación para la Investigación y Desarrollo Tecnológico de la Industria del Metal de Castilla-La Mancha
Castile and Leon (4)	Fundación CIDAUT; Instituto Tecnológico de Castilla y León; Fundación Centro Tecnológico de Miranda de Ebro; Fundación CARTIF
Catalonia (3)	Acondicionamiento Tarrasense – LEITAT; Fundació EURECAT; Fundació privada i2CAT, Internet i Innovació Digital a Catalunya
Community of Madrid	Fundación para la Investigación, Desarrollo y Aplicación de Materiales Compuestos
Extremadura	Asociación Empresarial Centro Tecnológico Nacional Agroalimentario Extremadura
Galicia (9)	Asociación Nacional Fabricantes Conservas Pescados y Mariscos - ANFACO-CECOPESCA; Fundación Instituto Tecnológico de Galicia; Asociación de Investigación Metalúrgica del Noroeste; Fund. para la promoción de la innovación, investigación y desarrollo tecnológico en la industria de automoción en Galicia; Fundación Centro Tecnolóxico de Telecomunicacións de Galicia; Fundación Centro Tecnolóxico de Eficiencia e Sostenibilidade Enerxética; Fundación Centro Tecnológico de Investigación Multisectorial; Fundación Centro Gallego de Investigaciones del Agua; Cluster de la Acuicultura de Galicia, S.C.
La Rioja (2)	Asociación para la Investigación Desarrollo e Innovación del Sector Agroalimentario Asociación para la Promoción de la I+D+i Tecnológica Industrial del Calzado y Conexas Rioja
Navarre (4)	Asociación de la Industria Navarra; Fundación LUREDERRA; Centro Nacional de Tecnología y Seguridad Alimentaria; NAITEC - Fundación I+D Automoción y Mecatrónica
Region of Murcia (6)	Asociación Empresarial de Investigación Centro Tecnológico Nacional de la Conserva; Centro Tecnológico del Mueble y la Madera Murcia; Asociación Empresarial Centro Tecnológico de la Energía y del Medio Ambiente de la Región de Murcia; Asociación Empresarial Centro Tecnológico Naval y del Mar; Asociación Empresarial Centro Tecnológico del Metal Región de Murcia CTMETAL; Asociación Empresarial de Investigación Centro Tecnológico del Mármol, Piedra y Materiales
Valencian Community (11)	Asociación Investigación Industrias del Calzado y Conexas (INESCOP); Asociación de Investigación de la Industria del Juguete, Conexas y Afines; AINIA; Instituto Tecnológico Metalmecánico, Mueble, Madera, Embalaje y Afines; Asociación de Investigación de las Industrias Cerámicas; Instituto Tecnológico del Embalaje, Transporte y Logística – ITENE; Instituto de Biomecánica de Valencia; Asociación de Investigación de la Industria Textil; Instituto Tecnológico de la Energía; Instituto Tecnológico de Informática; Asociación de Investigación de Materiales Plásticos y Conexas

Note: This is not a comprehensive list of CTs and CTAIs as it only includes those providing information to the Ministry of Science and Innovation.
Source: SICTI Indicators of knowledge transfer and innovation based on ETCI survey. Ministry of Science and Innovation.

Box 21. Technological Corporation of Andalusia (CTA)

CTA was founded in 2005 as an initiative of the Andalusian Regional Government. It is a private foundation that works to promote innovation in Andalusia and currently comprises more than 160 member companies (up from the initial 40 founding members). For every euro provided by companies as membership fees to fund CTA, the Andalusian government commits to provide an additional euro. However, the management of CTA is in the hands of member companies, since the large majority of the governance board is held by those companies. There are three categories of member companies, with different membership fees (15 000, 60 000 or 250 000 euro) that bring along different levels of participation in the governance bodies of CTA. With membership fees and matching funds provided by the regional government, CTA currently provides a total of around EUR 8 million annually to R&D projects developed jointly by firms and regional universities. Since it is a private foundation, CTA can provide grants in a more flexible manner. Indicatively, the average time to evaluate proposals is below 8 weeks. In addition to its competitive project financing role, CTA offers a wide array of complementary services to businesses, universities, technology centres and public administrations, including strategic R&D advice; evaluation of innovative initiatives; support for the internationalisation of R&D; consultancy in processes involving public procurement of innovation; and support for technology scouting and studies. These services are offered on preferential terms to member companies. In recent years, CTA has also worked closely with Andalusian universities, providing support to their technology transfer offices to facilitate their links with companies. CTA does not feature as a nationally-registered CT and self-describes as multisectoral business cluster.

Source: Interview with managers of CTA and https://www.corporaciontecnologica.com

Following the example of Tecnalia and Eurecat, there are various initiatives underway in other Spanish regions aimed at merging technology centres or developing different kinds of strategic alliances, aimed at avoiding duplication and attained a higher critical scale to be able to provide better services in a more efficient fashion. The network approach is indeed adopted in several other European countries (see Box 22). However, these alliances are principally taking place only within regions, not across them. Arguably, this type of initiatives should be driven by more of a sectoral or market-based logic. It is worth noting that, for example, there are seven technology centres across Spain specialising in the agro-food sector, but there is no plan underway to realise synergies across them. The fact that each belongs to a different regional administration seeking to preserve its own identity and cater to rather concrete specificities should accelerate rather than prevent the exploitation of such synergies. Without necessarily moving towards effective cross regional mergers, there is a clear need for more ambitious consolidation effort between similar lines of research undertaken independently by the different technology centres. This is precisely one of the objectives of the abovementioned Cervera programme for technology centres (see section 4.4.5). One suggestion for SICTI would be to attempt to provide a mechanism for illustrating the actual degree of and potential for greater interconnectivity across centres in terms of financial flows, services and joint project participation.

Box 22. Technology centres in Germany and the United Kingdom. Fraunhofers and Catapults compared

Fraunhofer-Gesellschaft in Germany is the well-known technology centre model which has been recently partly imitated by the United Kingdom through the so called Catapults in response to the perceived need to provide a bridge between the research base and industry. Unlike the Catapults, individual Fraunhofer institutes do not have a direct relationship with the German government. Whereas Innovate UK allocates budget to each Catapult, Fraunhofer-Gesellschaft HQ negotiates its overall budget with the Government, then uses an algorithm to allocate core funding annually to each institute. This algorithm accounts for factors such as number of employees, industrial income, and EU income.

While the Fraunhofers and Catapults both use a funding model where approximately one third or their funding should come from – respectively - public funding, commercial work, and collaborative R&D, this is implemented differently. The 'thirds' model is aspirational for the Catapults, but the Fraunhofer algorithm is finely tuned to incentivise the right amount of industrial work – too much or too little will result in less government funding.

The Fraunhofers are fully evaluated every five years using expert panels. Each institution writes a detailed document explaining its technical strategy along with commercial, financial and other information. The document is shared with two industry and two academic experts, who then hold an in-person evaluation with the Fraunhofer over several days. If a Fraunhofer is considered not to be performing well enough, Fraunhofer-Gesellschaft can put it on special measures to help it improve. When a Fraunhofer is performing well, its annual budget will be set using the algorithm and it will be left for the year to deliver its strategy. This differs from the Catapults, which are given a 5-year funding agreement by Innovate UK, based on a strategy and delivery plan. The Catapults then report quarterly against their KPIs and these quarterly reports can be used to trigger enhanced performancemanagement if necessary. In 2017, Innovate UK used review panels to assess the seven longest-established Catapults, which supported 2018-2023 funding decisions, along with economic evaluations. This review process has not been formally embedded into Catapult evaluation.

A key lesson from the Fraunhofers is that formal governance, monitoring and evaluation do not need to constrain organisations. While the Fraunhofers are subject to annual budget reviews, these can be done in a single day and are part of a clear and consistent process. The five-yearly evaluations genuinely help the Fraunhofers assess and improve their own performance through the involvement of academic and industry experts. Fraunhofer-Gesellschaft has put governance and systems in place that finely tune the tensions between the Fraunhofers' work with industry and universities, so that the benefits are realised without barriers being introduced.

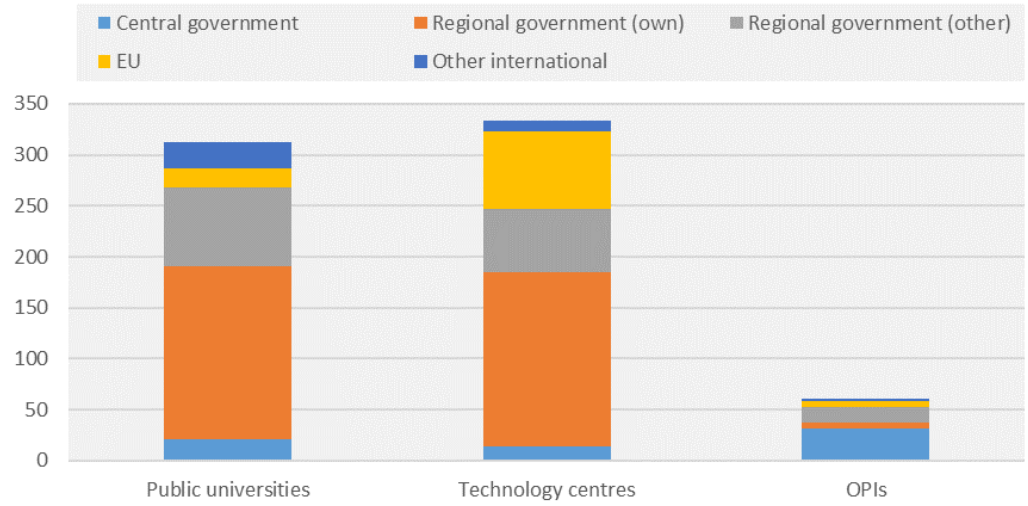
Source: Adapted from BEIS (2021). Catapult Network Review. BEIS Research Paper Number 2021/013 https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/975595/catapult-network-review-april-2021.pdf

Technology centres play a critical role as intermediaries of science-industry relations in Spain, but they suffer from some limitations. They have the advantage of being set up as private associations or foundations, which gives them more operational flexibility than other public sector intermediaries such as universities' technology transfer offices while this entitles them to receive public support on more favourable terms. However, their financing structure, with relatively little predictable institutional funding support, makes

them very reliant on project-based funding, in contrast to other European CTs.[108] This compels them to actively bid not only for private customers but also for publicly (European, national and regional) funded resources, often in competition with other types of PROs. Figure 57 shows, based on data from SICTI, how CTs compare to public universities and OPIs in terms of contract-based revenue sources. The similarity in volumes and distribution of sources with public universities is rather striking for organisation with a different ethos and organisational set-up, asides from the CTs comparative greater success at obtaining EU funds. The latter appears to be connected with CTs success in participating in contract-based EU programmes, presumably concentrated in a small number of CTs.

Figure 57. Value of contracts for R&D and innovation activities in public universities, PROs and technology centres, 2018

By type of organisation and contracting body



Note: Values do not include amounts perceived for collaboration projects.
Source: SICTI Indicators of knowledge transfer and innovation based on ETCI survey. Ministry of Science and Innovation.

A concern raised by some stakeholders is that this situation with scarce and relatively unpredictable institutional effectively pushes CTs in the direction of competing for lower TRL projects (research) with more abundant funding levels, thus resulting in a potential redirection away from higher TRLs in which they can leverage on their technical competences and proximity to the market. Universities and CTs can often find themselves both competing and collaborating with each other for project based funding. Technology centres need to act as bridging organisations, combining their capabilities in applied technological research with the frontier research capabilities that universities and public research centres are better placed to provide. The compartmentalisation of project funding streams by type of actor is not the solution as that can hinder productive competition. Co-ordination could be improved by heightening mutual participation of each type of organisation in their mutual governing bodies and through strategy setting and planning at regional and national level.

[108] According to 2008 reported figures in the Hauser Review, the core institutional funding from government was 70% for AIST (Japan), 33% for TNO (Netherlands), 35% for Fraunhofer Institutes (Germany), 10% for GTS (Denmark); Carnot centres (France) accumulated 59% for public support from both public project and institutional funding, and only 26% for ETRI in Korea (Hauser, 2010[148]).

An important challenge for CTs when acting as business- and market-oriented knowledge brokers is to avoid conflicts with their interest to sell their own technologies and technical know-how, to generate trust among companies uncertain about undertaking an innovation-driven strategy. This risk needs to be more explicitly recognised and governance mechanisms and alliances put in place, as we saw in a number of cases, to convey to firms that CTs will effectively support them in finding the most appropriate technological solutions to their needs wherever they can be sourced. Public authorities, national and regional, should consider in a coordinated fashion the financing approaches best suited for preventing excess competition for low TRL project-based research funding.

5.3. Sponsorship of public universities

The general governance of public universities and the role of society has already been discussed at some length in section 2, while features of public universities' KTC activities have been extensively covered in section 3. This subsection covers for greater completeness the role played by regional governments in facilitating the KTC role of public universities in their territories.

The Universities Code provides access to the range of available dedicated university laws in Spain (Table 10). While a detailed analysis of the specificities of each autonomous region's legislation is beyond the scope of the study, it is worth noting a number of common elements:

- Regional legislation transpose national university legislation (2011 law) with some significant variations in few instances (e.g. career tracks for academics in Catalonia) although there are limited effective differences when it comes to knowledge transfer activities.
- Regional governments and universities assume responsibility for the adoption of measures that promote KTC, allowing universities to establish programmes and develop structures and entities with that object in mind.
- There are small differences in the provisions about the composition of University Social Councils as the organs for societal participation in university life within the margins of the national legislation.
- Some autonomous regions set up regional university coordinating and advisory bodies, and in general, the financing and control procedures foresee that universities develop periodic (4-5 years generally) university plans as condition of their institutional funding. Only a few also make reference to the possibility of complementary performance related funding and, by a large, with a number of exceptions, references to institutional evaluation are rather weak.

Table 10. Autonomous regions with dedicated university laws, 2021

Autonomous region	Name and links
Andalusia	Ley Andaluza de Universidades
Aragon	Ley de Ordenación del Sistema Universitario de Aragón
Balearic Islands	Ley de organización institucional del sistema universitario de las Illes Balears
Basque Country	Ley del Sistema Universitario Vasco
Canary Islands	Ley de Reorganización Universitaria de Canarias
Catalonia	Ley de Universidades de Cataluña
Castile and Leon	Ley de Universidades de Castilla y León
Community of Madrid	Ley de Coordinación Universitaria de la Comunidad de Madrid
Galicia	Ley del Sistema Universitario de Galicia
Region of Murcia	Ley de Universidades de la Región de Murcia
Valencian Community	Ley de Coordinación del Sistema Universitario Valenciano

Source: Spain's University Code. https://www.boe.es/legislacion/codigos/codigo.php?id=133&nota=0&tab=2

In addition to the specific legislation, several autonomous regions have in place sectorial plans for their regional university system, often mandated by the former, or plans set within their regional science and innovation strategies. Some of these plans stand out for the mix of concretion and ability to connect resource availability to expectations on universities to engage in collaboration with businesses (Box 23).

Box 23. Business-university relations in the Basque University System Plan

The Basque Government's University System Plan, the region's strategic planning instrument for the sector, represents an interesting and comprehensive example for articulating the role of business-university relations within an autonomous region. The plan considers university-business relations as a key channel for the economic and social transformation of the Basque Country, having in place a dedicated University-Business strategy since 2017 (EVUE 2022) focused on two main elements:

- Create and transfer knowledge based upon scientific excellence, applied to the local economy
- Train highly qualified human capital, adapted to the local business needs.

The strategy sets goals for 2022 taking 2016 as a baseline, with the plan foreseeing EUR 118 million (close to one-third through own resources, one-third competitive public funding and one third contracts) over a three-year period in support of the various elements under this part of the plan that requires Basque universities, among other things, to:

- undertake strategic planning and actions connected to the Basque R&D and innovation smart specialisation strategy (RIS3);
- plan their offer of degrees to ensure better alignment, ensuring business participation in their design;
- work towards implementing a dual university training system;
- train business tutors, to ensure effective internships and training opportunities for students;
- develop their own university-business strategies;
- enhance the commercialisation of knowledge generated;
- plan for the development of capacities that allow them to obtain resources through contract with third parties

In addition to the core institutional funding for the system, the plan incorporates 3 so called programmatic contracts, one of which corresponds to the theme University-business-society. The University-Business resources (annual EUR 1.7 Million over 4 years) are split into 9 different actions, which provide considerable clarity to universities in their planning.

Source: Basque Government (2019). Basque University System Plan 2019-22. https://www.euskadi.eus/contenidos/plan_gubernamental/10_planest_xileg/es_plang_10/Plan_del_Sistema_Universitario_2019-2022.pdf

At the level of universities, there does not appear to be a common repository of strategic university plans to facilitate comparisons and assessment of technology transfer and collaboration strategies. A 2013 study (García-Aracil, 2013[123]) identified very frequent references to knowledge transfer and societal impact in universities' missions and to a lesser extent in their stated future visions, exceeding those strictly related to the university's research function. However, this was not matched by a comparable number of references within priority strategies. While the count of initiatives and indicators is by no means representative, this situation is illustrative of a situation in which universities present themselves as contributing to their social milieu but struggling to articulate how to

effectively go about it. For this reason, it is important that national and regional governments provide the appropriate governance framework and incentives to allow universities to introduce effective plans that include collaboration with business as well as social and economy oriented knowledge activities within their strategies, activity and reporting.

5.4. Support for science and technology parks

Although initially developed as regional initiatives, since 2000 the central government launched specific policy programmes to support the development of the parks' infrastructures as well as targeted finance for innovative projects undertaken by firms or institutions located within the parks. However, since 2015 (following the 2008-2014 financial crisis) those national support programmes stopped, and as of today there are no specific policies or funding at national level to support science and technology parks. Regional funding was also severely cut due to fiscal adjustments, which challenged the survival of some parks that had not developed sustainable business models. Against this background, an open question is whether the central government should now partner with regional governments to co-fund specific initiatives to support science and technology parks, particularly considering their capacity to act as intermediary organizations that may catalyse large scale projects which could benefit from new streams of funding such as Next Generation EU. Another issue to consider is that the support provided by parks to start-ups coexists and to a certain extent overlaps with the growing number of accelerators and incubators that have emerged in recent years under the axes of large corporations, universities, technology centres and regional or local governments. In order to address this fragmentation and enhance synergies, one of the priority areas of the recently released Spain Entrepreneurial Nation Strategy[109] is to create a National Entrepreneurship Office to coordinate and organise all existing entrepreneurship support services, in collaboration with public and private actors.

5.5. Regional development of public research centres

Since the mid-2000s, Catalonia, the Basque Country and Madrid have launched new programmes to develop and fund public R&D centres outside universities, with a stronger focus on research (particularly basic research) than in the case of regional technology centres, but still closely aligned with strategic industries and societal needs in what one may describe as an applied research orientation or vertically integrated perspective as in the case of the CNIO and CNIC. Catalonia was the first autonomous region to establish its so-called CERCA centres in 2005, currently comprising a total of 40 research centres across a variety of scientific disciplines. Following the experience of Catalonia, the Basque Country established its network of 9 Basque Excellence Research Centres (BERCs) and 7 Cooperative Research Centres (CIC). CICs were created to build scientific capabilities in the Basque sectoral strategies (such as bioscience, energy and nanoscience) while BERCs conduct more basic research in transversal knowledge areas like mathematics, language or climate. Finally, the regional government of Madrid has also invested, since 2007, in creating a new network of seven research institutes under the Madrid Institutes of Advanced Studies (IMDEA) programme, each specialising in a different strategic area (water, food, energy, materials, nanoscience, networks and software). Compared to Catalonia, there a fewer such centres in the Basque Country and Madrid and they are aligned with a narrower set of strategic sectors and technologies.

[109] https://www.lamoncloa.gob.es/presidente/actividades/Paginas/2021/110221-sanchez_ene.aspx

The regional government funding provided annually towards these centres ranges from EUR 20 million in the case of Madrid's IMDEA to around EUR 120 million in the case of Catalonia's CERCA. In the case of IMDEA, this core funding represents around 50% of the centres' overall budget, while in CERCA it represents around 25%. The rest of the budget comes from competitive public funding (from European, national and regional programmes) and private sources of funding (including contracts and fundraising).

These research centres are playing a key role in terms of scientific production in their regions and are contributing remarkably to the attraction of international talent and European funding as result of their formal legal structure and in some cases to regional specific legislation, as discussed further below. In addition, a shared objective of these initiatives is to integrate science-business cooperation as an explicit part of their missions, thus placing scientific excellence on a par with knowledge transfer. Indeed, these centres are expected to conduct excellent research of international standards while collaborating closely with the business sector. To articulate those links with industry, the centres' governing boards include representatives from business that participate in the definition of research agendas, in the evaluation of projects and even in the selection of personnel. Interestingly, in the case of Madrid, in more recent years it was decided to include in the board of all seven IMDEAs representatives from the regional ministries in charge of those thematic agendas, as part of a horizontal view of science and innovation policies that tries to better align research agendas with societal needs.

Another common element of these programmes is the aim to improve the flexibility of the operations of research centres, avoiding the excessive bureaucracy and complex governance structures that typically characterise research centres of universities and public research institutes. For this purpose, they are set up as independent bodies outside universities, with their own legal entities (foundations in Catalonia and Madrid; associations in the Basque Country), and are expected to comply with international standards of excellence in research (Beato and Mas-Colell, 2012[124]). However, researchers working in these centres are often allowed to maintain a double affiliation at universities, which contributes to ensuring an intense cooperation between different research groups working on similar topics from universities and from the new centres. For example, many senior researchers at the Centre for Genomic Regulation (CRG), one of the most prominent CERCA centres, are also affiliated as professors with the Pompeu Fabra University, even though their employment contract is with CRG. This brings along mutual benefits such as the possibility of CRG researchers to participate in the university's Doctoral programme and share credit for their outputs. This is possible because their publications must include both affiliations, which benefits the university's indicators of scientific production. Moreover, CRG and Pompeu Fabra have jointly invested in shared facilities and scientific equipment to the benefit of both institutions. Similarly, some CERCA centres have strong links with national public research institutes, such as the Catalan Institute of Nanoscience and Nanotechnology (ICN2), where CSIC participates in its governance board, contributes to its annual budget, and offers CSIC researchers to work within ICN2.

It is also worth noting that these centres have established more agile procedures to create spin-off companies, circumventing bureaucratic barriers at national level. For example, the Catalan government has delegated on each CERCA's governance board the capacity to approve new spin-offs originating from the centre, whereas at national level an approval from the government is necessary before creating a spin-off from a public research centre.

Research centres belonging to these regional networks are subject to a common operational model, a strategic planning framework and a close evaluation from the regional government, often including a performance-based funding system. In the case of Catalonia, a qualitative model based on international peer review panels has been set up to evaluate

both the research excellence and the socioeconomic impact of the CERCA centres (Box 24).

Box 24. The evaluation model of CERCA research centres in Catalonia

CERCA research centres are evaluated every four years by an international panel of experts, in an evaluation system that is inspired in international practices such as the German Max Planck Institutes and the UK Research Excellence Framework. Based on those evaluations, centres are ranked from A to D. Those that obtain an A are granted an incentive in the form of additional funding that they can use at their discretion (EUR 5 million in the last round for all centres that obtained an A). Those ranked with a C or a D are asked to abandon the CERCA network and stop receiving baseline funding.

In addition to this performance-based funding system, the evaluations are important as a source of learning for the centres, since the assessment reports from the international panel experts include recommendations for improvement. Indeed, an essential feature of the system is the regular advice and assessment from a top-level international scientific committee that ensures that they comply with international standards of excellence in research. The evaluation system considers both research excellence and knowledge transfer. All centres are asked to provide a document describing their policies towards spin-offs and intellectual property, as well as a detailed description of their five most impactful projects or outputs. This is followed by on-site visits by the panel of experts, including meetings with the centre's managers and interviews with researchers or staff members. The evaluation panel then drafts an assessment report including recommendations. Thus, the evaluation relies mainly on qualitative indicators, narratives and case studies, and deliberately avoids setting quantitative targets of any kind.

Source: OECD elaboration, based on interview with director of CERCA and https://cerca.cat/

In the Basque Country, all centres are evaluated every 4 years based on a common scorecard of indicators comprising research excellence, technology transfer, international collaboration and outreach activities, but each centre negotiates through a contract with the Basque government the target indicators that it will focus on among those available in the scorecard, depending on its strategy. The evaluation system also includes qualitative assessments from a scientific panel that visits the centres and engages in in-depth interviews with its managers and staff. This kind of evaluation systems that consider not only research excellence but also socioeconomic impact offer an interesting learning model that could inspire reforms at national level. For example, it would be worth exploring the possibility of introducing a similar system within the Severo Ochoa programme.[110]

In addition, the Catalan innovation agency, ACCIÓ, provides the so-called TECNIO label to the research centres and groups more active in technology transfer in the region, offering firms the opportunity of identifying them easily through a website (see Box 13 in section 3.4.3)[111]. There are currently around 60 centres holding this label in Catalonia.

Other regions, such as Galicia, have adopted different models, opting for providing additional baseline funding on a competitive basis to the best research groups within public

[110] The Severo Ochoa programme, active since 2011, provides earmarked funding on a competitive basis to Spain's best performing research centres.

[111] https://www.accio.gencat.cat/en/serveis/innovacio/tecnologia-per-a-lempresa/tecnio/index.html

universities. The programme began in 2008 and has ran several calls since, currently providing earmarked funding to a set of 8 "strategic research groups" and 7 "singular research centres", with the former more clearly focussed on addressing the region's socioeconomic needs and the latter more focussed on scientific excellence. In contrast with the abovementioned approach adopted by the Basque Country, Catalonia and Madrid, the Galician model is more embedded with existing practices, building on universities' existing systems (rather than replacing them), but providing selected research groups with more autonomy and with additional baseline funding over the long term conditional on a performance-based evaluation system (Pereira-Puga and Sanz-Menéndez, 2020[125]). The initial selection of the centres and the subsequent evaluations are primarily based on research excellence, but also consider indicators of knowledge transfer and the alignment of their research agendas with the region's smart specialization strategy. The Galician government has complemented this policy programme with other initiatives, such as the Oportunius programme focusing on the attraction of foreign researchers holding ERC grants.

5.6. Financial support for collaborative projects

Many regions offer **competitive grants for collaborative R&D projects** involving firms, universities and public research institutes, complementing those available at national level from CDTI. In Catalonia, for example, the RIS3CAT Communities programme provided 72 million euro in grants from 2013-2020 to 13 consortia, comprising firms and public research centres that embrace joint R&D projects lasting 3 years and focusing on some of the challenges set forth in the Catalan research and innovation strategy for smart specialization (RIS3). Likewise, Madrid launched the Innovation Hubs Support scheme in 2018 with a EUR 20 million budget over a period of 4 years, targeted to consortia of large firms with at least one SME, one start-up and one university or public research institute. The Basque country also offers different kinds of support schemes and competitive grants to collaborative R&D projects between firms and universities or research centres located in the region. For example, in its 2021 edition, the so-called Elkartek programme provides a total of EUR 40 million to support collaborative research between actors of the Basque science and innovation system in a set of designated strategic areas (intelligent manufacturing, energy and health). The Hazitek programme also offers competitive grants to collaborative projects, with a broader thematic scope and a stronger focus on firms. Similar initiatives, albeit with lower budgets, are present in other regions, such as Galicia ("Unidades Mixtas de Investigación"), Cantabria (INESNOVA) or Andalusia (IDEA collaborative grants).

Regional support schemes have increasingly emphasised the **proof of concept stage** of R&D projects, in line with recent developments at national level (see section 4.4.1). For example, in 2015 the regional development agency of Asturias, IDEPA, launched the Primas Proof of Concept programme in collaboration with the University of Oviedo. Selected projects from the university's research groups, focussing on the priority areas of the region's smart specialization strategy, are co-financed at 50% by IDEPA and by an "anchor" firm participating in the programme. Those anchor firms are typically some of the largest firms operating in the region, including some large multinationals (e.g. Arcelormittal and Thyssenkrupp). In the three editions of the programme to date, a total of 41 proposals have been presented and 12 have been selected for funding. Following the early success of this programme, IDEPA plans to expand it over the coming years.

Another kind of open innovation subsidies are **innovation vouchers**, consisting in small financial grants for firms to purchase R&D or technology-related services from researchers from universities or public research institutes. These are typically addressed to SMEs and

may include different kinds of services such as technology diagnostics, process improvement, digital transformation, technology road-mapping, product development, etc. In some cases, these services can only be contracted from pre-selected (or certified) research groups or consultants. This kind of innovation vouchers can have a strong contribution on knowledge transfer to SMEs and are being provided by many regional governments, including Andalusia, Asturias, Basque Country, Cantabria, Catalonia, La Rioja and Madrid.

5.7. Talent mobility programmes

Regional governments in Spain have also put in place specific policies addressed to the mobility of human capital as a key mechanism to foster science-business links. On the one hand, in addition to the national industrial doctorate programme (see section 4.4.2), many regional governments have created specific support schemes to stimulate industrial doctorates in their territories, including Andalusia, Basque Country[112], Catalonia, Madrid, Navarre and Valencia. Some of these programmes alone, such as Madrid's, have a larger budget and fund more doctorates per year than the national programme. As noted when referring the central-government schemes of this sort, it is important to evaluate and share the experience of these different national and regional programmes, in order to identify good practices and to explore possibilities for converging towards similar rules and application processes.

On the other hand, several regions have launched specific programmes to **attract foreign talent**, on top of those available at national level.[113] Through these programmes it becomes possible to compete for international talent and to facilitate the return of scientists that had emigrated abroad, offering more attractive salaries, circumventing regulatory barriers, and dodging the usual inbreeding of universities and the favouritism for local candidates. Again, Catalonia was the pioneer in Spain in this regard, with the establishment of the Icrea programme in 2001. Following the successful example of Icrea, in 2007 the Basque government launched a similar programme called Ikerbasque. Other regions such as Andalusia, Galicia, Madrid and Valencia have also established similar initiatives over more recent years. Altogether, national programmes offer around 600 contracts per year, while regional programmes an additional 225 combined (Candela and Mas-Colell, 2020[126]). A visible benefit of these programmes consists in attracting international research funding, particularly from the European Commission and the European Research Council.

Although talent attraction programmes are usually based on research excellence criteria, they also **consider the capacity of candidates to engage with industry** as part of the selection criteria and, increasingly, they are targeting specific research fields aligned with smart specialisation strategies. For example, in the Basque Country, Ikerbasque fellows are evaluated every three years and, besides indicators of scientific production, one of the blocks of the evaluation system includes indicators of knowledge transfer such as patents or spin-offs. It has been found that on average one spin-off company is created for every ten Ikerbasque fellows, a much higher proportion than for typical researchers in the Basque science system. This suggests that they have a disproportionate contribution not only to scientific publications and competitive funding, but also to socioeconomic impact. It is also

[112] In the Basque Country, the so-called BIKAINTEK programme is open not only to industrial doctorates, but also to companies that hire PhD holders, as in the case of the Torres Quevedo programme at national level. See: https://www.euskadi.eus/ayuda_subvencion/2020/bikaintek_2020/web01-tramite/es/

[113] National programmes to attract talent include Ramón y Cajal, Juan de la Cierva, Torres Quevedo and Beatriz Galindo, each offering different kinds of contractual arrangements depending on the stage of the researcher's career.

worth noting that in recent years Ikerbasque has launched a number of *ad hoc* calls to hire candidates tailored to specific needs of Basque research centres associated with new demands from Basque firms. Based on these regional experiences, it would be advisable for the national talent attraction programmes to integrate in their selection and evaluation processes new criteria related to knowledge transfer, rather than only focusing on scientific excellence. This would be particularly interesting if national talent attraction programmes are to be expanded in the near future, as recommended by Candela and Mas-Colell (2020[126]). Alternatively, two separate calls within the programme could target research excellence separately from knowledge transfer candidates. Also, there could be a specific window of the Torres Quevedo programme (that funds the employment of doctorate holders by firms) targeted to international candidates with international knowledge transfer experience that could be useful in Spain.

Indeed, new measures to better connect international talent attraction programmes with knowledge transfer should be explored. An interesting experience in this respect is the TECNIOspring programme[114] from ACCIÓ, the Business Competitiveness Agency of the Government of Catalonia (see Box 13 on TECNIO in section 3.4.3). Fellows of TECNIOspring are offered 2-year employment contracts to develop applied research projects with focus on technology transfer. ACCIÓ provides 100% financial support to cover the fellow's salary (up to EUR 58 500), as well as an allowance for research and mobility expenses. Host organizations can be either Catalan research centres or technology-based firms. In the case of fellows hosted by research centres, they need to be seconded to a company already interested in the outcomes of the applied research project. Between 2013 and mid-2021, 136 researchers have been funded and 207 R&D contracts with experienced researchers are expected to be granted for the period 2013-2024.

5.8. Soft policy instruments to foster networking and science-business cooperation

Regional government are also relying on other types of "soft" policy interventions to promote science-industry links, focussing on networking, facilitating relationships, mobilising and building trust. This typically includes outreach activities to raise awareness and provide relevant information; organising events, workshops and fairs that bring together actors from business and academia; and collective roadmapping and foresight exercises. The latter have become increasingly embedded in the policy-making practices of Spanish regional governments, as they form part of the system prescribed by the European Commission to develop smart specialisation strategies. In addition, several regions have developed specific strategies bringing together networks of universities and public research institutes comprising different kinds of activities to promote science-industry knowledge transfer. Examples include the Ignicia programme in Galicia and the T-CUE programme in Castilla y León.

It is also worth mentioning that the organisation of large events, exhibitions and trade fairs bringing together academic and business stakeholders has served as an important catalyser of science-industry cooperation in Spanish regions. For example, in Catalonia, the Mobile World Congress, celebrated annually since 2006, has fostered new linkages between global telecommunications companies and Catalan research groups. In particular, an innovation programme called The Collider has been established as part of the Mobile World Capital Barcelona Foundation, with the broader aim of fostering science-business links and providing support to technology-based start-ups (Box 25). Similarly, in Valencia, following the organization of the Global 5G Event 2019 by the Polytechnic University of

[114] https://www.interregeurope.eu/policylearning/good-practices/item/2421/tecniospring-accio-s-international-talent-attraction-programme/

Valencia, a research group from this university initiated conversations with Huawei that led to the establishment, in 2020, of a new R&D unit financed by this company within the university, with an annual budget of around EUR 1 million euro to develop different research projects related to 6G technologies. Another interesting example is the case of the Foro Transfiere, organized annually in Malaga (Andalusia) since 2011, the biggest professional and multi-sectoral Forum for technology transfer in Spain, bringing together researchers and firms across a variety of industries to exchange new knowledge and develop new contacts.[115]

Box 25. Supporting scientific entrepreneurship: The Collider

The Collider was established in 2016 as the innovation programme of Mobile World Capital Barcelona Foundation as a private-public initiative with the participation of central, regional and local governments, with a focus on connecting scientific and entrepreneurial talent to create disruptive technology-based start-ups. The Collider helps realise deep tech potential by bridging the gap between science, corporates and entrepreneurs. It provides different kinds of support services catering the various stages of start-ups' life cycle, including challenges definition, call for technologies, talent match-making, market validation, piloting and scaling. It is a public-private initiative that works with large corporations to identify their business challenges and create deep-tech start-ups to solve them relying on top-tier scientific and entrepreneurial talent.

In 2020, it developed 40 pilot projects with its 10 corporate partners, involving collaboration with researchers from universities and research centres. It has an annual programme to support the creation of spinoff companies structured around corporate challenges developed jointly with over 100 corporations throughout Spain. In four years, The Collider has contributed to the emergence of 14 technology-based start-ups and has provided training to over 62 institutions, mainly technology transfer offices. It has offered proof of concept and valorisation services to around 200 projects per year. The Collider has also developed a community of scientific entrepreneurs that meet periodically and organise engagement events.

Source: OECD, based on interview with the director of The Collider and https://thecollider.tech

[115] https://transfiere.fycma.com/transfiere-360/,

6. Opportunities for improving knowledge transfer and collaboration in Spain

Having diagnosed in detail the state of knowledge transfer and collaboration in Spain, the next and final question for this report concerns identifying what conclusions can be drawn in terms of reform potential. This section assesses ongoing policy reforms in the field of knowledge transfer and collaboration at the central government level, and identifies some priority areas for further policy action.

6.1. Perspectives on ongoing reforms

Policy activity in the field of science and innovation in Spain has been particularly vigorous over the past months. A new Spanish Strategy for STI for 2021-27 was published in September 2020, which has been followed by the release in June 2021 of the State Plan for Scientific and Technical Research and Innovation 2021-23.[116] A national Recovery, Transformation and Resilience Plan (RTRP) was also released in April 2021, which will allow channelling Next Generation EU funds into the Spanish economy and society, to implement important reforms and investments in a wide diversity of areas between 2021 and 2023, including in the field of STI.

One STI policy area that has received particular attention in recent years is that of knowledge transfer and collaboration, as reflected in the new STI Strategy and State Plan (see section 4.2.2 above) and the RTRP (as explored in section 6.2 below). In February 2021, the Spanish Parliament (Deputies Chamber) approved, with no votes against, a non-binding law exhorting the government to develop a "Roadmap for knowledge transfer" in Spain[117], thus giving a broad based endorsement to this project. Box 26 summarises a number of other developments in the policy landscape relevant for knowledge transfer and collaboration.

Box 26. An intense period of STI policy developments for knowledge transfer and collaboration

At the point of writing this report, a number of recent developments in the policy landscape relevant for knowledge transfer and collaboration include the following:

- **Pact for Science and Innovation**[118], presented in November 2020 and subscribed as of March 2021 by 72 organisations representing the scientific community, universities, business and workers. The document aims to reflect a broad-based agreement on the role of science and innovation in Spain, and includes a series of specific commitments in terms of public R&D investments and human resources. It argues in particular for strengthening policies that support knowledge transfer and business innovation, with a focus on SMEs.

[116] https://www.ciencia.gob.es/site-web/Noticias/2021/Junio/Aprobado-el-Plan-Estatal-de-Investigacion-Cientifica-Tecnica-y-de-Innovacion-2021-2023.html
[117] Find the press release here
[118] https://www.lamoncloa.gob.es/serviciosdeprensa/notasprensa/ciencia-e-innovacion/Documents/2021/040321-PactoCiencia.pdf

- **Reform of the 2011 Law of Science, Technology and Innovation**[119]. This reform aims to reconcile separate provisions of the 2011 Law of STI and the 2011 Law of Sustainable Economy. The reform focuses on three areas: 1) improving the governance and coordination of the Spanish STI system; 2) improving careers in the PSR (career tenure track); and 3) enhance KTC across actors. The latter includes a range of proposals to support the mobility of research personnel and reward researchers that participate in knowledge transfer activities, among others. The proposal went through a process of public consultation (from 24 November to 9 December 2020) as well as a round of bilateral consultations with the main stakeholders of the STI system. Section 6.1.2 explores the KTC-related provisions in detail.
- **Reform of the Organic Law of the University System** ("*Ley Orgánica del Sistema Universitario*", LOSU). In September 2021 a draft proposal for a new Law of the University System was circulated for consultation with stakeholders and parliamentary groups[120]. This reform would modify the 2007 Organic Law of Universities. This draft contains various elements related to university-business knowledge transfer and cooperation. It envisions changes in the governance structure of universities (including a new system for the nomination of members of the Social Council) and changes in the financing system of universities. Section 6.1.3 explores these in some more detail.
- **Component 17 of the National Recovery, Transformation and Resilience Plan (RTRP)**[121]. Measures to be implemented by the Ministry of Science and Innovation as part of the RTRP aim at reforming knowledge transfer instruments to support the creation of innovative start-ups, facilitate the incorporation of doctorate holders in the private sector, consolidate some existing programmes and boost pre-commercial public procurement, among others (Gobierno de España, 2021[127]). Section 6.1.1 explores these in detail.
- **Publication of the "Spain: Entrepreneurial Nation Strategy"**[122] in February 2021, a 10-year plan aimed at spurring innovative entrepreneurship. It contains 50 measures in four main areas: attracting investment; developing, attracting and retaining talent; supporting the scalability of companies; and forging an entrepreneurial public sector, to ensure the public sector offers speedy administration that generates favourable regulatory frameworks, boosts venture capital investment and acts as a lever for innovation (La Moncloa, 2021[128]).
- **Publication of the draft Law on the promotion of the start-up ecosystem (or "Start-up Law")**[123]. The Law aims to recognise the specific nature of emerging

[119] https://www.ciencia.gob.es/portal/site/MICINN/menuitem.8ce192e94ba842bea3bc811001432ea0/?vgnextoid=0319fc086faf5710VgnVCM1000001d04140aRCRD&vgnextrefresh=1

[120] https://www.universidades.gob.es/portal/site/universidades/menuitem.21ef60083f296675105f2c10026041a0/?vgnextoid=660607559eaab710VgnVCM1000001d04140aRCRD

[121] https://www.lamoncloa.gob.es/temas/fondos-recuperacion/Documents/05052021-Componente17.pdf

[122] https://www.lamoncloa.gob.es/presidente/actividades/Documents/2021/110221-Estrategia_Espana_Nacion_Emprendedora.pdf

[123] The draft law on the promotion of the start-up ecosystem, published in July 2021, https://portal.mineco.gob.es/RecursosArticulo/mineco/ministerio/participacion_publica/audiencia/ficheros/210706-APL-START-UPS.pdf

companies (or star-ups) with a high potential for growth, job creation, and innovation. One of the specific objectives of the law is to contribute to increase knowledge transfer between science and business.

- **Publication of the "Spain 2050 Strategy"[124]** in May 2021, a study prepared by a hundred researchers of recognised prestige from diverse academic disciplines with the objective of setting a long-term national strategy for Spain. It includes a number of proposals in the field of science and innovation, including in the area of knowledge transfer and collaboration (La Moncloa, 2021[129]).

These vigorous policy efforts are encouraging for the sector and the overall visibility of the innovation agenda within government and with respect to society as a whole. The represent a unique opportunity to implement necessary regulatory reforms and launching new policy programmes that contribute to addressing a number of the reported gaps and deficiencies in the policy mix for STI policy in general and policies for knowledge transfer in particular. However, past experience shows that it should be accomplished with reasonable caution, mitigating against potential unintended efforts. The remainder of this sub-section describes and summarily assesses two of the main ongoing developments in the STI field with implications for the area of knowledge transfer and collaboration: 1) the national Recovery, Transformation and Resilience Plan (RTRP) and 2) the reform of the Law of Science, Technology and Innovation.

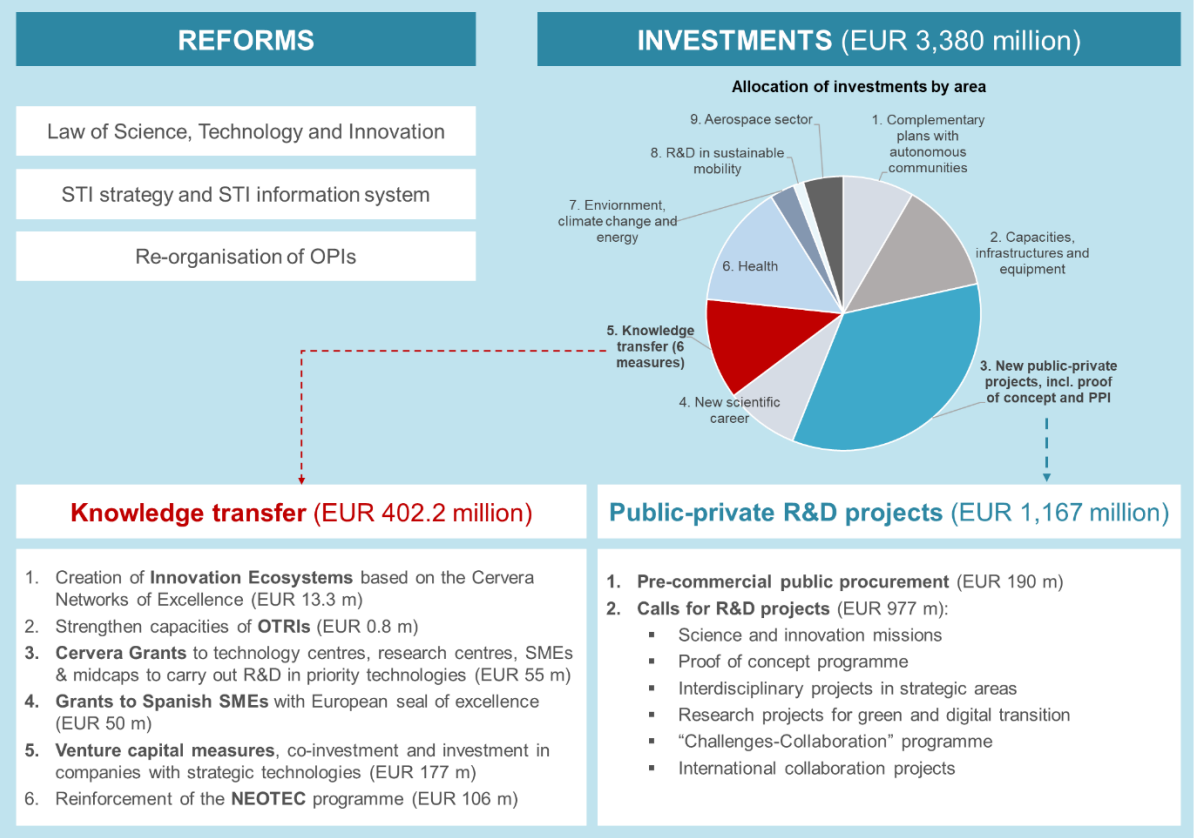
6.1.1. National Recovery, Transformation and Resilience Plan (RTRP)

On 11 May 2021, the Spanish Minister of Science and Innovation presented the component 17 of the Recovery, Transformation and Resilience Plan (RTRP)[125] – the part of the Plan that falls under the responsibility of the Ministry, with a total budget of close to EUR 3.4 billion to be disbursed between 2021 and 2023, presented alongside a number of reforms and policy measures intended to simultaneously increase the system's efficiency. Component 17 thus foresees reforms in three areas –the 2011 Law of STI, the STI strategy and STI information systems, and the re-organisation of central government public research bodies (OPIs in Spanish)– and investments allocated across 9 areas (Figure 58).

[124] https://www.lamoncloa.gob.es/presidente/actividades/Documents/2021/200521-Estrategia_Espana_2050.pdf

[125] https://www.ciencia.gob.es/stfls/MICINN/Ministerio/FICHEROS/Plan_Recuperacion_Transformacion_Resiliencia.pdf

Figure 58. Component 17 of the National RTRP: STI institutional reforms and investments



Source: OECD elaboration based on Gobierno de España (2021[127])

On the investment side, public-private collaboration (area 3) and knowledge transfer (area 5) will be significantly reinforced, with investments of more than EUR 1.5 billion. Overall, these two areas account for close to half of all investments foreseen under component 17 of the Plan. Albeit in a less direct fashion, other areas will also contribute to fostering science-industry collaboration, for example by supporting joint research projects in strategic areas (e.g. in environment, climate change and energy – area 7; sustainable mobility – area 8; or aerospace – area 9), as well as through "complementary plans" co-funded by regional governments (area 1) or investments in new infrastructure and equipment (area 2). Moreover, other components of the RTRP also rely on public-private cooperation (eventually including universities and PROs) to develop Strategic Projects for Economic Recovery and Transformation (PERTE, in Spanish).

Investments on **public-private R&D projects** (area 3) aim at boosting the transfer of research results to society with a focus on priority areas, such as the green and digital transitions, as well as increasing the presence of Spanish research groups in international competitive calls for proposals. Such investments will reinforce some existing instruments (e.g. "challenges-collaboration" programme, science and innovation missions, see section 4.4.1) and enable the creation of new ones (e.g. proof of concept projects, interdisciplinary projects in strategic areas). An important share of the funds will also be allocated to pre-commercial public procurement.

Investments on **knowledge transfer** (area 5) aim to increase the impact of scientific excellence on the productive system and address the investment deficit in support for the creation of science-based start-ups. The planned investments will operate principally by consolidating some existing programmes, incorporating a number of adjustments to

enhance their impacts. For instance, the Cervera R&D transfer projects that previously targeted only technology centres and businesses will now also be open to knowledge generation centres (i.e. universities and PROs), consistently with this report's recommendation to de-compartmentalise as much as possible policy support by type of actors. This call will be coordinated with the industrial doctoral programme and the Torres Quevedo Grants (both under investment area 4) to stimulate the recruitment of doctors in private companies, another area relatively under-financed. The NEOTEC programme, which supports the creation and consolidation of technology-based firms, will also be reinforced and the recruitment of doctors by those firms will be incentivised. Building stronger connections between different policy programmes is a useful way of creating synergies that, in this case, promises to contribute to a much-needed increase in the employability of doctorate holders in the private sector.

In addition to reinforcing existing yet insufficiently financed programmes, a number of new programmes will also be created under this area, including a programme to support the creation of innovation ecosystems based on the Cervera Networks of Excellence; a programme to support SMEs with a European seal of excellence but not mature enough to apply to the EIC Accelerator; and the creation of public-private venture capital initiatives to invest in technology-based firms at very early stages of development (proof of concept, seed funding and early-stage funding). Resources will also be invested in strengthening the capacity of knowledge transfer offices (TTOs, OTRI in Spanish), although the precise instruments and procedures to be used remain to be publicly disclosed at the time of preparing this report. A number of potential recommendations on this subject are provided in section 6.2.5 below.

Assessment

Overall, there is a good alignment between the investments announced and the gaps identified earlier in the report (section 4). The EU funds allow an increase in support towards cash-constrained programmes, as well as measures aimed at allowing PROs (in the broad sense of the term) to participate as partners in collaborative projects, and not only as subcontractors. A number of specific considerations on each of these initiatives are presented in Table 11.

Table 11. Considerations for policy makers to improve the efficacy and efficiency of RTRP investments on knowledge transfer and collaboration

Areas of investment	Considerations
Area 3: Investments on public-private R&D projects (EUR 1 167 million)	• Increases in funding available for collaborative projects should be accompanied by measures to make proposals review and award processes more agile (see assessment of grants and loans for collaborative R&D and innovation projects under section 4.4.1) • The introduction of a proof-of-concept programme responds to a long-standing demand from stakeholders. Lessons from international practices and initiatives sponsored by regional governments or private foundations in Spain should inform this programme. Efforts should also be devoted to increasing the visibility of valorised technologies, so that these can be easily identified by potentially interested businesses. • The legal framework and procedures for public administrations that engage in pre-commercial public procurement should be clarified and simplified, to avoid current legal insecurities and risks. A review of existing regulations would be necessary and should be accompanied by clear operational guidelines for those involved. • Information about the programmes available on the agencies' official websites should be streamlined, up to date, and easily accessible by all actors, especially for those that have never benefited from public funding support. The creation of a one-stop-shop for the dissemination of information about all support mechanisms available should be a priority. • To be effective, the new measures should be accompanied by regulatory reforms that facilitate public-private cooperation, as discussed in section 4.3. The plan however does not include regulatory measures beyond those related to the reform of the STI Law (explored in the section 6.1.2) and complementary activities such as the reinforcement of SICTI and the promotion of the STI Pact.
Area 5: Investments on Knowledge transfer (EUR 402 million)	• Funds invested in the industrial doctorate programme and the Torres Quevedo programme should be increased for them to have effects at scale, as only 61 and 176 contracts were awarded under the 2019 calls, respectively. Resources devoted to the Torres Quevedo programme have significantly decreased over time (from EUR 54 million in 2008 to EUR 15 million in 2020). An increase in funding for these programmes is not explicitly reflected in the Plan as it stands. In the case of the Torres Quevedo programme, some adjustments could also be made to facilitate the period of transition of doctors to the private sector (see assessment of programmes supporting the mobility and industry engagement of doctorate students, including post-docs, under section 4.4.2). The coordination of these programmes with the Cervera and the NEOTEC programmes is a positive step forward although some flexibility should be allowed for highly skilled individuals who may not have attained a doctorate degree. • Strengthening the capacity of knowledge transfer offices should be a key priority, but the RTRP, under its current level of detail, does not provide any specific details about measures to be adopted with that particular goal. Section 3.4 provides an analysis of their main challenges and areas requiring policy support. An important consideration is to bring relevant market and technology expertise into their management, or establish a technical expertise network. • The plan highlights the need to support public-private investments in technology-based firms through the creation of funds and the INNVIERTE programme. However, the plan does not specify the specific channels that will be used and the participation of specialised venture capital firms does not appear to be effectively incentivised (Alcalá et al., 2021[130]) • The plan does not include reforms in the institutional incentive system of universities and research centres aimed at promoting knowledge transfer and collaboration.

Note: The analysis is based on the official document presenting the component 17 of the Spanish National Recovery, Transformation and Resilience Plan, published in May 2021.
Source: OECD own elaboration.

In addition of increases in funding disbursed, it is important to invest in optimising the processes of selection of beneficiaries and disbursement of support. The new programmes outlined in the Plan, and in particular the proof-of-concept programme, the programme supporting start-ups and SMEs with an European seal of excellence, and the creation of a public-private venture capital fund to valorise and exploit public knowledge, respond to long-standing demands from stakeholders and are expected to address some of the most important shortcomings of the system. The expansion of the Cervera programme for technology centres is also promising, offering the opportunity to advance towards new modes of intermediation and mutualised technology transfer platforms along the lines discussed in section 3.4.3. In this sense, some of the new policy instruments to enhance the

capacity of TTOs could be aligned with the Cervera programme, to exploit complementarities and synergies between both initiatives.

To be effective, the new measures should be accompanied by regulatory reforms that facilitate **public-private cooperation**, as discussed in section 4.3 as well as better **coordination between central and regional governments in this area**. The RTRP do indeed provide support for the recently announced **Complementary Plans** under 8 priority programmes that central and participating regional governments co-finance (66% and 34% of EUR 456 million, respectively). Although not strictly speaking envisaged for knowledge transfer and collaboration with business, the joint organisation of these programmes is a welcome initiative that could help reinvigorate the role of the Council for STI Policy, which should not lose sight of the necessary commercialisation or societal use perspective.

Moreover, to ensure that these instruments reach their intended objectives, it is important that information about all support mechanisms available is streamlined and easily accessible to all relevant actors. Awareness raising activities that reach all potential beneficiaries (and in particular for instruments that target SMEs) are also desirable.

As explained above, the effects of these measures will take some time to materialise, and will only achieve their full potential if budgetary commitments are sustained over time. In this regard, the main challenge will be to increase the commitment of the private sector to finance/co-finance such knowledge transfer and collaboration activities, in order to compensate for the eventual phasing out of Next Generation EU.

6.1.2. Reform of the Law of Science, Technology and Innovation: measures related to knowledge transfer

The protection of the public interest is a key consideration for legislative policy reforms in this complex area, as it is not necessarily best served by retaining all ownership over concrete or hypothetical economic results within the public sector institutions that play a role in originating the necessary knowledge. As pointed out at the outset of this report, the effective utilisation of knowledge requires considerable, complementary investments on the part of several actors, private and public, who in order to invest resources and bear risks also need to foresee some reasonable return. It is therefore necessary to have a broader view of what public interest means beyond the narrow sectoral definition of the public sector, while putting in place measures that prevent abuses against which the Spanish public opinion is highly sensitised. The 2011 legislation and other precursors, as described in Section 4 of this report, contributed to enabling activities by actors within the public sector which had hitherto been prevented by either banning legislation (e.g. incompatibilities applying to public sector personnel) or lack of a clear enabling framework allowing the responsible authorities to assume responsibility for their institutional engagement in certain KTC practices.

The Spanish Chamber of Commerce had in 2019 published a set of recommendations, through its University-Business Commission, on the basis of an analysis carried out by the legal firm RCD (RCD and Cámara de Comercio de España, 2020[131]). These recommendations are summarised in Table 12.

Table 12. Principal KTC-oriented legal reforms proposed by Spain's Chamber of Commerce/RCD

Thematic orientation of proposals	Domain / law	Key points within proposals
Protection of knowledge generated in PROs*	Intellectual property/ computer software – Decree Law 1/1996	Extend, for the case of computer software, the regime that assigns PRO ownership, warrants it with ability to transfer rights, and warrant economic rights to contributing PRO personnel.
	Intellectual property – Law 24/2015	Clarity on PRO invention disclosure, retention of free teaching and research licence under transfer, and establishment of minimum share (1/3) in proceeds for contributing PRO personnel.
	Researcher's economic rights - Law of STI 14/2011	Establish minimum share (1/3) in institutional proceeds for contributing PRO personnel.
Knowledge transfer promotion from PROs	Ownership over IP rights - Law of STI 14/2011	1) Vest ownership of commercialisation rights onto PRO, as per IP law above 2) Promote KT activity through business structures 3) Extension of applicability of private law, from foreseen cases to also include the transfer of rights to third parties, specifying cases in which it is possible to assign rights directly.
Activity of PRO R&D personnel in technology-based companies	Incompatibilities Law 53/1984	Maintains baseline incompatibilities and limitations regarding employment- and ownership based roles but clarifying scope to allow for STI Law to foresee exemptions.
	Law of STI 14/2011	1) Extend legal definition of R&D personnel to comprise also R&D personnel other than researchers 2) Remove absolute 5 year leave limit 3) Foresee regulation to address potential conflicts of interest, requiring R&D potentially conflicted personnel to excuse themselves from relevant PRO decisions 4) Implements potential exemption of incompatibilities law. Allows PRO R&D personnel to be authorised to have economic interests in and provide employment based services to legally defined technology-based firms in which the PRO has an interest. Defines authorisation responsibility for OPIs and other PROs. 5) Foresees possibility of adapting working conditions to accommodate the arrangement.

Note: * The term PRO refers in this table, for space economy reasons, to the broad range of PSR institutions, including universities.
Source: OECD elaboration, based on RCD and Cámara de Comercio de España (2020[131]). Accessed from https://www.camara.es/sites/default/files/publicaciones/transferencia_tecnologica_1.pdf

As indicated in the initial public consultations[126] initiated in November 2020, subsequent announcements and summary drafts shared with the OECD, the planned amendment of Law 14/2011 on Science, Technology and Innovation has two main stated aims: reconciling separate provisions of the 2011 Law of STI and the 2011 Law of Sustainable Economy[127] and addressing several of the regulatory shortcomings of the Spanish STI system. Its objectives are structured in three main areas: 1) Improving the governance and coordination of the Spanish STI system; 2) Improving careers in the public research system; and 3) Strengthening the transfer of research results to society. The latter is the most closely connected with the objectives of this report. Envisaged measures in the field of knowledge transfer and collaboration touch upon barriers applying to different knowledge exchange mechanisms while protecting the public interest:

- Clarifying the allocation of ownership of IP rights resulting from collaborative activities between public research institutions and private entities
- Regulatory adjustments to facilitate the creation of start-up companies derived from findings from public research.

[126] See https://www.ciencia.gob.es/site-web/Convocatorias/Participacion-Publica/Consulta-publica-previa/Tramitacion-cerrada/Consulta-publica-sobre-el-anteproyecto-de-ley-de-modificacion-de-la-Ley-14-2011-de-1-de-junio-de-la-Ciencia-la-Tecnologia-y-la-Innovacion.html

[127] This passes by consolidating the LCTI as the single reference piece of legislation.

- Reward knowledge transfer activities conducted by research staff, so that they enjoy the same treatment as research activities in promotion processes and in internal resource allocation processes.
- Adapting the regulation of mobility of research personnel to minimise the career risks associated with entrepreneurship and the start of a new career in other centres.

Assessment

While a detailed legal assessment of proposals is well beyond the scope of this study and the competences of the OECD team, it is possible to discuss their merits and implications from a utilitarian implementation perspective, taking into account relevant evidence on their likely effect. Table 13 presents an overview of planned measures and a number of considerations based on the assessment of the reform proposals as presented to the OECD project team. Overall, several of the points raised in the Chamber of Commerce/RCD assessment appear to be effectively echoed in the interim government proposals. The draft provisions clarify the ownership regime over outcomes of R&D and related activity in PROs but most importantly create significantly greater room for manoeuvre for the different types of institutions in the PRS in relation to KTC activities and their relationship with researchers contributing to them, while setting a minimum standard for entitling the share in the proceeds. The greater institutional margin of operation concerns principally, as indicated in section 4.2, the still complex incompatibility regime, the transfer of IP rights, and the potential exploitation of IP rights through company structures, a move that could potentially revolutionise the TTO subsector. This greater autonomy would be a welcome development in line with this report's diagnosis.

The minimum entitlement to economic benefits by contributing researchers is broadly in line with practices in other countries and backed by the consistent evidence that commercialisation activities by researchers are positively encouraged by small increases in researcher's entitlement share to proceeds perceived by the PRO[128]. As in any floor price legislation, a key question is whether this might be interpreted by PROs that currently provide better terms to their researchers to make them worse, as this would then have negative effects on KTC. Furthermore, it is important that the communication of this rule recognises the role of teams as well as of individuals, since research and innovation are effectively team and not individual sports. The proposals also need to clarify what is the role of R&D personnel that does not qualify formally as "researcher" or equivalent, as well as whether the IP law will be also modified.[129] It would also remain critical to assess, however, how much the behaviour of the different actors in the ecosystem can be really influenced by the measures contained in the law and what accompanying implementing actions (not strictly funding) need to be undertaken (e.g. changing practices, internal rules, codes of behaviour, etc.).

[128] Indeed, evidence from several European countries' abolition of professor's privilege points to a net reduction (ca -50%) in KT measures (Hvide and Jones, 2019; Martinez and Sterzi, 2019). According to Arqué-Castells et al (2016), evidence from the inventors' survey in Portugal and Spain indicates that one third of respondents are incentivised by current royalty sharing arrangements, one third could be incentivised by higher royalty shares, and the remaining third is totally insensitive to royalty sharing. The proposed "one third" is a minimum mandatory share for institutions dependent on central government organisations, and a default when regional government controlled institutions do no set such limits.

[129] In several other countries, domestic IPR legislation does not include specific provisions for different types of domestic actors whose actions with regard to IPR are already included in actor-specific legislation. In the United Kingdom for example, the patent act does recognise the rights of inventors but does not need to differentiate according to who they work for. Duplication coverage can result in over-specification of rules and generate considerable uncertainty if the different pieces of legislation do not appear to be entirely consistent.

Table 13. Proposed areas of reform of the 2011 Law of STI and considerations for policy makers

Proposed area of reform*	Considerations
Institutions	
Designation of institution as sole assignee of ownership over IP outcomes of R&D activities as default, but renounceable under defined conditions	• **Aim**. Clarify baseline ownership position regarding IP rights generated in the PSR. • Statement needs to be reconciled in its formulation with rules on the split of rights elsewhere in the proposed legislation (see below). Potential confusion about assignee roles, and economic rights. • In practice, funding agreements signed by PROs (including universities) will in many cases impose alternative ownership arrangements over the results of the work. Such arrangements will explain the intended distribution of assignee roles over PRO/University-generated IPs
Applicability of private law to collaborative activities in the public sector	• **Aim**: Allow public sector institutions of all types to adopt private law instruments that are more flexible in their relationship with third parties outside the public sector. • Positive move enabling more agile contracting in the commercialisation / intermediation space. • Importance of clearly defining the taxonomy of activities/contracts within the scope
Capacity to transfer rights over public IP assets generated in the PSR to third parties	• **Aim:** Provisions specify instances where it is possible for PROs to adopt faster mechanisms for the direct allocation of rights avoiding complex (formal competitive) bidding procedures. • It would be important to clarify if this would imply an assignment of ownership or of specific rights • Standardised competitive procedure may not be fully appropriate for the cases not considered suitable for direct rights allocation. Alternative competition preserving mechanisms that maximise value generated should be considered. • There is no defined IP market, and therefore allusion to market value would not be easily operable.
Participation of PROs (incl. public unis) in the corporate capital of business enterprises	• **Aim**: Enable more agile TTO institutional set ups, e.g. allowing universities to hold assets and certain commercialisation functions as companies (for instance, replicating international examples such as Oxford Innovation). • Importance of ensuring agile procedures.
Researchers **	
Research personnel shall be entitled to a share of the profits (minimum of 1/3) obtained from the exploitation of research results. Discretionarity for bodies dependent of autonomous regions to increase that share	• **Aim:** Entitle researchers to a minimum share of PRO's proceeds to entice them to engage in higher levels of R&D activity resulting in marketable knowledge. • The implied logic is that the incentive effect will compensate for what institutions might otherwise lose in terms of share compared to a lower share. The international evidence suggest that there is indeed an incentive effect when individuals receive a higher share. • However, likely implication of minimum level legislation is that it anchors potential future agreements that may have otherwise offered a higher share to researchers. Anecdotal evidence suggests that several PROs already allocate a higher percentage. • The 1/3 figure is in line with what some other countries stipulate, but literature (e.g. Borowiecki and Paunov (2018[132])) show there is wide diversity of arrangements. Indeed some countries and also PROs (esp. universities) foresee 3-way split arrangements, with shares corresponding to the overall institution, department and team or individual researcher. • Practicalities: presume no retroactivity; transitional arrangements and short term impact on TTO revenues that may impact on their ability to operate and support enhanced activity.
Possibility for institutions to grant researchers permission to provide employment-based services on part time basis and over a defined period	• **Aim**: Facilitate dual careers in PROs and business, removing blank prohibition to give discretion to the institutions on the optimal arrangement with respect to its own researchers and allowing them to retain within their organisation if that is part of their preferred strategy. • Public employment per se is not the root of incompatibility but the potential underlying conflict of interests and effective potential for abuse of a dual position. The blank prohibition overstated the risks in relation to benefits. • Maintains barriers to the engagement of public researchers in innovative tech-base firms that are not created or participated by the public sector (except for university researchers, which according to art 83 of LOU can provide technical assistance to any firm). • Adjustment of baseline work schedule should be possible in order to allow for public researchers' engagement in business undertakings. • Need for laying out separate guidelines (code of conduct) regarding types of substantive incompatibilities and IP risks, laying out concrete examples. It may be necessary to provide a model agreement. • There appear to be no substantive changes in relation to leave of absence to work full-time for 5 years or more in a company.

Notes: *The analysis is based on a draft document summarising the main planned areas of reform of the 2011 Law of Science, Technology and Innovation, which was provided to the OECD by the Spanish Ministry of Science and Innovation in May 2021. The reforms under consideration may have evolved since and should therefore not be interpreted as confirmed legislative proposals. ** The proposals also need to clarify what is the role of R&D personnel that does not qualify formally as "researcher" or equivalent.
Source: OECD own elaboration.

A long term perspective for today's reforms and investments

While somewhat reasonable given the celerity with which legislative and investments measures are being put in place, there is clear concern around implementing capacities within ministries, agencies and institutions. There is already a significant debate about control and assessment procedures to help expedite these measures. It is important to avoid the creation of an overly complex policy mix that creates confusion to potential beneficiaries. The capacity of funding agencies to manage those programmes in an efficient way should also be enhanced in some cases, to ensure their swift deployment with no delays or excessive bureaucratic hurdles. An efficient deployment of the new programmes will probably require expanding the analytical capacity of the Ministry of Science and Innovation, to be able to properly design, implement and evaluate the emerging policy mix. Beyond the increased capacity needed to deal with a higher number of programmes and a higher budget, shifts in the orientation of public policy will require capacities to orchestrate strategic projects bringing together different types of stakeholders.

The effects of the ongoing reforms and investments will take some time to fully materialise, and will only achieve their full potential if budgetary commitments are sustained over time, particularly after the Next Generation EU funds have run out. These funds have allowed for a 60% increase in the budget of the Spanish Ministry of Science and Innovation in 2021, compared to 2020. While such funds will allow for the implementation of the wide range of actions detailed in section 6.1.1, it is important to reach a multi-partisan political commitment that:

- ensures the long-term sustainability of funding for research and innovation (i.e. after 2023) and the structures and programmes that demonstrate their worth;
- stimulate private investments up to a scale that is sufficient to compensate for the expiration of Next Generation EU funds by 2023, something that requires changes in the culture of innovation of firms that operate in fields that could benefit from knowledge transfer and collaboration with public research, as well as addressing the mistrust or misperceptions of firms vis-à-vis public research.

A clear knowledge transfer and collaboration perspective that pervades all actions and not only those formally designated as such, across all sectors, is essential for both objectives, since the accomplishment and demonstration of defined economic and social impacts are vital for sustaining political budgetary support to STI in the face of potential financial adversities, while there need to be self-reinforcing dynamics between the public and private sectors to compel business to raise up its innovation capacity to the levels found in other countries.

The remainder of this section focuses on identifying what measures can provide the basis for a knowledge transfer and collaboration roadmap that can sustain such a vision, avoiding the risks of a reversal as damaging as that caused by the global financial crisis and its aftermath which is still impairing the Spanish STI system.

6.1.3. Reform of the Organic Law of the University System

In September 2021, a draft proposal for a new Law of the University System ("*Anteproyecto de Ley Orgánica del Sistema Universitario*") was circulated for consultations with stakeholders and parliamentary groups. Taking into account that the consultation and final approval process will take several months and will likely result in modifications, it is worth noting that the current draft contains various elements related to university-business cooperation and knowledge transfer. A number of them relate to recommendations contained in this report.

The draft Law envisions changes in the governance structure of universities, including a new system for the nomination of members of Social Councils. It continues to state that the law of autonomous regions shall regulate the composition of Social Councils but specifies that the election of their members will correspond to the regional legislative assembly. Social Councils should be composed of a maximum of 20 members that are representative of the local, national and international cultural, professional, business, labor union and social life, with a demonstrated commitment to the university but, in contrast to the current regime, should not be members of the University community or have a conflict of interest. The President of each Social Council should be elected by vote from among its members. The mandate of the members of the Social Council would be of a maximum of six years, non-extendable. In addition, the draft Law establishes that at least 10% of the members of the university's Governing Council (the highest-level management body of the university, chaired by the rector) should come from the Social Council.

Another important change relates to the financing system of universities. The draft Law proposes to introduce a new financing system combining baseline funding with a performance-based component. Under this new system, universities will be asked to develop multi-annual plans, subject to approval by regional governments, which will then mark measurable strategic objectives linked to the improvement of teaching, research and knowledge transfer. The additional performance-based funding awarded to each university will depend on its success in achieving the objectives marked in its strategic plan.

Assessment

The new provisions for the designation of Social Council membership and presidency represent a significant change with the current regime (described in section 2.3.3), making these bodies more independent from university management. A priori, this could help address one of the challenges identified above. However, this "solution" comes with two major caveats. Firstly, there are no firm resourcing proposals to make the Social Councils more effective in their defined role, with the risk that they remain peripheral advisory boards in university decision-making processes regardless of the independence and merits of their members, whose engagement and remuneration, if any, would require greater definition. Secondly, the nomination procedure of Social Council members by the regional assembly risks politicising the Social Councils, since procedures may end up allocating available council seats quota based on party-based political affinities. These two elements combined create ample room for a clash between two different "democratic legitimacies" in the university governance, namely those arising from the university's own internal election system for its Governing Council on the one hand, and the parliamentary based appointments to its Social Council on the other. The remaining consultation period should be used effectively to consider a broader range of options and assess their respective pros and cons in light of the stated policy objectives.

The rationale for limiting mandates to a maximum number of years is clear and consistent with best practices although it also implies a potential loss of human capital. It is important that Social Council teams have some degree of continuity with overlapping cohorts of members in order to preserve know how and strategic direction.

The proposed introduction of a performance-based component to the financing of universities is well aligned with the recommendations of this report. What the proposals do not specify and would require additional legislation, possibly both at national and regional levels, is the size and operation of the performance-based component. This report has already outlined the challenges and opportunities from different types of performance-based institutional incentives (see section 6.2.3 below in connection to the use of quantative and qualitative indicators).

6.2. Conclusions: Opportunities for improving science-business knowledge transfer and collaboration in Spain

The analysis presented in this report points to some priority areas for policy action to improve science-business knowledge transfer and collaboration in Spain. These represent the basis of a potential action roadmap, focused on the following five priority areas:

1. Put in place sound science and innovation policy foundations (including stable resources and policy frameworks) to make knowledge transfer and collaboration possible and effective.
2. Re-design the governance systems of universities and PROs to increase their engagement with and accountability towards society.
3. Rebalance and align individual and institutional incentive mechanisms, so that external knowledge transfer and collaboration activities are more attractive endeavours for all types of researchers, their teams and organisations.
4. Facilitate and co-ordinate the operation of diverse knowledge intermediation agents – including knowledge transfer services within universities and PROs as well as independent knowledge intermediaries such as technology centres, science and technology parks and clusters.
5. Promote and sustain business capacities to innovate, to render the sector willing and ready to exchange with the PSR and other relevant actors through ever-deeper engagement mechanisms.

6.2.1. Science and innovation policy foundations and enabling conditions for knowledge transfer and collaboration

A key condition for science-business interactions to flourish, intensify and become more productive over time is to have appropriate framework conditions in place to facilitate such engagement. A number of recommendations to improve the framework conditions for science and innovation in Spain were put forward in the ERAC Review of 2014. As shown in Table 14, while important steps have been taken since then, many of these recommendations are still relevant today and have a clear KTC perspective.

Table 14. The 2014 ERAC review and relevance in 2021 in the context of this study

2014 ERAC review recommendations	OECD commentary on relevance in 2021 and implications for science-business engagement
1. Spain's R&I system needs **increased resources** but these must go **hand in hand with structural reform** for a more efficient and effective use of public investment. This will ensure a faster and more sustainable recovery for the Spanish economy. The additional resources should be used exclusively to incentivise reform.	This message is still pertinent today as the system did not receive resources at the time. As resources are becoming available through the EU RTRP, the reform requirement has to accompany the new efforts in order to put the system back on the path to greater sustainability and self-reliance, opening a pathway for private resources to bring additional resources in the future.
2. **Human resources** are the most pressing problem and rapid action is needed. The structure of research careers needs to change.	The planned reform of the STI Law (see section 6.1.2) aims to address some of these challenges but the actual proposals for an ad hoc tenure track figure circulated thus far have been met with considerable controversy. Reducing the precariat of research careers from a holistic perspective (i.e. not only academic) remains a key priority.

2014 ERAC review recommendations	OECD commentary on relevance in 2021 and implications for science-business engagement
3. **Institutional reform** is critical. For each central government public research body (OPI), university and for the laboratories and departments within them, much greater autonomy is needed. This autonomy needs in turn to be matched by a strategic approach and by greater managerial accountability (including regular independent evaluation and assessment).	The governance system of universities and several PROs should be revised to support a greater engagement of industry and civil society in strategic decision making, their effective autonomous operation and stimulate the attraction of (external) talent to perform managerial positions (see section 6.2.2).
4. Research institutes and universities need to be subject to an **assessment system** that influences resource allocation both directly and indirectly. There is also a need to increase the proportion of competitive funding.	This remains a significant deficit today. Connected to the above, establishing appropriate institutional incentives to promote knowledge transfer activities among the broader range of activities in the organisation's missions and strategies should be a main priority (see section 6.2.2), and relevant lessons can be drawn from the mechanisms put in place by several autonomous regions.
5. A new level of **coordination between actors** is required for effective innovation. We propose national consortia, termed Strategic Innovation Arenas. Spain is lacking critical mass and needs to maximise the benefits from concentrating its resources. The step that is needed now is to establish business-led initiatives in key areas of focus and targeting global competitive environments.	Spain channelled efforts towards strategic priorities, but did not fully address the critical mass issues and the norm for actors in the system to work in silos which keep separate the public research system and the business sector. Programmes remain compartmentalised targeting a prototypical agency-customer pattern even when they require presence of other actors. The ecosystem of priorities has become too complex and instrument specific.
6. Bringing more **business actors into the innovation system** is critical. Spain will not progress unless several thousand companies enter the innovation ecosystem.	This message is still very much pertinent today, requiring business support policies to effectively entice companies to place innovation, in its different forms, as a strategic priority. PROs can partly assist with this process.
7. A **market and a culture for innovation**. The area of most immediate potential is on the demand side and the creation of a market friendly to innovation	This message is still pertinent today. Spanish society is highly accepting of scientific developments as demonstrated by high COVID-19 vaccine take-up but there is still considerable lack of personal experience of innovation and organisational workplace culture is not sufficiently innovation friendly, including in the public sector. Spain is doing efforts to strengthen the demand side of innovation through the promotion of public procurement of innovation solutions. Many challenges remain however to ensure their effective implementation.
8. The need for an **autonomous agency** with two main functions. 1) Promotion of excellence through grants and fellowships. 2) Knowledge Exchange to promote contribution of the research system to the economy and to societal challenges [understood as] based on engaging research, business and other stakeholders in co-creation around strategic agendas. Engage the whole of government such that research and innovation are seen as part of the mainstream economic agenda, and to be drivers of reform, preparing the necessary legislation for this agenda	Spain, like many other OECD countries, has progressed in terms of advancing towards a whole of government approach to innovation policy, but it remains significantly compartmentalised despite the existence of coordination mechanisms. The agency (AEI) has been set up with some degree of autonomy. There has been progress towards a whole of government approach but there is still a significant silo-based approach to innovation policy.
9. Incentivise **regional synergies** in support of business and business creation.	Efforts have been made to improve the dialogue and coordination across regions in the field of STI policy, with mixed results. The Council for Science, Technology and Innovation Policy has met very seldom and has not lived up to its promise to adopt a leading role in fostering central-regional coordination. RED IDI, created in 2010 and more focused on the operational and technical side of policy implementation, has played a very relevant role in the development and coordination of regional smart specialisation strategies. It has proved very valuable in coordinating different agents of the Spanish science and innovation system to share experiences and mobilise resources and access to financing from EU funds.
10. Effective **monitoring and evaluation** to support evidence-based policy.	There has been continued progress in the articulation of data resources and new evaluation mechanisms have been introduced, but evidence and analysis is still not a driving force of strategy and implementation. Legalistic approaches prevail.

Source: OECD, drawing partly on ERAC (2014[133]).

Resources and coordination

For knowledge transfer policies to have positive long term effects at scale, it is also essential to ensure political commitment to sustain and stabilise STI resources over time, not only for R&D investments, and to engage in efforts to spread a culture of innovation across all layers of society. As the innovation imperative that Spain faces today widens the scope of innovation policies, it requires co-ordination and new institutional arrangements that extend beyond the confines of the Science and Innovation Ministry (and Universities by the same token) to a "whole-of-government" approach to innovation policy. This implies establishing stable platforms for co-ordinating actions, a focus on policies with a medium and long-term perspective, and attention from policy makers at the highest level. It also involves coherence and complementarities between the local, regional and national levels (OECD, 2010[2]). Spain needs to frame its approach to innovation policy in a more visible and coherent fashion so it does not appear to be a subordinate or afterthought to R&D policy. Therein also lies the ability to connect R&D policies with multiple government agendas such as industrial policy, entrepreneurship, digitalisation and energy transitions to cite a few.

The accumulated policy experience in the field knowledge transfer and collaboration, both at the central government and regional levels, offers invaluable opportunities for policy learning, as this report points out in several occasions. Further efforts should be made to institutionalise such processes of best practice exchange and policy learning, as is currently the ambition of RED IDI, which can still do much in terms of adopting genuine policy co-creation approaches.

Regulation

The assessment in the previous subsection has pointed out a number of ongoing reforms and the extent to which they can remedy a number of challenges to KTC within the PSR. These are incremental solutions that in light of the evidence available should in principle help address several of the regulatory and administrative barriers identified in this report, particularly those that currently hinder the agile establishment of collaborative agreements or research contracts as well as the mobility of research personnel. Experience does show that one needs to regard regulatory reform in Spain's STI system with some caution for a number of reasons:

- Spain's STI system has a tradition of overly relying on regulation to establish the rules and conditions that govern all conceivable interactions between actors, as well as the management of their joint activities and results. Amidst a complex distribution of powers between the national, regional and institutional levels, there is a risk the system becomes increasingly complex as regulations call on additional implementation rules that need to foresee each contingency, in what is bound to be a losing proposition amidst rapidly changing global innovation trends. The reality is that all legislation requires implementation efforts on the part of different actors and these should be spell out more clearly.
- Regulations, especially if they do not have direct financing implications for the government authorities, tend to avoid formal evaluation and assessment in relation to their ultimate objectives and alternative options. In this context, policy makers are likely to rely on anecdotal evidence is likely to assess the relative merits of different provisions and monitor whether implementation is in line with expectations compare to reasonable counterfactuals becomes particularly difficult.

For these reasons, we would suggest considering in parallel, as part of a broader reform roadmap, a range of genuine simplification reform options over a longer time horizon

which allow a progressive transition from a rules based to a principles-based system whenever that is possible, as well as place emphasis on mapping out processes, bottlenecks and inefficiencies, co-producing soft guidance and codes of conduct that are revisable and help respond effectively to the needs of all actors regarding knowledge transfer and collaboration activities.

Policy evaluation capacities

Defining and implementing the appropriate policy mix for knowledge transfer and collaboration (and for R&D and innovation more broadly) requires developing evaluation and impact assessment capabilities within the public administration, in order to be able to monitor the effects of different policy instruments and introduce the necessary adjustments in a timely fashion. Expanding impact evaluation capacities would also allow quantifying the economic return of those measures, providing evidence-based arguments to support the approval and implementation of policies during strategy and budgetary negotiations across Ministries and policy areas, allowing them to be part of the national policy debate. Evaluating the economic return of measures is particularly complex, however, due to significant time lags as well as attribution challenges.

Some countries have stronger traditions of impact evaluation in this area and use it to justify and improve their policies. Examples of knowledge transfer programmes that have been evaluated in other countries include the Technology Access Centres (TAC) in Canada (in 2018) and the Valorisation Programme in the Netherlands (mid-term evaluation in 2014 and a final evaluation in 2018). Others have been evaluated several times, such as the FORNY Programme in Norway and the Knowledge Transfer Partnerships (KTP) in the United Kingdom (Guimón, 2019[98]). The latest evaluation of the KTP programme, conducted in 2015, included a model to estimate the programme's economic impact. It concluded that every GBP 1 of KTP grant invested resulted in up to GBP 8 of net extra gross value added to the UK economy. The evaluation was based on both qualitative and quantitative methods, including interviews with stakeholders, a review of the information held in Innovate UK's KTP databases and ad hoc surveys (Siora et al., 2015[145]). A key recommendation for the Spanish national and regional authorities is to embed independent evaluation and resource requirement at appropriate stages in the policy process. Ex-ante impact assessment, through the evaluation of different options, should also be undertaken in a more systematic and transparent fashion, and policy reforms should be generally accompanied by a "logic model" that explicitly sets out expectations on its operation from inputs to outcomes (OECD/Eurostat, 2018[6]).

A first critical step to set up a culture of evaluation is to strengthen the information and intelligence systems in the field of STI and STI policy, which should combine both quantitative and qualitative data. This requires not only reinforcing the capacities to collect high-quality and granular data, but also to manage and store it efficiently, and make it publicly accessible for researchers and any other interested stakeholders. Priorities to consider include the following:

- Establish common definitions and typologies to facilitate the analysis of data collected, going away from the current typologies that are often too linked to legal classifications.
- Ensure that institutions (and individuals) have sufficient resources and incentives to generate the necessary data (quantitative and qualitative). Specific funding should be allocated to support the sustainable generation of systematic information, which is critical to build a well-functioning information an intelligence system. Incentives to generate high quality information are also important. The literature

argues that for this to be the case, low stakes situations are better conducive to the obtainment of good data than when there are high stakes, as the latter risk compromising data integrity. In that regard, the moderately funded KTS system is an interesting approach for generating actionable data on KTC.

- Sponsor the creation of maps of research and technological capacities with a high level of granularity. This would allow identifying, for instance, which research groups are working in specific areas and at what TRL levels, therefore facilitating the process of matching between science and industry partners.
- Ensure sustainable indicators on inputs, processes and outputs, available over long periods of time, so that it is possible to monitor the full cycle of projects, and funders and evaluators can rely on information about institutions and individuals at all stages of their decision making process.
- Strengthen collaboration and co-ordination between all information-generating actors, demonstrated through the adoption of a common strategy in addition to bilateral data generation and use agreements.
- Encourage open access to data that is not strictly speaking confidential. The Spanish system has been traditionally characterised by many dispersed and diverse initiatives, with results not being easily accessible. Opening data resources for analysts and academics, with the necessary conditions to preserve confidentiality, would be a good way to increase analytical capacities by engaging the data using research community.
- Create an inventory of case studies of successful knowledge transfer experiences that systematically collect the impacts of specific initiatives, and that would complement quantitative indicators. These could be identified by universities themselves. Another alternative could be to ask the KTS evaluation panels to select the outstanding examples among all those that have been evaluated.

6.2.2. Governance systems of universities and PROs: missions, autonomy and accountability

Universities

As revealed throughout several interviews with Spanish and international stakeholders, knowledge transfer and collaboration between university and business in particular have been hindered by the prevailing governance arrangements of universities. Such arrangements have resulted in a system that is overly exposed to politicisation, hampers the attraction of external talent to fill universities' management positions, and curtails the influence of society on how universities make use of public resources. Spain's university system has been described as fundamentally "academically-driven and inward-looking", despite efforts over the past decades to increase the engagement with industry and civil society through its so-called "third mission".

Analysts of the Spanish university system have amply commented on the governance-over-regulation interface, as already reported in the aforementioned OECD Review of Spain's Tertiary Education. For example, Salaburu (2007[134]) is cited in that report when commenting that "the wish to regulate these powers until exhaustion has given way, in practice, to a wave of state, community and university regulations […] so that the university system is one of the most regulated environments that exists today. There are two consequences: the difficulty of university authorities to take autonomous decisions with agility – there is always a regulation to consult – and the difficulty of demanding that

someone is responsible because it is not completely known which body should assume responsibility; on one occasion someone said that in the university everyone is empowered but no one is responsible". This assessment is still pertinent today.

Table 15. University governance assessment: implications for knowledge transfer and collaboration

Dimensions of governance	Assessment	Implications for knowledge transfer and collaboration (KTC)
Mission and goals of the university and its bodies	Formally stated and clearly defined.	KTC mission clearly stated but treatment as third mission implies last in priority.
Management mechanisms – traditional or results-focused	Management and funding not generally oriented towards results. Power is highly concentrated in the rector and closest team.	Difficulty of incorporating KTC results in the management. Advancing KTC agenda requires high levels of commitment of the leadership.
Autonomy – academic, human resources, financial	Unbalanced autonomy, constrained by public administration bureaucratic procedures and rigid processes for the accreditation, selection, remuneration and promotion of academic staff.	Difficulty of university authorities to take autonomous decisions with agility regarding KTC practices and suitable staff, e.g. within TTOs.
Accountability – responsibility vis-à-vis stakeholders	Limited accountability in relation to external stakeholders – direct funders (regions) or broader society (taxpayers).	Lack of genuine institutional expectations showing disconnect with high profile of KTC in missions. Engagement on KTC activities dependent on individual initiatives of researchers.
Participation – voice of internal and external stakeholders	Limited voice of external stakeholders in strategic decision-making.	University activities tend to be academically driven and disconnected from market needs.

Source: OECD own elaboration

Recent reforms in several European countries have been characterised by a move towards increasing levels of institutional university autonomy coupled with arms-length steering mechanisms and greater accountability, often via performance based contracts between governments and universities (Kruger and Parellada, 2018[135]; Aberbach and Christensen, 2018[136]; Maassen, Gornitzka and Fumasoli, 2017[137]). This has entailed:

- Changes in autonomy and accountability
  - Greater autonomy with expectations of institutional relevance towards societal challenges
  - Greater accountability with the incorporation of external stakeholders in the management and oversight of the organisations, more focused on outcomes
  - Greater professionalisation of institutional management
- Changes in human resource policies
  - Change in labour status of academic staff from civil servants to employees, with increased freedom in the contracting of staff
  - Greater focus of academic governance bodies on strict academics matters, which can include elements such as tenure as mechanism to protect academic freedom
- Changes in financing models
  - Greater diversification of financial resources and shift towards private and international sources amidst tighter domestic public budget restrictions

- Greater degree of assignment of financial resources to institutions based on performance criteria and indicators, shifting away from strictly unconditional funding mechanisms
- Greater competition[130] between institutions, in particular for students

In the specific case of Spain, undertaking this direction of reform which has been effectively tested elsewhere, would most likely entail addressing a key governance point, namely, either transform completely the current governance system to give an effective voice to external stakeholders in the strategy setting of the university or effectively strengthen the role and capacities of Social Councils. The latter would require ensuring they have sufficient resources and autonomy to efficiently fulfil their functions; increasing the number of external stakeholder representatives that can participate in the governing council (currently limited to only three); and providing greater clarity regarding the eligibility criteria and level of commitment of its members.

The OECD has listened to calls for increasing the flexibility of the current system of nomination of rectors and high executive officers at universities. In contrast to many other countries, rectors in Spain can only be selected among incumbent full professors (*catedráticos*) with permanent positions within the same university prior to their appointment. Removing this condition would allow attracting external talent combining academic with professional management credentials (from other national or international universities) or appointing other members of the same university, ensuring that the selection process is based on merit and demonstration of key managerial competences. Higher flexibility would also contribute to creating a "labour market" for academics and university leaders, which remains limited in Spain. The experience of Austria is rather illustrative in this regard (OECD/European Union, 2019[138]). Systems in which university leaders are elected by a broader constituency, encompassing stakeholders outside HEIs, tend to be more effective in promoting innovation and knowledge transfer activities.

Other reforms would depend on the approach adopted on the core governance. Regardless of the choice, in a multilevel system like Spain's, it would be necessary to provide sufficient flexibility to implement experimental governance approaches at regional and/or institutional level. This "test and learn" approach would benefit the whole system in the longer term, as it would allow testing a diversity of approaches and generate evidence regarding their impacts. Regional governments have a very important role to play in exploiting these opportunities, but the overarching country-wide framework needs to support it.

These reforms require concerted action between the central government (in charge of reforms in the Law of Universities and accreditation policies), regional governments (in charge of the implementation and funding of university policy) and the universities themselves (with their own statutes and practices).

The current governance arrangements in Spain's universities have, as noted in previous sections, a sound historical reason in the country's transition from a dictatorship to a democracy. However, in the current international and domestic landscape, they are not fit for serving the social purpose of universities, something which should be itself a matter of democratic debate at the different levels of government in Spain. The experience of reforms in European countries illustrate how deep reforms can be implemented with full respect of democratic and public service values, fulfilling a vision of university within society. These

[130] Currently, the level of competition in the Spanish higher education system is low, especially when compared to Anglo-Saxon systems. Universities do not have to compete for their core funding based on performance and hardly engage in fundraising (Berbegal-Mirabent, Gil-Doménech and de la Torre, 2021[149]).

reforms have in most cases not happened overnight, and have required considerable leadership on the part of elected officials at responsible levels of government as well as focused additional resources to support the transition process. The ongoing reform of the Organic Law of the University System (see section 6.1.3) and the available EU funds represent a unique opportunity for Spain.

Public research organisations (PROs)

Spain, similarly to other major European countries, has a dual PSR system that combines HEIs and PROs, the latter under a myriad of legal regimes. From a historical perspective, the configuration of Spain's PRO system attempts to pursue two objectives:

- the interest in promoting scientific advancement, liberating PRO science professionals from burdens such as tuition requirements common to their university counterparts (basic research oriented institutions and centres);
- the need for mission-driven public bodies with specialised scientific and technological capabilities, services, infrastructure and expertise of value to both public and private sectors (applied research and related institutions and centres).

Over time, the first mode has become dominant in Spain's PROs as individual incentive mechanisms have primed publications as metrics of success. Constrained by the rules of the general government public administration, a major asymmetry in functioning has arisen within this subsector, hampering the capacity of public research bodies under central government oversight (OPIs in Spanish) to operate effectively at these two levels (including engaging in KTC activities relating to both) in comparison to universities and new generation foundation-based public research organisations.

Furthermore, responsibility for nurturing institutions that help businesses manage innovation risks through the provision of R&D infrastructure, specialist knowledge and expertise, partnership and collaboration building capabilities, and business support services principally rests with regional governments, using several types of arrangements among which technology centres are the most salient example.

In light of this, we conclude that it is about time for the government to commission an independent review of the PRO sector in relation to government strategy and perceived new requirements. The review's recommendations should spell out options for organising the public research and innovation facilitation infrastructures and the significant human and material resources in synergy with the university system. Such review would also promote a public debate on the principles that should underpin the missions of PROs and their connection with Spain's current socioeconomic situation, its main challenges and opportunities.

6.2.3. Individual and institutional incentive mechanisms in the PSR

Having laid out the key aspects concerning framework conditions for STI policy and institutional governance, it is turn to pay attention to the incentives of PSR actors to engage in KTC activities and do so in an efficient fashion. Owing to multiple factors discussed in this report, Spain's PSR has been a relative latecomer to the notion that KTC can and should be incentivised to reflect the extent to which it is reported as a priority in strategies and plans at different institutional levels. Both individual and institutional incentive mechanisms in the Spanish research system should support and encourage knowledge transfer and collaboration activities. The responsiveness of the PSR system to research excellence incentives introduced over the past decade is illustrative of the scope for influencing behaviour and outcomes.

Individual incentives

The Spanish authorities have made the provision of individual incentives a major focus of their KTC policy strategy. This is manifest in the adoption of rules that entitle university and PRO researchers to benefit from the economic outcome of their knowledge generating activities on more favourable terms. In addition to measures that allow individuals to have a stake in the upside of KTC activities, the Spanish authorities also wish to incentivise KTC activities as such and on a broader platform. The knowledge transfer sexennium (KTS) introduced as a pilot in 2018 aimed at rewarding knowledge transfer activities of public researchers is a very significant step in this direction. Section 4.4.3 provides a detailed assessment of this initiative and its implications. To our knowledge, this type of periodically assessed earnings premium instrument is rather unique to Spain in that it has no international equivalent to which it can be directly compared.

As implemented to date, several observations can be made based on the initial experiences and the challenges encountered. These nonetheless do not prevent a majority of stakeholders interviewed for this project from expressing considerable optimism about its potential to drive culture change and impact, in ways that are similar to what occurred to the research sexennium several years ago with respect to research quality.

Some procedural deficiencies were detected during the 2018 pilot that need to be addressed for the instrument to achieve its intended effects, such as the clarification of criteria used to value merits and fine-tuning the evaluation process in order to make it more predictable, focused, agile, and transparent. The pilot initiative has accentuated asymmetries in the treatment of researchers and other R&D support personnel, by type of PRO, and research area. If this type of incentive is ultimately retained, key priorities are to:

- Build consensus on the intended scope of the KTS and consistently improve the assessment process, e.g. by issuing clearer guidance (something that the pilot should help inform) and increasing the diversity of evaluation panels, for instance by including business sector representatives (and not only academics) so that more impactful activities are given the appropriate recognition.
- Consider the appropriate mix of financial incentive and credential effects of the KTS, for example through recognition of merit for career promotion procedures or project funding merits for national STI funding programmes, especially when those programmes relate to the scope of the KTS. This would help put the KTS on a par with the Research Sexennium as an instrument.
- Align more closely the merits recognised with the effective funding sources, other earnings premia in place (avoiding unnecessary overlap) and the rewards provided to reduce deadweight and increase the incentive effect. This requires engaging the parties that pay for the researchers' salaries, considering awarding the bonus for shorter periods but allowing to claim rewards for new merits more frequently. Institutional asymmetries that cannot be justified should be addressed in a timely fashion.
- Monitor and correct for potential unintended effects by professional, age and gender groups, as the sexennium system can ultimately exacerbate existing disparities in the Spanish public R&D workforce, characterised by an important degree of precarity among the younger generations of researchers and those requiring career breaks, which coexists with a very protective system for those with permanent positions (OECD, 2021[97]).

Institutional incentives

Individual incentives help formalise existing KTC activities operating under the institutional "radar", and universities and other PROs need to be empowered to reward their staff for those accomplishments in a manner that is consistent with the institution's strategy, but they often lack the necessary autonomy to do so. For individual incentives such as those described above to achieve their intended effects of changing the culture and practices in the PSR, these need to be accompanied by effective institutional incentive mechanisms. A key challenge with excess reliance on an individual incentive perspective is that it risks regarding institutions as passive agents of change. The scientific enterprise and the commercialisation of their results are team co-production endeavours in which every individual counts but credit needs to be appropriately shared across all relevant contributors. Universities and PROs can do a better job at explaining their institutional overheads. As indicated in section 4.4, it is necessary to avoid that incentives for KTC activities result in uncoordinated efforts, developed at sub-optimal scale and without the necessary support by the institutions in which researchers work. Such direction would accentuate the current conflicts over the sharing of the burdens and benefits of knowledge transfer and would not contribute to improving the performance of TTOs whose contribution is ultimately necessary for more complicated KTC activities.

- A priority for reforms would thus be to consider, in a cautious but firm fashion, the introduction of institutional funding mechanisms that reward KTC activities and results at the institutional level, taking into account the plurality of missions and strategic objectives of such institutions. This would require to consider the issue of performance related institutional funding which was alluded in earlier remarks about university and PRO governance. Institutions could draw upon the resources provided by KT funding stream to strengthen their KTC support capabilities, as well as reward researchers and other staff internally who contribute to transfer results, not only in terms of salaries, but also providing them with better support services, or with the possibility to hire assistants and purchase equipment.

Adopting an institutional perspective can also favour the development of a greater culture of measurement that supports accountability, and contributes to embedding knowledge transfer and collaboration within the culture of universities. In addition, having comparable metrics is useful for HEIs to engage in a peer-to-peer dialogue on the type of activities they are carrying out in connection with their missions and strategies, thus contrasting declarations of intent with actual behaviour and outcomes. The United Kingdom's Knowledge Exchange Framework is one clear example (Box 27) of investment in developing monitoring infrastructures that allow authorities to promote KTC activities in connection with institutional incentives, is an interesting practice that Spain's SICTI would potentially be able to emulate.

Box 27. The United Kingdom's new Knowledge Exchange Framework

In 2017, the UK government asked Research England to produce a "Knowledge Exchange Framework" (KEF) to evaluate universities' contribution to the exploitation of knowledge and support HEIs' knowledge interactions with business, public and third-sector organisations, community bodies and the wider public. This framework would prepare the R&D system as a whole to meet the goals set out in the UK Industrial Strategy. In addition, the KEF was created to ensure that public funding in support for knowledge exchange was allocated effectively through the pre-existing Higher

Education Innovation Fund (HEIF), and to obtain accessible and comparable information on knowledge exchange performance of different HEIs.

To consolidate this framework, Research England organised a consultation process. The proposed framework was well received by participants who validated the inclusion of qualitative metrics in the form of HEI narrative statements, and made some suggestions regarding quantitative metrics. In addition, Research England selected twenty-one English HEIs, taking account of the type of institutions and their geographical location, and invited these to participate in a pilot exercise, consisting in a series of workshops in 2019, to test the new refined framework with revised metrics that emerged from the consultation process. The pilot exercise worked well as HEIs provided positive feedback on the KEF and suggested areas of improvement for the metrics used.

After the consultation and pilot exercise, the first knowledge exchange framework round took place in academic year 2019/2020. All HEIs eligible to the knowledge exchange funding participated in this exercise. For this and subsequent rounds, the KEF is evaluating HEIs based on quantitative metrics and qualitative metrics (narrative statements). These knowledge exchange metrics are grouped in seven different categories (research partnerships, working with business, working with the public and third sector, skills enterprise and entrepreneurship, local growth and regeneration, IP and commercialisation, public and community engagement). Data for the KEF is collected by the Higher Education Statistics Agency (HESA). HE providers that receive public funding in the United Kingdom are obliged to contribute to the HESA data collection exercise. To enable comparability between HEIs, the institutions were grouped in clusters by capability (research institutions versus more teaching oriented institutions), by size and discipline (STEM, non-STEM, arts). The KEF assesses seven clusters of universities: five general clusters, the STEM cluster and the "Arts specialist" cluster. The results of this first exercise were published in 2021 (https://kef.ac.uk/dashboard). An interactive dashboard presents results per metric category by cluster and by institution.

Source: Research England (2021[139]), Research England (2021[140]), https://www.hesa.ac.uk/data-and-analysis/business-community

While the availability of a broader set of knowledge transfer indicators such as those developed by the Ministry of Science and Innovation can greatly facilitate this vision, it is also important to consider the importance of introducing complementary qualitative evaluation components to avoid falling into reductionist approaches that distort incentives towards what can be measured quantitatively. This could also encourage experimentation in the generation of evidence to support evaluation processes. The experiences documented in research and technology centres in Catalonia and the Basque Country provide relevant examples within Spain (see section 5.4).

In this sense, information systems should be improved in order to systematically collect such quantitative and qualitative data at the institutional level. This would allow conducting assessments not only based on traditional knowledge transfer indicators (e.g. patents, spin-offs), but also on a broader range of measures. It is important to complement these with qualitative data that inform the assessment of how results align with knowledge transfer strategies and missions set at the institutional level. For example, if universities and public research centres had access to data on the KTS applications of their researchers (which is currently not the case), this could help them have more precise knowledge of the KT activities conducted in their institutions, which could help them build institutional narratives.

6.2.4. An effective knowledge intermediation ecosystem

This report's analysis of the knowledge intermediation landscape in Spain has portrayed a dual system that combines TTOs, which are embedded within individual PSR institutions, with external independent intermediaries under a wide range of configurations, legal regimes and services provided (e.g. brokerage, hosting, legal services, technical services, investors) to both PSR institutions and businesses.

Technology transfer offices (TTOs)

Concerning TTOs, our analysis concludes that they have been disproportionately used for project management tasks that in other countries would be left to the core administration function of the organisation. The orientation of Spanish TTOs tends to be supply-driven and not sufficiently close to the marketplace and potential users. Their professionalisation and recognition within universities and PROs and their partners has been a long-standing challenge in Spain. As explored in section 3.3, to successfully achieve their mission, a wide range of competences are required from TTO professionals. These range from scientific and technological knowledge to understand the offer of technology and knowledge from research institutions and their potential applications in specific sectors and types of firms, to specialised legal and commercial capacities in order to connect to potential clients and advice and provide legal guidance in processing different types of agreements. Most TTOs however face limitations in terms of financial resources, as well as personnel dedicated to their different activities. Low recognition and high turnover in TTO personnel also hinders the professionalisation of such intermediary services.

Another challenge is the high level of fragmentation of those services, and the fact that a large share of TTOs do not have sufficient scale to be able to recruit professionals specialised in each of their diverse areas of activity, or are not able to devote enough time to activities other than the management of government or EU project funding calls.

Strengthening the role of TTOs is indeed one the priorities of the new Spanish STI strategy. In May 2021, the Ministry announced that strengthening TTOs was one of the main measures to be promoted thanks to the enhanced budget available through the Recovery, Transformation and Resilience Plan funded by the Next Generation EU funds (see section 6.1.1). The objective is to convert the TTOs into real 'knowledge transfer offices' by implementing a program to improve their capabilities. The development of such a programme has been entrusted to the INGENIO research institute (CSIC-UPV), targeted at three groups: management of universities, PROs and other entities such as TTOs and technology parks; knowledge transfer professionals from TTOs, research institutes, technology centres, science and technology parks an OTRIs; and young researchers, professors and PhD students in universities and PROs[131]..

Under the reforms that are underway, the possibility of providing once again direct funding to TTOs is under debate. One possible option would be to offer a flexible line of (competitive) financing to support strategic plans proposed by each TTO, over a period of 3-5 years, where each TTO would present a proposal requesting funding for different planned activities. These plans would be monitored and evaluated periodically (after the 3-5 years), and TTOs would be able to reapply for funding if they receive a positive evaluation.

[131] See https://www.ingenio.upv.es/va/investigacio/projectes/programa-de-dinamizacion-y-formacion-para-fomentar-el-intercambio-y-la

A priority objective should be to create more attractive career opportunities for professionals interested in working in TTOs. In the Spanish context, the traditional approach to achieve this goal would be to regulate the technology transfer officer's profession to offer better career development, more recognition and certified training. However, this would also imply rigidities[132] in what is otherwise a fluid role so we consider it only as a potential second best solution in comparison with institutional based incentives and autonomy for attracting talent into the organisation's TTO function.[133]

According to some interviewees, the Ministry of Science and Innovation and the Ministry of Universities could encourage the further professionalisation of Spanish TTOs by coordinating the development of a training programme with various modules that could be offered to TTO professionals across the country, including a certification after completing the programme. Compared with having multiple training programmes of heterogeneous quality, this would avoid duplications and enable reaching economies of scale. The initiative could also include entrepreneurship education modules targeted to researchers. It would be an umbrella programme coordinated by the central government but with participation of various actors as training providers, based on their expertise, including RedTRANSFER, regional actors, technology centres, research groups, more advanced TTOs, etc.

Furthermore, the regulatory procedures under consideration highlighted in 6.1 would also allow PROs to set up TTO functions under institutions better capable of mutualising services and attracting relevant external talent. In this regard, international examples suggest the possibility of creating national policy programmes to foster mutualising mechanisms for knowledge transfer and collaborative activity.

Different mutualisation models built around national, regional or sectoral axes have emerged in various countries (see Table 16). These new models are based on the association of several universities or public research institutes that pool services and complementary capabilities in order to improve efficiency and competency development (Guimón and Paunov, 2019[141]).

[132] The regulatory approach would most likely prevent attracting professionals from business with a better view of the commercialisation landscape.

[133] In addition to improving career development opportunities within TTOs, offering more training opportunities to help develop the commercial and soft skills of professionals working in TTOs could help them improve their ability to engage with businesses.

Table 16. Examples of mutualised TTOs established through consortia of universities/PROs

Country	Year launched	Scope	Brief description
Belgium	2014	Regional	TTO Flanders is a joint initiative of the TTOs of the 5 Flemish Universities that offers an online portal and aims to be a unique point of contact for industry and to increase the international orientation of technology transfer.
Chile	2016	Sectoral	Following a competitive call for proposals, 3 "Technology transfer hubs" were selected in 3 priority sectors (agriculture, health, and industrial production and energy). The hubs are decentralised entities whose shareholders are a group of at least six universities/PROs.
Colombia	2013	Regional	Six regional TTOs have been created through a call for proposals, as alliances between universities, research centres and firms. The aim is to build sufficient critical mass to operate more efficiently and to be able to provide high quality specialist services.
Ecuador	2017	Regional	University Hubs are formed as alliances between the main universities in each region, in order to jointly develop new services and infrastructure (e.g. incubators, Fablabs) to stimulate knowledge transfer. Up to now, 6 University Hubs have been created in the country, involving 55 universities.
France	2011	Regional	A total of 14 "transfer acceleration companies" (SATTs) have been created to co-ordinate the TTOs of universities/PROs within the regions. They have pooled certain functions of their member organisations (e.g. IP management) and developed new activities (e.g. innovation development).
Ireland	2013	National	A national TTO called Knowledge Transfer Ireland (KTI) was established in 2013 as a partnership between Enterprise Ireland and the Irish Universities Association, to complement existing in-campus TTOs with a more centralized structure to promote knowledge transfer. Among other activities, KTI has created a web for companies to explore the research resources available throughout the country.
Netherlands	2010	Regional	The Valorisation programme has led to the creation of 12 regional consortia to foster entrepreneurship education and knowledge valorisation. They typically focus on supporting researchers or students that want to start a technology-based business, but the programme is designed flexibly so that each centre can define its own mix of activities in view of regional needs.
New Zealand	2011	National	The Kiwi Innovation Network (Kiwinet) is a consortium of 16 universities and PROs that aim to share resources and provide common services to leverage the country's technology transfer capabilities.
Norway	2015	Regional	The Bergen Teknologioverføring (BTO) was set up in 2005 to serve all universities and PROs in the region of Bergen. Over time, other regions of the country have also established joint TTOs or merged existing ones to encourage critical mass and specialised expertise.

Source: Adapted from Guimón and Paunov (2019[141]) and expanded with examples from Ecuador and the Netherlands.

For example, in France, the *Investments for the Future Programme* led, with the allocation of EUR 900 million, to the creation of 14 Technology Transfer Acceleration Companies (SATTs), conceived as local/regional entities at the service of universities and research centres and their relations with the private sector. The SATTs are created by one or more research establishments and their mission is to detect and evaluate the inventions that emerge from them, pursuing value creation, an economic-budgetary balance in transfer activities and the simplification of the commercialisation scenario (Alves Baptista, 2019[142]; Technopolis Group, 2021[143]). A previous process of university mergers had taken place in the country, which facilitated the creation of such mutualised services. Although the results of the evaluation recently carried out point to clearly positive effects, the transferability of this model, with its high level of funding, from the French to the

Spanish decentralised context could present several difficulties. An alternative would be to create this intermediate layer at sectoral rather than regional level, focusing on strategic sectors or technologies for Spain and taking advantage of existing structures such as technology platforms, technology centres or cluster organisations. This could be achieved through an expansion of the Cervera programme for technology centres (see section 4.4).

In conclusion, areas of policy action that should be further explored in order to improve the capacity of those TTOs include the following:

- Entice PROs and universities to assess the effective demands from each TTO in terms of specialist and administrative staff, their resources and their delivery mechanisms.
- Explore opportunities and potential inducements for mutualising a range of scale-dependent services across several universities or research organisations of comparatively smaller size. This would allow reaching sufficient critical mass to offer more specialised services while sharing their costs. In some cases, specialist advice (such as patent and legal counsel) can be effectively outsourced.
- As part of a potential third mission stream funding initiative from central and regional governments, increase resources available to institutions for their TTO activities so that they go beyond engaging in administrative activities linked to the management of contracts and calls for proposals, and become real innovation offices. An option could be the establishment of a competitive funding line to support the implementation of strategic plans proposed by TTOs for a period of 3-5 years. Positive evaluation of the impact of such plans would allow them to apply to the next round of funding. Funding should be used, in particular, to:
    - Provide tailored and regular training to all professionals working in TTOs, both for new entrants and for more experienced professionals. Training should be provided by practitioners and domain experts, as is the case of courses provided by RedTransfer (the Spanish association of knowledge transfer professionals) or by ASTP (the Association of European Science and Technology Transfer Professionals). Such courses could be complemented by the establishment of mentorship programmes or secondments, where a member of one organisation spends time in another (Campbell, 2007[144]).
    - Promote the attraction and retention of a diversity of profiles to TTO positions, particularly from business, and consider the possibility of increasing the sectoral specialisation of professionals working in TTOs, so that their advice and services can be more targeted and ensure better matching between research offer and industry demand.
    - Support effective mutualisation and critical mass, as proposed above.
    - Promote a more effective communication between TTOs and the rest of their university/PRO to stimulate an internal culture of collaboration, for example by having TTOs engaged in the KT sexennium processes and better communicating overhead charges and revenue sharing policies.

Independent knowledge intermediaries

It is important to recognise the dynamicity and broad range of intermediary roles played by a wide range of institutions, in particular the technology centres that operate under the sponsorship of regional governments and multi-level regulation. Section 5 has discussed

the role of technology centres in detail, and made a number of recommendations concerning:

- Their scale, which in most cases is insufficient to attain a visible impact, and their limited degree of coordination. While it is important that technology centres cater for local business needs, their outlook needs to be more networked and pre-disposed towards interregional and international engagement and co-opetition if they are truly instruments in support of business innovation. In order to face the multiple strategic challenges and missions that are currently under discussion, technology centres also need to be endowed with an appropriate component of baseline institutional funding that encourages them to specialise on their core mission.
- A more consistent approach towards the convergent provision of human resources training as well as technological extension services alongside R&D and technical services, learning from abundant experiences in Spain and abroad.
- Their financial support structure. An excessive reliance on project-based private and public funding (at regional, national or EU level) can lead to contexts in which such intermediaries might see the need compete in spaces that are less core to their mission.
- The importance of ensuring a clear functional separation between advisory roles, operation on own account and the provision of services to third parties, to avoid potential conflicts of interest. This is critical to build trust among users of intermediary and technological support services.

Similar recommendations have been made in relation to clusters, S&T parks and other categories of intermediaries. Furthermore, it is key to ensure a critical mass around innovation and science-business links to support the long-term consolidation of a world-class, highly specialised cadre of professional firms with the capacity to provide world leading investment, legal and IPR advice and attract business from abroad to establish operations in Spain. Behind every successful innovation cluster there is a rich ecosystem of independent professional advisory firms. There should be greater facilitation of networking and horizon scanning in this space.

Developing a comprehensive map of the intermediation ecosystem across the territory, including both public and private institutions, would be highly desirable. This map, which should be interactive, easily accessible and contain detailed information of the catalogue of services provided by each actor, would be very valuable for firms (and particularly for SMEs), sometimes overwhelmed and confused by the multiplicity of actors in the intermediary ecosystem. Such a map could also be used by policy makers to identify possible gaps and overlaps in the provision of services by different publicly funded entities.

In view of the diversity of existing intermediation agents, formal registers of different types of actors serve important administrative purposes, but do not necessarily reflect a changing and complex reality, and often lead to excessive compartmentalisation of the scope of programmes. They should therefore be used with caution and be easily adaptable.

Given Spain’s territorial model, different regions should be able to adopt different strategies to strengthen their knowledge intermediaries, with different types of institutions adopting the leadership role.

Authorities could also promote the use of new technologies and more advanced data management systems to facilitate the process of match-making and in particular the re-use of research results financed by public funds.

6.2.5. Business capacities to engage with and benefit from public research

Available indicators and stakeholder feedback have repeatedly pointed out how, on average, Spanish firms invest little on R&D and other innovation activities, hindering their levels of knowledge absorptive capacity and thus their ability to recognise and realise the full potential benefit of engaging in collaborations with research organisations. The problem of capacity for collaborating and making the most of such collaborations can be broken in two main parts.

Firstly, the main challenge for Spain's innovation system is broadening the base of companies with fundamental innovation capacities across the entire economy and the motivation to ground their growth and survival strategies on knowledge. Industrial structure and other factors represent only partial explanations of a deeply ingrained problem that is reflected in low productivity levels and low demand for knowledge exchange with the research base. Without such a basis in place that can support the most basic forms of open innovation, it is hardly possible for companies to decide when and how to progress to greater innovation and knowledge maturity levels, a journey along which there will be opportunities for fruitful interaction with the PSR and trust building.

Secondly, for companies with a baseline degree of readiness to engage with the PSR, other challenges explored in this report include the lack of awareness of businesses of potentially relevant R&D capabilities in universities and research centres, and the differences in research agendas and timelines between business and public researchers. Mistrust (mostly due to the lack of previous interactions and the use of different 'languages' and prevailing cultures) is also preventing the creation of effective science-business ties that are appropriate to the reality of individual firms and collectives. As it has been referred to the OECD through different channels (interviews, surveys), instrumentalist approaches underpin first time approaches across sectoral boundaries that can give rise to misunderstanding, with businesses often expecting PROs to provide them with narrowly defined subsidised services, while researchers engaging with business have the sole motivation to further their existing research agenda with limited consideration for the actual business requirements and possibilities.

The policy response to this dual challenge requires specific attention, since it goes well beyond the objective of promoting science-business collaboration. Stakeholders coincide in identifying a disconnection between sophisticated technological innovation support policies on the one hand, too complex for a majority of business to attempt to engage in, and the capacity and interest of a majority of business to make use of PSR resources, let alone collaborating with it. Central government innovation support initiatives, perhaps with the exception of the R&D and innovation tax incentive regime, tend to operate at higher levels of technical maturity. This gap is left to regional government programmes, linked to regional development strategies, generating a complex mosaic of initiatives and agendas that is rather challenging for domestic and potential incoming businesses to navigate. Digital entrepreneurship support programmes are also construed as if they were not part of a whole-of-government innovation policy.

Some areas of policy action that could be further explored in order to improve the business capacities to engage with and benefit from public research include the following:

At the level of support programme design and implementation:

- Consider the possibility of introducing initiatives at the base of the innovation ladder, engaging business and engineering schools, in collaboration with Chambers of Commerce, to provide management capability support to small businesses to

upgrade their business plans, and identify the appropriate role of innovation within them.

- As the main mechanism to entice firms to formalise a range of innovation activities into systematic R&D, streamline the process and address current challenges that prevent a wider use of R&D tax incentives by firms, and consider the possibility of easing or enhancing tax deductions for collaborative R&D activities with the research base.
- Fine-tune the newly launched proof-of-concept programme to support advancement of TRLs of technologies developed in universities and public research organisations.
- Progressively increase the use of public procurement of innovation solutions, by building capacities within the administration to effectively implement such programmes.
- Explore the potential of implementing a national innovation challenges programme, building on the best practices implemented by some regional governments, incubators and large firms in Spain as well as those implemented in other countries, particularly during the COVID-19 crisis. Such challenges can be a driver for the creation of knowledge-based start-ups and the public procurement of innovation solutions and can also be a valuable mechanism to promote knowledge transfer and collaboration.
- Streamline and regularly update the information about the programmes available on the funding agencies' official websites. The creation of a one-stop-shop for the dissemination of information about all innovation and entrepreneurship support mechanisms available should be considered. The PI+D+I Network (Red PIDI), an information and advice service for firms interested in R&D and innovation public support programmes, can play a key role in facilitating firms' access to existing support and their actions could be further publicised among SMEs and multinationals alike. There needs to be a mechanism to engage regional governments and their agencies in this process.

Concerning business innovation support infrastructures:

- Create open innovation platforms to accelerate the matching and interaction across different actors. An example is the platform launched by *UPV innovación*.
- Invest in demonstration facilities that are open to firms, following other international examples such as the *Mittelstand* 4.0 Competence Centers in Germany. These infrastructures, which would also count with highly qualified experts, would enable firms to test new technologies in real-world environments.
- Set up joint centres for collaboration and co-creation (e.g. Catapults in the UK). These would not require the creation of new infrastructures, but the use and upgrade of existing ones and covering the staff and running costs with the contributions of private funding.
- Make use of existing technology platforms to compel companies, in collaboration with other actors, to agree in laying out technology roadmaps for existing and new sectors that can inform future science and innovation support planning.

Concerning Spain's innovation culture:

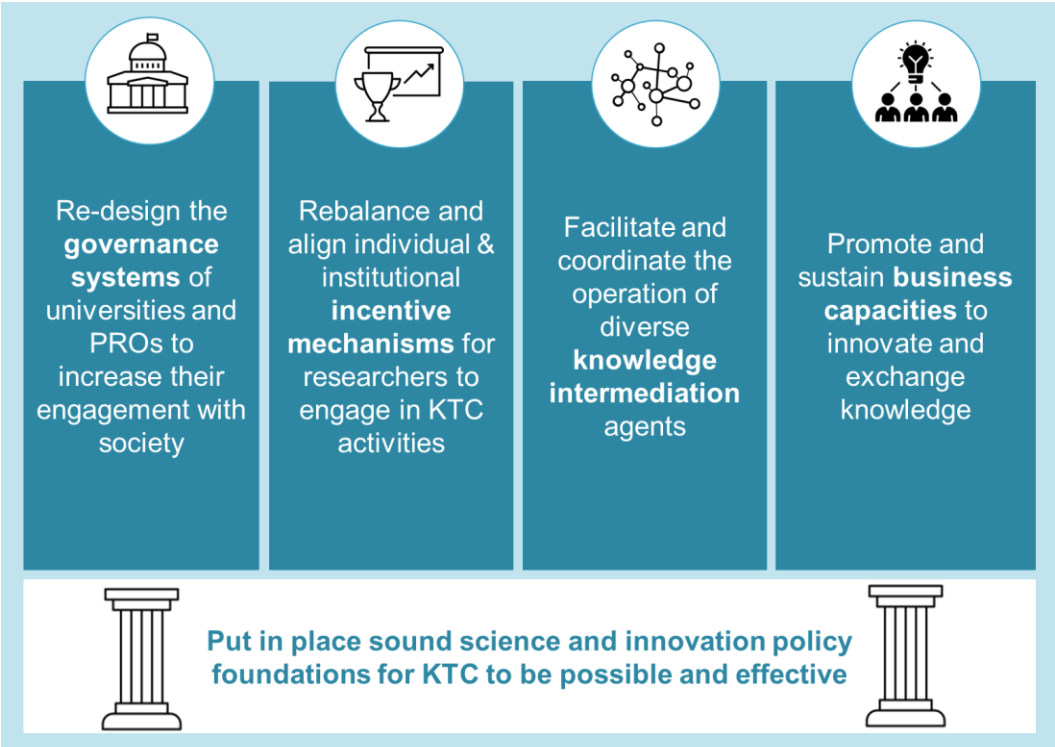
- Collaborate with the Ministries of Education and Universities as well as FECYT to build in innovation information and promotion initiatives aimed at students at all educational levels, not focusing solely on science and technology.
- Work with the National Statistical Institute, FECYT, COTEC and business associations to make effective use of innovation survey campaigns to alert firms about the intended scope of the surveys (not only aimed at R&D firms), their value to them and society, and ensure broad-based participation.

6.3. Final remarks – a call for action

This diagnostic and assessment report concludes with an emphasis on the ample opportunity space that is available to Spain's innovation system to achieve a healthier degree of knowledge exchange and collaboration across sectors. While there are significant outstanding challenges, even after taking ongoing reforms under consideration, there is a unique combination of conditions that make it possible to rethink, redesign and effectively address aspects of the system that have hindered its performance thus far.

This report does not aim to provide all the answers but to serve as a helpful conduit for public debate, enabling relevant policy actors to make well informed choices about which way to proceed. The recommendations that have been listed in connection with priority themes (Figure 59) touch upon incremental and more radical reforms, and call for greater use of co-creation mechanisms and use of evidence at all phases of the policy cycle.

Figure 59. Overview of priority themes for reform to enhance public research-business collaboration



Note: PSR stands for public system of research.
Source: OECD own elaboration

The experience from several European and OECD countries shows that reforms that enhance the performance of STI systems and their economic and social impact are possible and necessary at times of change. Realising the visions of the *España 2050* strategy requires Spain to make the best possible use of its public and publicly sponsored system of research and technology, and start doing it so through an action plan or roadmap that starts today and draws on the many accomplishments achieved to date.

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