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Opinion and Discussion Group on Political Economy

The whys and wherefores of R&D+i policy. The situation in Spain

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1. Economic growth and R&D+i

Economic growth is weak, while that of total factor productivity (TFP) is particularly so. Indeed, the latter goes a long way to explain the decline in potential growth since 2000 in advanced economies and, more recently, in emerging economies. Parallel to this, the relationship between innovation and economic growth is not easy to analyse because of the limitations of the traditional indicators used to measure research & development and innovation (R&D+i).

The hypothesis that R&D contributes to growth is widely shared (Romer, 1990; Aghion, 2006). In contrast, there is more debate as to whether public investment in R&D drives growth sufficiently enough to offset the opportunity costs of using public resources for this purpose.

Public incentives for innovation and the diffusion of knowledge can be successful by promoting human capital; by creating a business environment that is more conducive to innovation; and, by introducing economic policies that favour sustained growth.

The primary justification for the public support of R&D+i can be explained in terms of market failures: spillovers and high levels of uncertainty associated with R&D+i investment. Yet, public intervention might not be effective because of the displacement effect of private R&D+i, the difficulties of estimating the social rate of return on public investment or the consequences of "political capture" in the selection of projects.

For example, there is evidence that the effectiveness of tax relief in stimulating R&D+i is not especially great (OECD, 2016). Similarly, despite the apparently complementary nature of public and private investment in R&D+I in relation to public subsidies for private investment, in some cases public investment in R&D+i acts as a substitute for private investment (Veugelers, 2016a; IMF, 2016) .

In short, while debate still rages in most countries as to which budget items should be cut to maintain acceptable levels of deficit and public debt, a better line would be to recognise the importance of identifying which areas of public expenditure can guarantee future economic growth. In this way, to the extent that it is feasible, the debt-to-GDP ratio would be reduced.

Public policies associated with this objective give rise to a number of different questions (Mazzucato and Penna, 2015):

1) Direction of public policies. If these public policies aim to create new markets ("The important thing for Government is not to do things which individuals are doing already, and to do them a little better or a little worse; but to do those things which at present are not done at all" to quote Keynes), rather than creating the conditions for the optimum operation of existing markets, it is important to know how these policies have been implemented in the past and how a democratic debate on the direction to be taken by these policies can be stimulated that will ensure their social acceptance.

2) Evaluation of public policies. Traditionally, public policies have been justified on the grounds of market failures; yet, what is sought with these policies is not to act in existing markets, but in markets that have to be created. For this to happen, new indicators and assessment tools have to be developed that stretch well beyond static cost-benefit analyses.

3) Change of public organisations. By adopting these policies, public organisations take significant risks when taking decisions that are, by definition, more uncertain.

These organisations will have to learn to live with a system of trial and error in their decision-making, and they will have to integrate knowledge into their organisations as it is developed. To do this, they must have the capacity to envision and manage contemporary challenges.

4) Risks and rewards. How can a system be built in which public intervention serves not only to socialise the outcomes of unsuccessful decisions, but also to socialise the benefits of investment decisions that have been successfully implemented.

One example used to support the previous hypotheses is an analysis of what has happened in the commercial development of three of today's leading products: the iPod (the first generation of which was launched in 2001); the iPod *touch* and the iPhone in 2007; and the iPad in 2010 (Mazzucato, 2013). Each of these products incorporates a set of technologies that includes lithium-ion batteries, liquid crystal displays, microprocessors, signal compression technologies, multi-touch screen displays, GPS, voice-activated Siri, cellular technology and the Internet, among others, all of which were developed with public funds. Governments and other public agencies have supported these innovation policies, and have assumed the risks of taking these decisions, in anticipation of the rewards they hoped they would have for society as a whole. The market, above all during the initial stages of innovation, does not seem to be in any condition to assume the risks of investing in such projects.

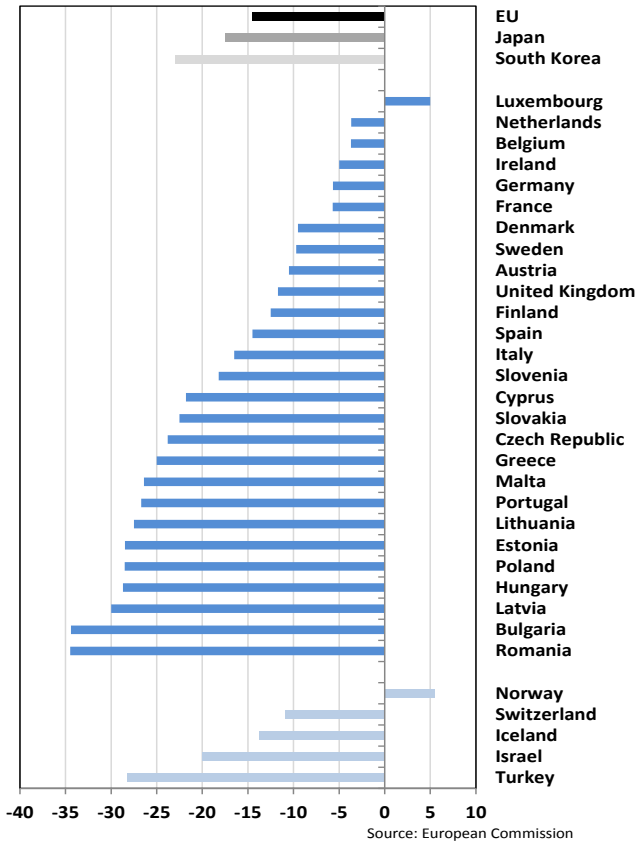
The relevance of this debate is undeniable, but it is certainly of greater relevance in the US or in the EU considered as whole, than it is at the level of individual countries such as Spain or its EU partners. What is better, to finance the same research 28 times or to do it once in the best research centres in the continent and to share the results?

The strengthening of the European Research Area must also help to build a more integrated European research policy. The orientation of resources to meet such challenges as guaranteeing energy supply, climate change, public health, ageing and guaranteeing the supply of water and food resources are obvious cases in point (Parellada, 2015).

2. The gap in labour productivity between the European Union and the United States

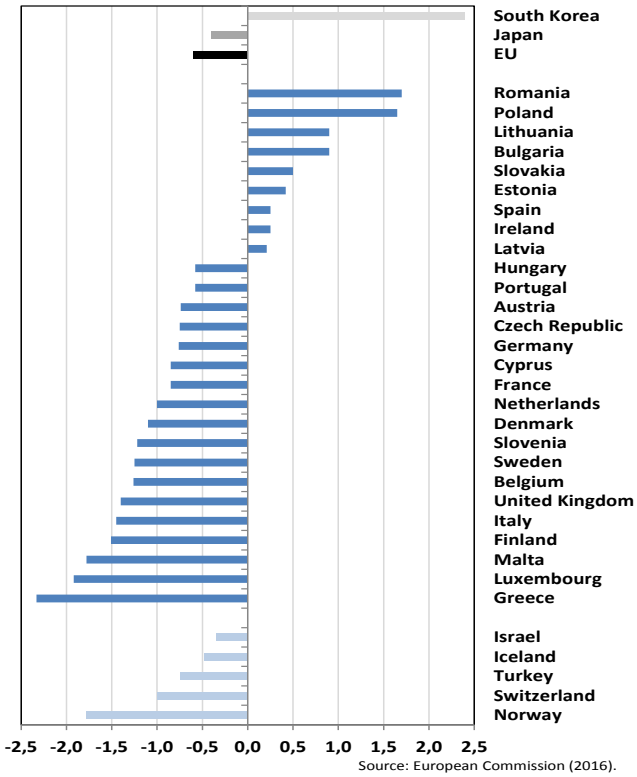
A recent publication by the European Commission (2016) provides up-to-date information from which we draw the following considerations. The gap in GDP and the rate of GDP growth between the European Union and the United States is largely due to the labour productivity gap, which continues to grow especially in the cases of the more developed European economies. Figure 1 captures the importance of this gap. No European country –with the exception of Luxembourg– has a higher level of real labour productivity than the United States, while the EU as a whole has a productivity that is 15% below that of the US. Furthermore, according to Figure 2, this gap between the EU and the US has increased in the period 2007-2013, although in this case some countries –most notably many Eastern European countries, as well as Spain and Ireland– have narrowed the gap with the United States.

Figure 1. The gap in real labour productivity (GDP per hour worked) between each country and the United States, 2014



Source: European Commission

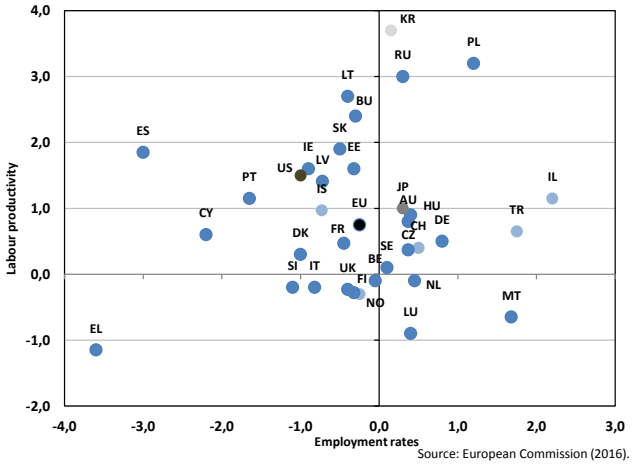
Figure 2. The gap in compound annual real growth in labour productivity (GDP per hour worked) between each country and the United States, 2007-2013



Source: European Commission (2016).

Despite these differences, both the European Union and the United States (Figure 3), as well as the majority of European countries, have seen their productivity levels increase in the period 2007-2013, but this has been achieved at the expense of a notable growth in rates of unemployment. This clearly provides no future guarantee of the sustainable growth of productivity and employment and points to the misuse of productive resources.

Figure 3. Real labour productivity versus employment rates (compound annual growth 2007-2013)

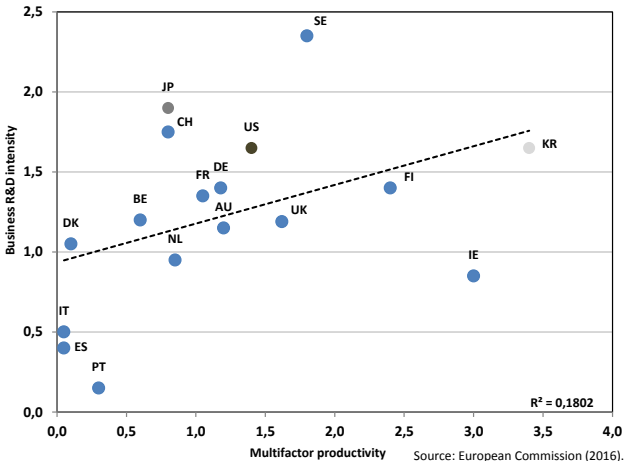


Source: European Commission (2016).

The growth in labour productivity depends on the capacity of national economies to increase the capital-labour ratio, by increasing capital intensity or increasing its efficiency (total factor productivity). Since the crisis, capital investment has fallen in most EU countries – with the exception of Ireland– while TFP has recorded zero or negative growth.

Many factors underpin TFP, but for most of the more advanced economies innovation and investment in innovation –that is, investment in R&D+i, in ICT and in human capital– are critical. Figure 4 shows the relationship between the investment intensity of business R&D (in relation to its turnover) in 1995 and the average annual growth in TFP between 1995 and 2007. It seems apparent that investment in business R&D is a relevant variable for accounting for differences in countries' productivity levels.

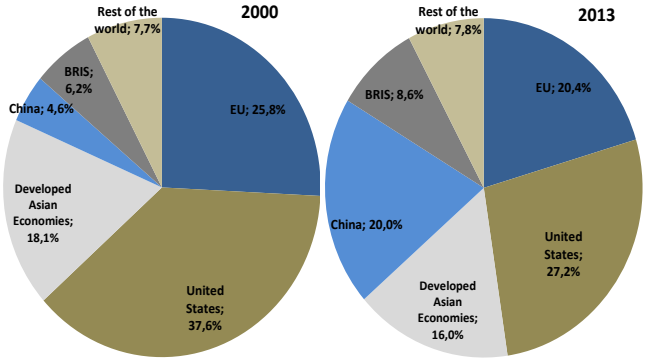
Figure 4. Business R&D intensity (1995) and multifactor productivity (average annual growth 1995-2007)



Source: European Commission (2016).

The diversity of growth recorded in R&D expenditure has led to a substantial modification of the contribution of certain countries to its global distribution. This is especially the case of China and the BRIS countries (Brazil, Russia, India and South Africa), who have seen their relative share in global R&D expenditure increase at the expense of the United States and the EU (Figure 5).

Figure 5. % distribution of global R&D expenditure by geographical area, 2000 and 2013



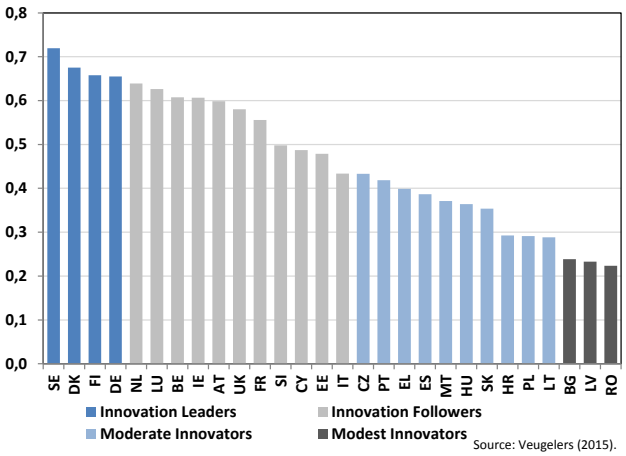
Source: European Commission (2016).

3. Innovation and intra-European differences

At the 2002 Barcelona Summit, in line with the Lisbon Strategy, the EU set itself the target of dedicating 3% of its GDP to R&D, an objective that has been maintained in Horizon 2020. Despite this, the percentage today stands at around 2% and continues to be lower than expenditure in the United States, Japan, South Korea and Singapore. In contrast, Chinese investment in R&D has undergone rapid growth.

Failure in this respect calls into question the policies implemented to date. Veugelers (2015), for example, recites a litany of weaknesses: insufficient public funding, inadequate governance, no real commitment beyond rhetoric, inefficient use of instruments and a lack of effective instruments.

Figure 6. Summary Innovation Index (IUS), 2014



Source: Veugelers (2015).

A further reason for not achieving this target are the marked differences between EU countries as regards their ability to innovate, as Figure 6 highlights. Moreover, the process of convergence between these countries has proceeded very slowly, while the crisis appears to have brought it to a complete standstill (Table 1).

Table 1. EU IUS trends, selected country groups, 2006-2013

	2006	2008	2010	2013
Average EU	0,49	0,50	0,53	0,55
Variation in innovation capacity	0,39	0,36	0,35	0,35
Innovation leaders (DK,FI,DE,SE)	0,67	0,68	0,70	0,72
	Performance relative to innovation leaders (= 100)			
Innovation followers (NL, BE, UK, IE, AT, FR, LU, SI, EE, CY)	76	79	79	81
Moderate innovators (IT,CZ, ES, PT, EL, HU, SK, MT, HR, LT, PL)	47	48	49	50
Modest innovators (LV, RO, BU)	27	31	33	30
Central and eastern Europe	42	44	45	46
Southern EU countries (AL, IT, ES, PT, CY, MT)	52	57	57	57
High fiscal consolidation countries	48	50	51	51

Source: Veugelers (2016*b*).

A key factor in accounting for the differences between the European countries on the European Commission's Innovation Union Scoreboard (IUS) is private R&D expenditure, as it is for explaining the differences between the EU and the United States. While there are no differences between the EU and the US in terms of the relationship between public R&D expenditure and GDP, in the case of private spending, the EU ratio is 57% that of the United States. The persistent divergences between European countries in private R&D investment explain the EU's difficulties in catching up with the innovation leaders, both in terms of R&D expenditure and in their capacity to innovate. The EU's score on the IUS as a whole stands at just 81% of that of the United States.

The differences highlighted by the innovation indicators are best captured by establishing four blocks of countries: innovation leaders, innovation followers, moderate innovators and modest innovators. By way of indication of these notable divergences, and in terms of their scores on the IUS, the group of modest innovators obtains a score that is around 30% of that of the innovation leaders, while the moderate innovators, among which we find Spain, obtain a score that is around 50%. The differences are not only manifest between Central and Eastern Europe but also, and more persistently, between north and south (Table 1).

Despite the differences between the EU countries in relation to the different components of the IUS (Table 2), the relevance of their innovation policy instruments and policy mix is relatively similar with the exception of the greater support for the relationship between the public and private sectors among the innovation leaders (Table 3).

Table 2. The components of the IUS: the divide in Europe

	Human resources	Public research systemsource	Finance	Investment	*Linkage*	Intellectual assets	Innovators	Economic effects
Average EU 2006	0,46	0,40	0,57	0,45	0,50	0,51	0,51	0,53
Average EU 2013	0,58	0,53	0,56	0,42	0,55	0,56	0,55	0,60
Variation in innovation capacity, 2006	0,32	0,64	0,49	0,35	0,46	0,65	0,51	0,36
Variation in innovation capacity, 2013	0,24	0,58	0,43	0,43	0,49	0,51	0,48	0,31
Innovation leaders, 2006	0,64	0,53	0,69	0,63	0,79	0,72	0,78	0,61
Innovation leaders, 2013	0,74	0,67	0,71	0,62	0,77	0,78	0,76	0,66
Performance relative to innovation leaders (=100)								
Innovation followers, 2006	83	86	72	75	74	59	79	85
Innovation followers, 2013	89	91	78	71	90	71	73	84
Central and eastern Europe, 2006	64	26	45	62	40	23	36	52
Central and eastern Europe, 2013	76	29	55	49	41	34	37	55
Southern EU countries, 2006	55	47	40	61	48	35	56	69
Southern EU countries, 2013	59	55	41	50	58	50	59	72
High fiscal consolidation countries, 2006	64	41	43	64	45	29	46	58
High fiscal consolidation countries, 2013	73	44	48	46	46	38	47	66

Source: Veugelers (2016*b*).

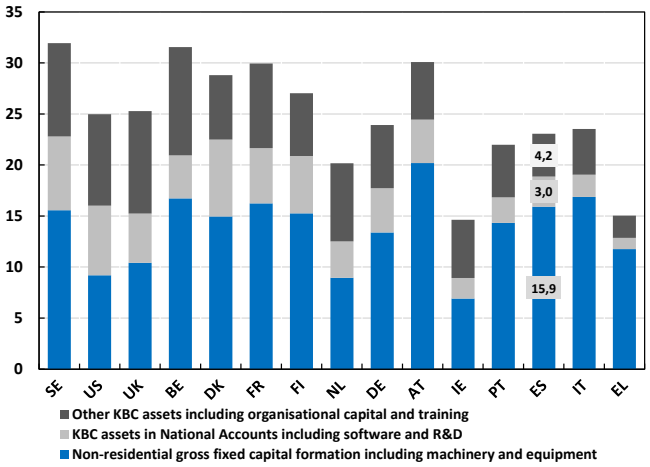
Table 3. Policy instruments

	Implementation, number of countries			Relevance
	Ever used, 1990-2013	Stopped before 2010	Started after 2005	(% overall funding)
Competitive funding of research	25	0	0	18,43%
innovation support service	26	3	4	0,13%
Direct business innovation support	25	2	2	9,77%
Support to start-ups	24	1	5	2,01%
Human resources support for R&D	24	3	3	4,22%
Collaborative R&D programme	24	1	2	11,82%
Direct Business R&D support	22	3	1	9,91%
Technology transfer	18	6	3	2,77%
Financial instrument	18	2	5	11,36%
Cluster initiatives	18	5	8	1,04%
R&D infrastructure	17	2	6	3,54%
Innovation skills development	16	3	0	4,79%
Innovation vouchers	14	0	11	0,07%
Support to venture capital	13	4	2	4,55%
Spin-off support	13	5	3	0,24%
Mobility schemes	13	4	7	0,43%
Centres of Excellence	13	5	7	1,35%
Tax incentive	12	0	1	8,75%
Innovation networks and platforms	12	7	5	1,35%
Awareness raising	11	5	5	0,17%
Incubators	10	7	2	0,70%
IPR measures	9	3	3	0,30%
Regional programme	7	3	1	0,71%
Science and technology parks	4	3	3	0,59%
Conmpetence centre	4	0	2	0,41%
Public procurement	3	0	4	0,30%
E-society	3	3	1	0,14%
Public sector innovation	2	0	1	0,15%

Source: Veugelers (2016*b*).

Likewise, the differences between the European countries are also evident in the different distribution presented by private investment in fixed and knowledge-based capital. The information provided by the OECD (2015), in Figure 7, identifies the weight of non-residential gross fixed capital formation in relation to corporate GVA for each of the countries considered, investment in knowledge-based capital and investment in other assets including organisational capital and training. The figure shows that while there are countries, such as the US and the United Kingdom, in which business investment in knowledge-based capital is 1.5 times that dedicated to fixed assets, in others, notably Spain and Italy, investment in knowledge-based capital barely represent half of that made in fixed assets. Presumably, this behaviour is another reason that explains the mediocre standing of the Spanish economy in terms of the Innovation Union Scoreboard (IUS).

Figure 7. Business investment in fixed and knowledge-based capital (KBC), selected economies, 2013 (*as a percentage of business sectors' gross value added)*)



What can be done to reduce the differences in the respective innovative capacities of the countries of the EU?

National policies could be complemented in one way or another by those of the EU: the Horizon 2020 Strategy and the Structural and Cohesion Funds could be used to complement State expenditure, especially in the case of those in high fiscal consolidation mode.

The lack of correlation between policies promoting innovation and the results obtained points to the need for a more rigorous assessment of the policies adopted. With the instruments available to it, the EU can strengthen its recommendations to Member States with regards to the implementation of its policies and also complement the R&D expenditure of the Member States in high fiscal consolidation mode (Veugelers, 2016b).

Fiscal policy plays an important role in promoting innovation, so that sound fiscal stabilisation policies can help firms maintain their R&D+i spending.

It is essential that tax incentives for R&D+i be carefully designed in order to avoid high-cost tax policies in relation to the amount of innovation actually fostered.

Along with a sound fiscal policy, the capacity to absorb technologies from abroad requires better institutions, better education and more infrastructure. In addition, well-designed tax relief should target new firms, and so promote entrepreneurship and innovation (IMF, 2016).

4. What policies and what reforms should Spain adopt to promote science and innovation?

As indicated, empirical research has shown a correlation between long-term productivity increases and the presence of high, sustained levels of investment in R&D+i activities. It has also shown that firms that invest in R&D and other intangibles in a sustained fashion enjoy competitive advantages. It, therefore, follows that the good health of the science and technology system is fundamental for the medium- and long-term development of an economy that promotes the well-being of its citizens by means of parallel increases in productivity and employment (European Commission, 2017).

On the basis of this evidence, various questions can be posed: Do Spain and Spanish firms invest what is necessary –or at least enough– in research and innovation, to provide the bases for increased productivity, sustained growth and higher levels of well-being? Are the public policies designed by the various tiers of Spanish government (State Administration and the Autonomous Communities) and their portfolio of instruments sufficient for achieving their objectives? Is the quality of the institutions that make up the country's system of science and innovation high enough to guarantee their contribution to the long-term improvement of the economy by providing research excellence and responding to the challenges of Spanish society?

The goals of the R&D+i policies can be summed up in relation to three elements that we derive from our diagnosis of the problems of the Spanish system of science, technology and innovation (see ERAC, 2014):

Invest more in R&D. The volume of resources that the country, and especially its firms, invests in R&D and innovation is very low.

Optimise the efficiency of public expenditure in R&D and its instruments. Public expenditure in R&D (both its direct implementation and promotion) is a highly significant factor and steps must be taken to guarantee that the composition of the portfolio of R&D+i actions and instruments and their efficiency meet the two basic objectives of spending policy: that is, promoting greater private R&D expenditure and improving the quality and excellence of public sector research, as well as increasing its contribution to tackling society's challenges.

Improve the institutional quality of R&D organisations. The institutional quality of certain R&D elements and organisations in Spain's public system can be improved. Good institutions and good governance are key for the optimum functioning of the processes of production, and for the valorisation and appropriation of knowledge.

4.1. Investment and resource levels for R&D

As we have seen, Spain lags behind the rest of the EU, which in turn lags behind the US, both in terms of global R&D expenditure in relation to GDP, as well as in terms of the poor contribution by the business sector to this expenditure and, consequently, its limited innovative performance.

Moreover, as a result of the crisis that broke out in Spain in 2007, there has been a significant reduction in public and private expenditure and investment in R&D+i, as well as a decline in the R&D capacity of firms and public research entities, which has reversed the process of convergence with the rest of Europe that had been initiated in the first part of the last decade (Figure 8).

The overall gap with the European and OECD mean rates of R&D investment has widened in recent years, but the main cause of this lies in very low rates of business enterprise investment (Figure 9). The origins of this can be found, on the one hand, in the limited number of firms that undertake R&D and that invest in innovation and, on the other, in the very low rates of investment effort of firms that undertake R&D in relation to their turnover or gross value added (i.e. their R&D intensity). All this is undoubtedly related to the sectoral structure of the Spanish economy, with the greater presence of micro-firms and with the difficulties firms, and especially SMEs, face in obtaining adequate financing.

Figure 8. Evolution on R&D expenditure as % of GDP. 1995-2015. Spain-OECD-EU (Differences with Spain)

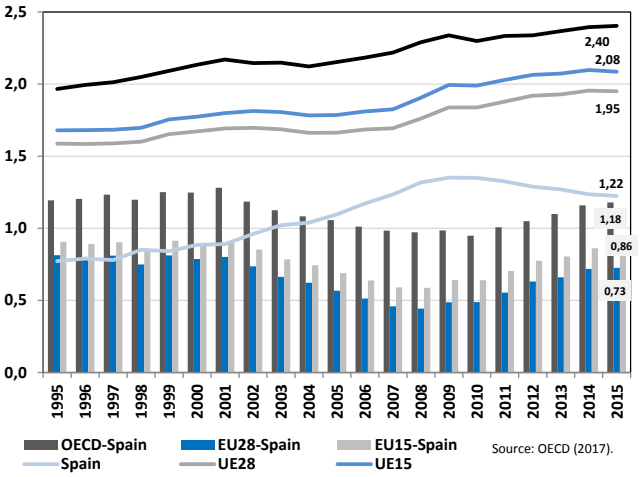
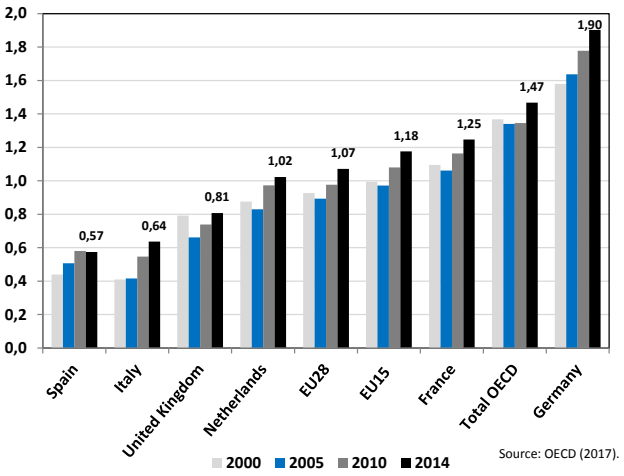


Figure 9. Business enterprise expenditure on R&D as a percentage of GDP. 2000-2014



The aggregate spending of the public R&D sector does not differ greatly from the mean values of the EU countries, but, against the backdrop of the fiscal consolidation of the Spanish economy, R&D+i policies have lost their importance in the political and budgetary agenda of recent governments. The main political priority in relation to R&D+i has been to contain public expenditure, which has led to a fall in public support for R&D and business enterprise innovation (at a time when it was necessary to act in a countercyclical fashion), as well as to radical cutbacks in direct transfers to universities and public research bodies (*organismos públicos de investigación*, henceforth OPIs) and a strict control of the replacement rates when research posts become vacant (including the non-renewal of fixed-term contracts). All these measures have been accompanied by an increase in administrative controls on any kind of expenditure, together with a marked bureaucratisation of all procedures as a containment tactic (Cruz-Castro and Sanz-Menéndez, 2016).

Moreover, in general, the policy of containing budgetary expenditure, both that of the Government and that of the universities and OPIs, has not been selective in its approach, but has focused on the budgetary items that are easiest to reduce (competitive funding, which tends to be assigned most closely on research merit). New public calls for competitive R&D financing have been delayed, their funds having to be approved each year by means of extraordinary credits. In universities and public research bodies, especially in the Spanish National Research Council (or CSIC in its Spanish acronym), in order to reduce conflict, the cutbacks have had a very uneven impact across CSIC's research groups, contributing to the ejection from Spain's R&D system (basically towards other European countries) of a generation of talented researchers. This in turn has accentuated the ageing of university and OPI workers to worrying extremes (Cruz-Castro and Sanz-Menéndez, 2016). The more selective funding mechanisms supporting business enterprise R&D have also been badly affected, with a reduction, in both absolute and percentage terms, of subsidies for R&D projects (a fall in the public funding of private R&D from 18% in 2007 to 9% in 2015), while the weight of tax relief for R&D+i, by definition both less selective and effective (Busom *et al*., 2014), has remained stable and has even grown as the economy has begun to recover.

Thus, the available data and empirical evidence indicate that Spain is spending very little by way of preparing itself for the future and that it needs to invest more in R&D+i. The general budgets of both the State and the Autonomous Communities need to do more in this area, both in terms of competitive funding and in direct transfers to universities and OPIs, although in the latter case what is perhaps needed is a review of current funding models.

However, despite the general economic upturn, it does not seem likely that the public administration will be able to increase the budgetary appropriations for R&D in any significant or sustainable manner, given the current level of public deficit, the more than likely rise in cost of Treasury financing, and the demands made by sectors with greater political clout (pensions, health, education), etc. Yet, in favour of calls for a greater budgetary effort from the State for the R&D sector, especially for funding allocated via competitive

mechanisms, it is significant that a large relative increase in this sector would have a very limited effect on the General State Budget, given its low budgetary volume. For example, according to the Working Program for the State's R&D+i Plan, the main calls for funding under its management between 2013 and 2016 provided, on average, around 600 million euros each year in subsidies (chapter 7 of the budget), which means a relatively small budget increase (e.g. 10% per annum of this figure), instituted each year over a four-year period, would give the State Administration considerably more room for manoeuver, both to improve the quality of its policies and to contribute to achieving the R&D expenditure target committed to by the Government for 2020 (i.e., 2% of GDP). In fact, it should be recalled that the European Commission (2016) estimates that the Spanish economy will have had to increase its R&D expenditure by 8.9% annually between 2014 and 2020 in order to reach this 2% target by the year 2020.

4.2. Optimising the efficiency of the policies and improving the instruments of the State's R&D+i Plan

Thus, given the limited capacity to increase public resources for R&D and innovation, public actions need to focus on increasing the efficiency of R&D funding programs and instruments.

Theories of public policy typically presuppose a rational model; thus, it is expected that government interventions will tend to solve the problems identified in the sector concerned. However, these theories also point to the tendency for the instruments of public policy to become institutionalised, due to problems of capture or of vested interests, or simply because of bureaucratic inefficiencies. Moreover, public policies and their instruments are heavily influenced by the moment in which they were devised, by the critical elements that were brought together in their definition, and by the paths that they have taken in their implementation, especially in the absence of learning cycles derived from the assessment of the results of using the instruments (something that does not occur in the public policy arena in Spain).

It should be borne in mind that the number and design of existing instruments, and their adequacy to meet the needs and objectives of current policy, and even the level of resources allocated to each, may well be the result of tradition, vested interests, or of the budget cycles that derive from the expenditure prepared on a multi-annual basis. All this makes a change in direction difficult, since it is easier for inertia to impose itself (especially in times of the stagnation of resource availability) than to take the necessary steps to define and design instruments of intervention that meet current needs for improving the system.

As part of a long-term recovery strategy, the Government must do more to promote R&D and innovation, but above all it must do better with regards to those areas that depend exclusively on government initiative. The National Reform Program (Government of Spain, 2016) is, with regard to R&D, extremely unambitious, which indicates how low it ranks on the political agenda.

In the meantime, since the Spanish Strategy for Science, Technology and Innovation (2013-2020) and the State Plan for Scientific and Technical Research and Innovation (pending approval for 2017-2020) serve as the coordinating frameworks for the State Administration's actions to promote R&D, the instruments and tools to implement these action need to be overhauled and improved. This should be done in order to increase the quality of research, promote excellence, and facilitate technology transfer and use. A labour market should also be created that facilitates mobility, openness and the circulation of knowledge. All this should be done, however, without overlooking the fact that the chief objective is to promote private R&D and the development of knowledge aimed at addressing society's main challenges.

Public policies designed to coordinate and manage the system need to undergo changes, so that they can better promote reforms that foster research excellence at the cutting edge of knowledge. This applies equally to curiosity-driven or blue skies research; research produced in the context of its use; as well as research which helps tackle the challenges faced by society and foster the modernisation of the production process, by means of innovations and the expansion of knowledge-based activities throughout the economy.

In fact, the structure of the programs of the State's R&D+i Plan, as determined by the Spanish Strategy for Science, Technology and Innovation, is more than appropriate for organising key interventions in R&D and innovation policy.

However, the State Plan (2013-2016) was characterised by a large number of instruments, and a very high degree of fragmentation of these instruments, as well

as by many overlapping functions and the absence of any synergies. For all these reasons, what is required is the rationalisation and restructuring of the instruments of competitive funding with the aim of reducing this fragmentation, and correcting the inertia that has established itself over the years and which is traditionally –in the absence of any assessment of efficiency– the only guarantee of continuity of many existing programs.

In summary, the main lines of government action in the area of R&D+i policy, and which need to be included in the State Plan for achieving the objectives outlined above, should be:

- Boosting business enterprise R&D and innovation by intensifying and expanding the number of innovative firms and promoting the creation of new firms.
- Promoting and strengthening joint public-private R&D+i initiatives to exploit the extraordinary scientific and technical capacities existing in universities and in the public research sector.
- Supporting the creation of new R&D capabilities.
- Contributing scientific and technological solutions to the challenges identified within European and Spanish society (digitisation, health, the environment, energy, etc.).
- Fostering research excellence, both curiosity-driven research and that aimed at solving social and global challenges.

Below, we define two main lines of action according to the main target groups: a) strengthening and promoting R&D+i in firms, and b) supporting and fostering public research excellence.

a) Strengthening R&D+i in firms

As stated, the main challenge facing Spain's R&D+i policy, in the short and medium term, is increasing levels of private investment in science and innovation. Here, we begin by analysing the challenges firms face and what public actions are required to promote the productive economy, technological modernisation and innovation as sources of competitiveness and employment.

Spanish firms, in a context of growing international competition, need to strengthen their technological capabilities and their ability to produce and use new knowledge in their business environment. While their competitors in other countries invest very high percentages of their turnover in R&D, Spanish firms need to boost this effort to prepare for the future.

Public policy, therefore, seeks to promote increased private investment in R&D+i, to intensify the efforts of those firms that already conduct research and, above all, to add to the number of firms undertaking R&D+i activities and which to date have not carried out their own R&D projects. If we break down the objectives of public intervention aimed at increasing private investment in R&D, suitable actions could be grouped around three major targets:

1. The main aim is to promote the financing of technologically advanced R&D projects with opportunities for commercial success (using commonly applied methods that combine traditional lending instruments and subsidies) that can ensure the financial additionality of private investments, as well as providing access to capital markets for the development of business enterprise projects based on technology and knowledge. In this way, the goal is to increase the intensity and to expand the base of firms that engage in R&D.

2. In addition, given the limited capabilities of firms to absorb knowledge, due to the qualifications of their personnel, it is essential to improve business enterprise R&D capabilities by promoting recruitment programs for highly qualified research staff and other actions to improve knowledge absorption capabilities.

3. Finally, given the distribution of scientific and technological capabilities within the Spanish R&D system as a whole, it is essential to promote business cooperation for R&D+i: on the one hand, that driven by market leaders working closely with other firms, universities and R&D centres; and, on the other, public-private cooperation aimed at promoting access to new knowledge for the productive sector.

Promoting private R&D investment

What principles should guide the State's action in promoting private investment in R&D+i? As discussed, public sector intervention needs to resolve market failures, correct imperfections in the way the system currently works, and promote spillovers across the economy.

Public actions in support of private R&D+i need to be based on clearly established principles, that is, projects

underpinned by excellence as regards their technology and market potential. Actions should preferably be based on horizontal approaches and not discriminate by area or sector; they need to address both market failures and systemic inadequacies; and, they should seek to reduce funding and capital constraints that might hinder the undertaking of high-risk, but potentially high-return, technological projects. National and regional government actions should only be undertaken in carefully assessed cases and should avoid the temptation to "select" certain sectors or technologies. This does not mean that they should not prioritise support for R&D+i as a mechanism for addressing social and economic challenges or for facing the broader challenge of digitising the economy.

However, when providing support for a specific intervention, it is first necessary to resolve any financial market failures that might limit access to funding for firms seeking to initiate innovative projects (OECD, 2017b). Likewise, the conditions need to be created to reduce the risk associated with the investment uncertainties of many of these projects, especially in their initial stages of development. At the same time, the group of innovative enterprises should be expanded, favouring the creation of new technology- and knowledge-based firms, guaranteeing support and advice, as well as the necessary access to capital in the initial stages.

In a context delimited by the European Union's state aid framework, the Spanish Government needs to instigate a dynamic policy to promote R&D+i activities among its business enterprises, by combining its use of a range of instruments. Clearly, the first step has to be the prioritisation of public resources for R&D and this needs to be done in the most efficient programs that also promote private investment. It should not be forgotten that the Government has at its disposal at least three mechanisms for supporting business enterprise R&D and which can be considered jointly: the first is that of tax relief for R&D, which in 2014 represented a total corporate tax (liquidated in those Autonomous Communities belonging to the common system) of more than 300 million euros, concentrated above all in large firms. The second constitutes subsidies for undertaking R&D+i projects, which represented about 600 million euros for all the Autonomous Communities. The third is the work of different public sector entities (CDTI, ENISA, ICO, AXIS, etc.) in their role as non-banking financial intermediaries for the granting of loans (at favourable rates, fully or partially redeemable, etc.). In addition, some of these public intermediaries have already had significant dealings in the area of venture capital, participating in investment funds or firms, as well as, in general, in investment capital.

Special attention should be given, in the general framework of the instruments that are available, to a careful re-examination of the conditions, implementation and effects of tax relief for R&D+i projects on the additionality of R&D investments (Busom *et al.,* 2014), as well as of ways in which their management and integration with other instruments might be improved, to determine if there is a better alternative and more effective use for the hundreds of millions of euros that are allocated each year to this goal.

An additional line of public policy that requires strengthening is that of guaranteeing the conditions for creating new, knowledge-based firms, especially in their initial stages, by providing appropriate mechanisms of promotion and of securing funding and venture capital. Facilitating funding and leveraging capital resources, via the promotion of venture capital funds, and even by using new micro-investment mechanisms for venture capital projects guaranteed by proven technical expertise, could be especially interesting in helping entrepreneurs launch new technology-based businesses and, at the same time, represent new investment opportunities for savers. This would complement traditional portfolios of policy instruments supporting R&D and innovation (subsidies, soft loans, etc.). In the case of these "traditional" instruments, special attention should be paid to the vital need to support and advise SMEs. The instruments for supporting business R&D+i projects need to be adapted to the SMEs with specific funding or external resources, since they are the ones that face the most obstacles in the search for finance.

Finally, the potential for the selective use of other instruments, such as innovative public procurement, should be re-examined.

Increasing the scientific and technical capabilities of Spanish firms

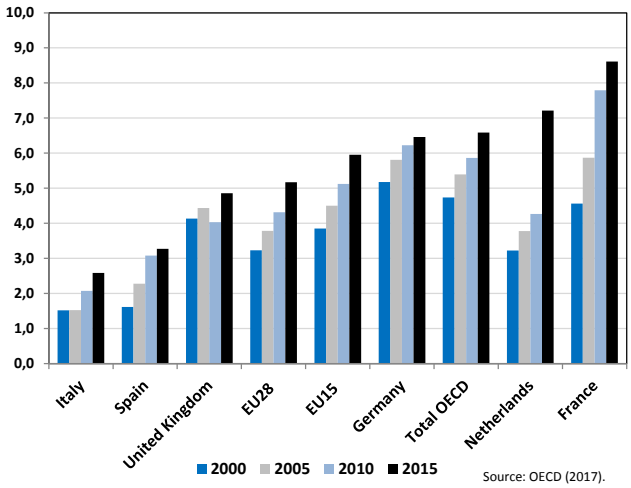
One of the factors that accounts for the limited business enterprise investment in R&D+i is the level of education and training of Spanish workers and, as a consequence, the low level of scientific and technological capabilities to be found in the country's firms.

Spanish firms have a limited capacity to absorb available knowledge, which in turn restricts their application of it and their direct contribution to producing it.

It is well-known that the number of researchers in the private sector is highly limited (Figure 10) and that the level of qualification of Spanish firms is lower on average than that encountered in neighbouring countries.

Public intervention to promote the technological capabilities of firms, as well as indirectly to foster the expansion of the labour market of researchers trained in the public sector, is essential to increase the scientific and technical capabilities of firms.

Figure 10. R&D personnel per 1000 employees in private firms, 2000-2015



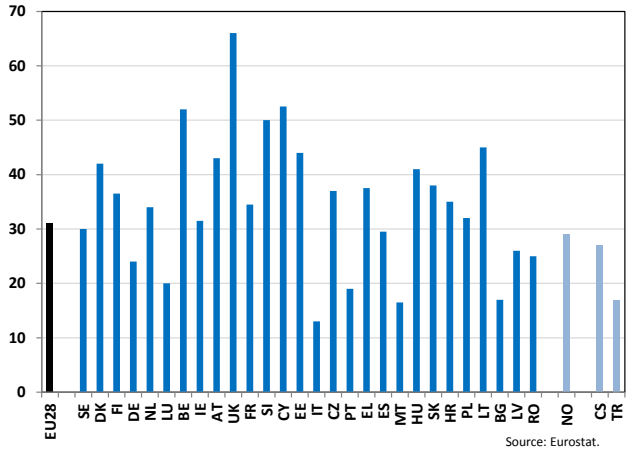
Promoting joint R&D+i projects and public-private consortia

Spain is marked by a systemic paradox: its main scientific and technological resources are to be found in the public research sector. Given the concentration of scientific and technical capabilities available in the public R&D sector, it is essential that efficient instruments are designed to support R&D cooperation and to promote the creation of public-private consortia, in order to exploit to the full the scientific and technical capabilities of the public sector.

From the perspective of Spain's innovation system, it is essential that the outstanding scientific and technical capabilities of the country's universities and public R&D centres be fully exploited. There have been many examples, both of support for joint projects and for technology transfer, as well as of large public-private consortia that have initiated major R&D projects involving large firms, SMEs, public research centres and universities. For instance, the CENIT Program, which has had a positive impact, serves as an ideal model for guaranteeing structural links between actors. Here, the driving role taken by the major firms has been a highly positive element for the subsequent incorporation of SMEs and other actors. Currently, on a smaller scale, the CIEN Program is operating in a similar fashion.

Promoting cooperation in innovation activities, fostering technology transfer, especially to SMEs, is another important dimension of R&D policies in this field, given that the levels of cooperation shown by Spanish firms are markedly worse than those of their neighbouring countries, which is a handicap when seeking to ensure appropriate access and exploitation of knowledge sources (Figure 11). Active participation in joint R&D funding programs, as represented by many Horizon 2020 instruments (H2020), provides access to essential business opportunities.

Figure 11. Innovative firms engaged in any kind of cooperation, 2012 (in %)



To achieve this, budgetary and financial resources must be available, but above all a strategy must be followed to simplify and integrate existing instruments (grants, loans, tax relief, venture capital funds, etc.) within a portfolio that can be used in an integral fashion. Such a system should eliminate all overlaps and ensure the more efficient management of the agency responsible for the policies.

In 2015, Spanish firms invested almost 7,000 million euros in R&D; 9.4% of that, just under 650 million, were financed (subsidised) by the various public administrations (in 2008, public funding reached almost 1,500 million euros). To this we should add corporate

tax relief. In addition, the CDTI, the main public agency responsible for developing industrial technology, provided financing, mainly via loans, to the tune of slightly less than one thousand million euros. On the basis of these figures, some estimates indicate that, over the next few years, the availability of 1,500 million euros of public funding each year for financing R&D+i loans (to which can be added some specific subsidies for some instruments –non-reimbursable aid– and indirect aid from tax rebates) should facilitate the leverage of a considerable sum of private capital, which would boost the number of firms conducting research, though at all times guaranteeing the additionality of the investment and not its substitution.

Which public institution has the capacity to carry out this strategy, either directly or by coordinating other public actors? Fortunately, the CDTI has responsibility for most of the horizontal instruments for promoting business enterprise R&D+i and, over the years, has consolidated its technological capabilities with the capacity to determine financial risk and opportunities for market success. The problem here is not so much the capacity of the CDTI, but rather the existence of many other operators at the level of both the State (ENISA, etc.) and the Autonomous Communities that need to integrate these strategies and improve their coordination.

b) Promoting research excellence in the public sector

The second major objective of Spain's R&D policy should be to support research excellence in the public research system. At present, this objective does not have the importance it should be assigned, with some exceptions, such as the centres run by Severo Ochoa and Maria de Maeztu. The current situation is characterised by an excess of differentiated, separate *ad hoc* instruments, which fail to offer the necessary synergies and complementarities with the main goals of public sector R&D. The objectives of this sector (comprising universities and the official R&D bodies), by resorting to the competitive funding instruments included in the State R&D+i Plan, are to reduce the number of instruments available, while guaranteeing their synergies.

It is essential that the fragmentation of State instruments be radically simplified and limited. The growth in the number of instruments and calls for funding recorded in recent years is not an efficient way to improve the processes of resource allocation or to reduce management costs. Improving efficiency will also involve a reduction in costs, which should include those incurred by firms involved in the application process (as well as the evaluation of their projects) for competitive R&D funding.

In order to improve the implementation of the competitive funding programs, it is essential that the autonomy and independence of the recently created Research Finance Agency be consolidated, and that its management procedures be defined in accordance with the highest standards. The ultimate objective of such improvements is the undertaking of more and better science in the public R&D institutions. The new State Plan (2017-2020) should serve to provide guidelines for the actions of the State Research Agency.

Promoting stability and consistency is essential, and two characteristics that have not been guaranteed in recent times. Stabilisation should be accompanied by the need to guarantee financing for all calls for funding. As such, the competitive funding system faces many critical challenges: achieving reasonable funding levels, guaranteeing the stability and consistency of calls throughout the year, reducing the number of instruments significantly, simplifying procedures of application and the awarding of funding, and reducing dramatically the time taken to make funding decisions, especially with regard to human resource programs. Likewise, a more efficient economic management, openness and transparency in the peer selection processes, as well as an improvement in the methods of evaluating and reviewing proposals should ensure projects are selected on the basis of their quality and expected outcomes and not so much on the length of the curricula of those applying for funding. Employing international evaluators would be a key factor in this direction. Finally, an effective monitoring of the results and impacts of competitive funding is vital for the optimum functioning of the R&D system.

Competitive State funding should not replace the baseline funding that all institutions should be able to guarantee their researchers if they manage their budgets successfully. Responsible public institutions, which have autonomy of management (such as the universities), cannot dedicate their entire budget to 'hiring and job positions' (the weight given to these items in some Spanish universities is disconcerting), and then not provide their employees with the minimum means to carry out the research activity for which they were hired.

Competitive funding should serve as a differential, that is, to finance the best with powerful instruments; it should not serve to grant minimum per capita subsidies that barely cover participation at international conferences. R&D policy is not meant to cover these minimum costs, nor should it focus on solving the problems created by the practices of some of these institutions. Understanding a science policy as a policy of resource distribution or redistribution to guarantee equality, instigating very low levels of requirement, is an error and a form of self-deception.

The ideal model for the competitive funding of science should consist of just a few, powerful tools that are carefully coordinated one with another: the funding of centres of research excellence; the funding of projects of research excellence (led by just one or two principal investigators) or mission-based projects; the funding of human resources (at pre-doc, post-doc and senior levels) integrated, that is, within the first two instruments, given that it is unreasonable to expect good students to be well trained in centres that are not recognised as undertaking research of excellence. The science policy implemented by the government must seek to strengthen and make visible the outcomes of the best research teams, and should not try to disguise the lack of research strategy of some universities or public R&D centres.

In this case, the improvement of the policy aimed at promoting excellence depends not only on the design improvements incorporated in the new State Plan, but on the way in which the new institutional actor (the State Research Agency), with responsibility for executing the policy, is constructed and consolidated.

There seems to be a broad agreement in the scientific community that one of the central challenges of scientific policy –if not the most important– is the setting up and consolidation of the Agency and, hence, being able to break with past practices of program management and public calls for R&D funding. In the 1980s and 1990s, the General Secretariat of the National R&D Plan established itself as the point of reference for the institutional management of competitive R&D funding. Today, the challenge is even more complex as the Agency seeks to consolidate best practices and avoid the perverse effects of administrative and bureaucratic routines, which often mean the mission of R&D funding is lost, drowned by the need to comply with administrative, budgetary, and accounting norms.

His experience in the institutional set-up of the European Research Council (ERC) enables Mas-Colell (2017) to draw the following lessons: 1) The ERC is subject to the Union's budgetary decisions (Horizon 2020, H2020), but it enjoys a critical level of institutional autonomy, being governed by the Scientific Council, which is responsible for selecting and appointing all evaluators and panel members, where the reputation of the evaluators is central to the institution's credibility; 2) The sole principle for the assignment of funding is excellence, that is, the quality of the research proposal; 3) Research grants target individuals, that is principal investigators, who have the capabilities of organising their team and carrying out the project. In short, the application of these principles to Spanish research organisations is what is needed to initiate a virtuous circle that can attract and retain talent.

It is, therefore, imperative to promote research policies focused on excellence, on the competitive awarding of funding and on the financing of institutions and universities with increasing levels of funding associated with research outcomes and technology transfer.

4.3 Improving the institutional quality of public R&D organisations and the universities

Finally, although traditionally scientific policy has only explicitly considered the competitive funding of R&D, we should examine other lines of action that could be especially relevant for improving the R&D system and which should contribute to improving the Institutional quality of public R&D organisations (Sanz-Menéndez, 2017). In general, universities and OPIs suffer a range of problems that can be attributed to their organisational structures and which generate serious inefficiencies as they seek to fulfil their missions, and that require special attention in any reform program.

The key lines of action required in addressing the organisational shortcomings of the public sector can be defined as follows:

1. Reforming university governance.
2. Overhauling CSIC and the OPIs.
3. Strengthening (and expanding as a model of scientific management) the newly founded R&D centres.

In addition, given its relevance for the future of the public system and the way it cuts across all R&D organisations, it is important to reform the prevailing civil service model governing labour relations, as well as the systems of recruitment employed by public research organisations. This is important because the future of scientific policy (in terms of its long-term impact) will depend on how scientists are recruited to fill new positions in the universities and OPIs, once the restrictions on replacement rates have been lifted. The way in which each university and OPI manages this process of renewal and what the governance bodies do with these new resources will condition whether or not the best talent available in each research field is selected.

It is imperative that the expansion of research teams at universities and R&D centres takes place within a framework of open, competitive recruitment systems that reject nepotism, and that conform to European standards, such as the accreditation of Human Resources Strategy for Researchers (HRS4R), and that adhere to the European Charter for Researchers and Code of Conduct for the Recruitment of Researchers.

These decisions are in the hands of Spain's university professors and researchers (and, to a lesser extent, in those of OPI researchers), who would no longer be able to blame the government for the outcomes of staff selection processes. It remains considerable cause for concern, for example, that some universities consider accreditation from ANECA, the national quality assessment agency, as sufficient (and not just necessary) merit for obtaining a research post, as evidenced by the criteria for awarding places that some universities employ. It is undoubtedly not a good practice to effectively block access to all external applications calls, as this just serves to increase the nepotism within the system.

a) Overhauling the universities

Spain's universities account for most of the country's public R&D system and are key institutions in the production and diffusion of knowledge and, therefore, in the modernisation of the economy and society. Over the last two decades, other European countries have introduced reforms in their universities. Some of these have been of a general nature, such as measures designed to strengthen the decision-making capacity of those responsible for the universities, in a context of greater autonomy from Government bodies, albeit without weakening the accountability of the universities. Others have introduced funding parameters for universities linked to the assessment of their results and performance. Other more specific transformations have involved the integration of public R&D centres within the universities, as in Denmark, and the provision of incentives for the merging and reorganisation of universities, as in France.

All in all, a number of common features might be highlighted in the reform processes carried out by many countries in Central and Northern Europe (Kruger, Parellada, Samoilovich and Sursock, 2017):

- The size of their governing bodies has been reduced, including that of the body equivalent to the academic senate (or *claustro* in Spain). At the same time, the powers of the collective bodies that represent the faculty and other members of the university community have been limited to academic matters. In all countries, the presence on its governing bodies of representatives from outside the university has been strengthened and, as a general rule, the rector is appointed by the governing body and, in some countries, the faculty deans are appointed by the rector.

- Strengthening university autonomy has been paralleled by an increase in university accountability. Governments have, however, retained some elements of control, including resource allocation policies, quality assessment and (with some differences across countries) personnel policies. In the case of quality assessment, there has been a shift away from the syllabuses and courses taught towards an institutional evaluation.

- University funding models seek a balance between the need to guarantee equitable financing of the universities' basic resources and the financing of excellence. This explains the need to complement the unconditional resources received by the universities with other resources awarded on the basis of performance indicators.

- The universities of these countries are defined by the quality of their human capital. For this reason they are obliged to attract talent, to offer academic careers that are as transparent as possible and to introduce systems of promotion. With these objectives, university systems, in general, have changed the status of academic staff, who have gone from being civil servants to being given employment contracts.

In Spain, each time university reform has come up for debate, the issue has become a political problem that has held back any initiatives, and any ministerial actions have been limited to "solutions" linked to greater government control of the universities. Various structural reforms have been proposed in recent years (Bricall, 2000; Tarrach, 2011; Miras-Portugal, 2013), but here, it is perhaps worth reflecting on areas that could be addressed without major legislative changes, given that they focus on the practices of the university actors themselves.

Given its importance within Spain's overall system of science and technology, the reform of its university model should be undertaken in line with the changes made in other European countries: namely, modify its system of governance, replace the public model with a contractual system, promote the assessment of institutional quality rather than of the syllabuses and courses taught, develop a more stable system of financing in which funding is more closely linked to results, define a national strategy that includes the strategic guidelines of the individual universities, etc.

Recently, a number of actions have been proposed in an attempt at changing the inertia (Peña, 2016 and 2017). These changes, promoted by the Government and the Autonomous Communities, could contribute to modifying the incentives of the actors of the system and so initiate a virtuous circle. These proposals are quite specific and could be implemented, in some cases with specific modifications provided for under prevailing university legislation (i.e., LOMLOU), and in others with changes in the practices of the universities themselves. These changes can be grouped in three areas: in general, the recruitment of teachers and researchers could be improved. Currently these practices are conditioned by the Law and the work of ANECA, but they are also heavily influenced by the Autonomous Communities and, above all, by the universities themselves and their capacity to resist the pressure groups that operate within them. Models of good practice exist in Europe and these could be implemented in Spanish universities, given that their adoption can be made on an individual basis. This is the case, for example, of the European Charter for Researchers and the Code of Conduct (Charter & Code), and HRS4R accreditation.

A second area is that of the funding of universities by the Autonomous Communities and the suggestion that a significant part of this funding, as occurs in other countries, most notably the United Kingdom, should be linked to performance indicators or assessments of the results of various university activities undertaken by peer review.

Finally, the need to address improvements in internal governance should not be overlooked. Here, attempts are needed to boost the awareness of universities and their members to the demands of the society. At the same time they need to increase the flexibility and transparency of their operations, implementing the decisions of those responsible for their governance, but without losing the academic freedom that must characterise all university activity.

b) The reform of public R&D organisations

The reform and internal reorganisation of the State research institutions also remain pending. The future of CSIC and of the IPOs in the research system requires very careful reflection, as CSIC and the rest of the IPOs are very different in nature and have very different missions.

Over the years, processes of convergence in the administrative practices of the IPOs –including the integration of their research scales, common calls to fill research positions, etc.– resulting from this common dependence have been developed. However, the identities and missions of each of the IPOs are quite unique, being closely linked to the sectoral ministries and productive sectors that require their knowledge and support. The development of these common administrative practices, introduced to improve coordination, is not, and cannot be, the justification to merge all these centres under the umbrella of CSIC, which –since the first government of the People's Party in 1996– has sponsored them.

Proposals for the cold merger or integration of the other IPOs within CSIC (or under a common umbrella) are not based on any rigorous analysis of the missions or roles of the IPOs in the system, but rather on a government notion that if they increase the size of the problem it might solve itself. Yet it is true that there are applied research groups in CSIC that might perhaps be better off in the IPOs that carry out similar tasks, and that a "transfer of assets" might even be considered to rationalise the different IPOs. However, the reform of these bodies cannot be undertaken without first addressing the reform of CSIC, and its conversion into a holding to control the investments in more autonomous

research institutes, which can be assessed and financed on the basis of their research output.

The CSIC is, in terms of its budget, staffing and scientific output, the largest scientific institution in Spain. After an exponential growth of its resources between 2005 and 2009, CSIC suffered that same year the effects of the radical cut in direct transfers from the Ministry of Science and Innovation. This led to an unprecedented financial crisis in the summer of 2013 and there were fears that CSUC would have to be bailed out.

The crisis, the cutback in direct transfers and the virtual freezing of research positions within CSIC and the other IPOs have served to highlight the deficits in the governance of these institutions and revealed the challenges they face to survive and adapt.

In CSIC, as in the universities, the effects of the budget cuts have been distributed very unevenly, threatening the very survival of the organisation. The decisions adopted have served mainly to protect the research jobs of civil servants, while forcing out younger talent, Thus, today, CSIC faces a problem of an ageing staff, a generational vacuum and the general absence of any kind of strategy for the future. Moreover, CSIC, as a result of the increasing centralisation of its decision-making, has markedly strengthened its administrative controls and internal bureaucracy, subjecting its research to these administrative checks rather than placing this administration at the service of its research. Paradoxically, at the same time, in CSIC, the autonomy enjoyed by the researchers holding civil service posts is maximum, as it is in the universities, which hinders the development of joint projects that extend beyond the ambitions of the individual research groups.

CSIC, with about 120 institutes located the length and breadth of Spain –which is almost twice as many as the Max Planck Society, albeit the latter has three times its budget and twice as many researchers and staff– faces serious problems as far as its organisational structure, scientific governance and internal heterogeneity are concerned.

Any reform of CSIC will necessitate changes in the following key areas: a) The first concerns CSIC's overall strategy and its relationship with the research conducted in the university, as the Council will be required to respond to questions regarding the "value added" of its own research; b) The second concerns CSIC's excessive dependence on political decisions and on the Ministries, as made apparent by the political appointment of its president, who controls the Advisory Council –failure to widen its autonomy and change the system for selecting and appointing the president of the CSIC constitutes a threat to its future; c) No joint projects can be endorsed by the institution (that is, in well-defined scientific institutes), without first strengthening the decision-making powers of the scientific directors and limiting the administrative discretion of the CSIC president and the scientific discretion of the principal investigators, thus creating space for joint projects that can be represented by these institutes; d) This will require overhauling the institutes and their staff, so as to establish viable and sustainable scientific projects of excellence.

Given the challenges faced, the application of the new Law governing the Legal Regime of the Public Sector (Law 40/2015) within CSIC and in the IPOs does not bode well for the future, given the flexibility of administrative conditions needed for the proper undertaking of research activity.

c) Protecting Spain's newly founded research centres

Against the somewhat sombre backdrop of research activities in Spain, a number of positive changes have been made over the last twenty years, not least the consolidation of the new-style R&D centres (labelled *centros de nuevo cuño* to distinguish them from their older, more traditional counterparts). These new centres have been granted a new legal status as nonprofit foundations, generating a population of medium-sized R&D centres. From the outset they have been endowed with considerable organisational flexibility and are designed to respond to the political mandate of providing research excellence, albeit research produced in order to be of immediate use (what Donald Stokes has labelled "Pasteur's quadrant"), and, today, they represent the main thrust of research excellence in Spain.

Within this new sector, we find the centres promoted by different government bodies: the Ministry of Health (CNIO, CNIC), the *Generalitat* or Catalan Autonomous Government (CERCA centres), the Community of Madrid (IMDEA), the Basque Government (CIC centres), etc. It includes research institutes that, without losing their public nature, and while still subject to governmental control, have adopted legal structures which facilitate the effective management of their resources and a greater efficiency in their undertaking of R&D activities. The results of these new institutes in terms of publications and patents, per public euro invested, and of the consequences of the reputations

they have earned, as reflected, for example, by the number of European Research Council grants won, are extraordinary. In short, implementing effective policies for attracting and retaining talent has proved to be the best strategy and tool for investing in research.

However, the crisis and the exceptional measures adopted in response to it have begun to "dismantle" these protected spaces that enjoyed such a high degree of delegation and autonomy in their management. These R&D centres have begun to suffer a partial loss of that very flexibility that allowed them to flourish in the first place. Increasingly, public sector standards of remuneration have been introduced, regardless of the productivity and income obtained by researchers, as have the controls on contracting and public procurement, etc. acting as a strong disincentive to their work. The response of the political system (with some exceptions, including that of the *Generalitat*) has been to assimilate the conditions of these new centres within the conditions of the rest of the public sector, thus worsening their situation, rather than granting CSIC and other IPOs the same conditions as those enjoyed by these new centres, as the president of CSIC had been calling for over many years. As a result, there is a very real threat that these new centres will acquire all the out-dated characteristics of Spain's traditional institutions. Anti-crisis policies, and now the new Law governing the Legal System of the Public Sector, are serious threats to their working conditions and, therefore, to the expected output of these institutions.

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