CATALAN ECONOMIC SURVEY 2009
MONOGRAPH CHAPTER

The Catalan Innovation System in Perspective Challenges and Policy Orientations[*]

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1. Introduction

Since the first autonomous elections of 1980, Catalonia's government has recognised the importance of S&T and innovation policy to foster the region's economic growth, industrial diversification and social welfare. Important successes have been achieved. The public research system has reached a high level of excellence that is internationally acknowledged in various scientific areas. In various industrial sectors there are firms that operate at the technological frontier with investment in R&D and other innovative activities that allow them to successfully compete in world markets. In high technology sectors such as ICT and biotechnology innovative SMEs and clusters have successfully developed. Yet, on the whole, the innovative performance of Catalonia's industry still lags behind that of more advanced regions in Europe and does not yet match the level of excellence achieved in scientific research activities. In Catalonia the development of a comprehensive innovation system underpinned by policies that better articulate the production and diffusion of knowledge and the relationships between public research and industry has experienced vicissitudes and been slow to emerge.

Notwithstanding the dramatic impact of the world economic crisis on the Spanish economy and large sectors of the Catalan industry, the Catalan government seems determined to continue to give a high priority to the development of scientific and technological infrastructure in its policy agenda as a means to promote the innovative capacity of the region's economic fabric and the well being of its population. Pursuing this priority will not only call for sustained budgetary efforts in support of S&T and innovation already committed in 2008 and 2009. It should also imply efforts to increase the efficiency of support measures, to better adapt the innovation policy mix to the structural weaknesses of the regional innovation system, in particular those related to non-technological innovation and to knowledge diffusion linkages between public research institutions and the productive sector.

This monograph chapter reviews the main features and performance of the Catalan Innovation System as it has developed over the years from the early '80s to the endorsement of the Catalan Agreement on Research and Innovation (CARI) in 2008 and the preparation of the current Research and Innovation Plan (2010-2013). It highlights the strengths and weaknesses of the system and offers some policy recommendations aimed at improving the governance and the efficiency of the Catalan S&T and innovation policy so as to strengthen the valuable knowledge assets of the Catalan society and the Autonomous Community's productive sector and increase

[*] This monograph chapter, and more particularly its last sections, draws substantially on the *OECD Reviews of Regional Innovation: Catalonia, Spain* carried out at the request of the Catalan government (OECD, 2010a). More recent sources of information made available since the preparation of the review have also been used. The current Research and Innovation Plan (2010-2013) was not available at the time the Monograph was drafted.

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the overall innovative performance of its economy. Following the introductory section the monograph is organised as follows.

The second section reviews the current trends affecting the dynamics of innovation – and related policy challenges – as determined notably by (i) evolving patterns of firms' innovation strategies (ii) the increased importance of regional and local ecologies in the development of knowledge infrastructures and innovative platforms (iii) the impact of the current economic crisis on the very nature and scope of innovation policy.

The third section briefly presents the main characteristics of the recent evolution of Catalonia's industry as regards its productivity, sectoral specialisation and enterprise structure as a background against which innovation strategies need to be considered.

Section four analyses the performance of the Catalan innovation system over the recent years with a view to highlighting its main strengths and weaknesses. The analysis is based both on a quantitative approach using standard internationally comparable indicators[1] and, from a more qualitative perspective, on the role and performance of the main actors of the system.

The fifth section reviews Catalonia's initial approaches to innovation policy and the relative emphasis given over time to supply, demand and integrated policies. It highlights the institutional and international contexts that have underpinned these approaches and influenced policy priorities

The next section addresses the more recent efforts made by the Catalan government to better balance its S&T policy between support to research infrastructure and to innovation promotion with an emphasis on knowledge and technology diffusion instruments. It points out some of the limitations met by this shift of emphasis notably as regards the difficulties to implement a more an adequate governance structure and an efficient policy mix.

Following a brief review of the CARI exercise as a process to build a consensus among the main actors of Catalonia's innovation system and society at large around strategic priorities and commitments to implement them, the Monograph's final section highlights the policy orientations aimed at fostering the Catalonia's innovative performance through improvement of the governance of its innovation system and the implementation of a more efficient policy mix.

2. The dynamics of innovation: current trends and policy challenges

2.1. The notion and dynamics of innovation are evolving

Over the past decade, throughout the OECD area including at regional level, the notion of innovation has broadened reflecting important changes in the dynamics and scope of innovative activities. While efforts have been made to improve the measurement of innovation (see Box 1), the implication of these changes have often been taken into account with a certain lag in the policy-making process.[2]

[1] Such as those developed at the OECD and Eurostat or those compiled by the Spanish and Catalan Statistical Institutes (INE and IDESCAT) and the Spanish Patent Office (OEPM).

[2] The Innovation Strategy project currently developed at the OECD in response to a Ministerial mandate given in 2007 aims at promoting integrated policy approaches that take into account these changing dynamics, scope and patterns of innovation in member countries.

Box 1: Defining and measuring innovation

Innovation is a continuous process rather than a static activity which makes measurement difficult. Firms constantly make changes to products and processes and collect new knowledge. With the objective of capturing this process, the *Oslo Manual* (OECD-Eurostat, 2005) focuses on measurable indicators such as expenditures, linkages and factors that influence innovation activities.

Innovation, thus defined, is clearly a much broader notion than R&D and is therefore influenced by a wide range of factors, some of which can be influenced by policy

The latest (3rd) edition of the Oslo Manual defines innovation as the implementation of a new or significantly improved product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations (OECD-Eurostat, 2005). This definition, for measurement purposes, captures the following four types of innovation:

- Product innovation: the introduction of a good or service that is new or significantly improved with respect to its characteristics or intended uses. This includes significant improvements in technical specifications, components and materials, incorporated software, user friendliness or other functional characteristics.
- Process innovation: the implementation of a new or significantly improved production or delivery method. This includes significant changes in techniques, equipment and/or software.
- Marketing innovation: the implementation of a new marketing method involving significant changes in product design or packaging, product placement, product promotion or pricing.
- Organisational innovation: the implementation of a new organisational method in the firms' business practices, workplace organisation or external relations.

Source: Based on OECD-Eurostat, 2005

Among the main elements that characterise this evolving scope and dynamics are the following (FORA, 2009; OECD, 2009b; Box, 2009):

Innovation is increasingly pervasive not only across economic activities but also across functional activities within a firm. The scope of knowledge inputs to innovation broadens, raising the importance of a wide array of *intangible assets* that jointly contribute to firms' innovative performance. Beyond R&D, intangible assets encompass inter alia investment in human capital, training, design, computerised information collection, marketing and organisation, highlighting the growing importance on non-technological innovation;

This pervasiveness spurs the diffusion of technological progress and non-technological innovations within value chains between firms and their suppliers or clients and facilitates the development of innovative clusters. It also fosters final demand-led innovation and highlights the eminent role of *knowledge-intensive service activities* (KISA) in diffusion processes across the economy, notably at regional level (OECD, 2006a). As emphasised in the FORA report on the

New Nature of Innovation,[3] "Technology has always played an important role in driving innovation, and it will continue to do so in the future, but for many companies technology will gradually move from being a driver of innovation to becoming an enabler of innovation" (FORA, 2009).

While companies rely more on their intangible assets for their innovative activities, they also put a greater *emphasis on external sources of knowledge* (OECD, 2008a). This trend is facilitated by the expansion of market and non-market knowledge interactions involving collaboration and/or intellectual property transactions, by the globalisation of R&D activities and the increasing costs of innovation that lead to seek to diminish risks associated with more exclusive in-house development of such activities.

Companies source external knowledge in various ways and the development of collaborative innovation strategies is a corollary of the trend towards a *more open innovation environment* notably through partnerships with external parties such as alliances, consortia, joint ventures, joint development, *etc*.). Available evidence suggests that scientific collaboration at both domestic and international levels have increased over time (Figure 1). This is also true, more generally, for international flows of knowledge. Moreover, An OECD cross-country study of innovation at the firm level showed that collaboration is an important part of the innovation process: in 16 out of 18 countries, firms that collaborated on innovation spent more on innovation than others. This suggests that collaboration is not mainly undertaken as a cost-saving measure, but rather as a means to extend the scope of a project or to complement firms' competencies (OECD, 2009a).

The frontier between scientific and innovation activities in high technology sectors such as biotechnology, nanotechnology and ICT becomes increasingly blurred and calls for more intense *collaborative activities between public research institutions and private companies* operating in these sectors. This blurring that puts a premium on collaborative ventures opens new opportunities for the creation of innovative firms such as spin-offs from public research or spin-outs from existing companies. For such opportunities to materialise sound framework conditions regarding the financing of innovation or the mobility of researchers must prevail.

The *importance of demand as a driver of innovation is growing*. This can be observed at various levels. First, individual consumers and intermediary users in production value chains stimulate market demand for innovations and have an influence on standard setting.[4] Second, social demand for innovations that can improve the provision of collective and public goods is also on the rise and opens the ways for a more important role of public procurement in innovation policy.

Innovation activities are unevenly distributed in national boundaries as their location is strongly influenced by regional institutions and assets. This is hardly a new phenomenon but it should be stressed that, notwithstanding the globalisation of R&D, *agglomeration economies related to the availability of knowledge* physical and intangible assets play an increasing role in determining regional innovation performance and ultimately, as highlighted in OECD (2009e), in fostering regional growth. Hence the growing emphasis given at national levels to the complementarity/coordination between national and regional approaches to innovation policies

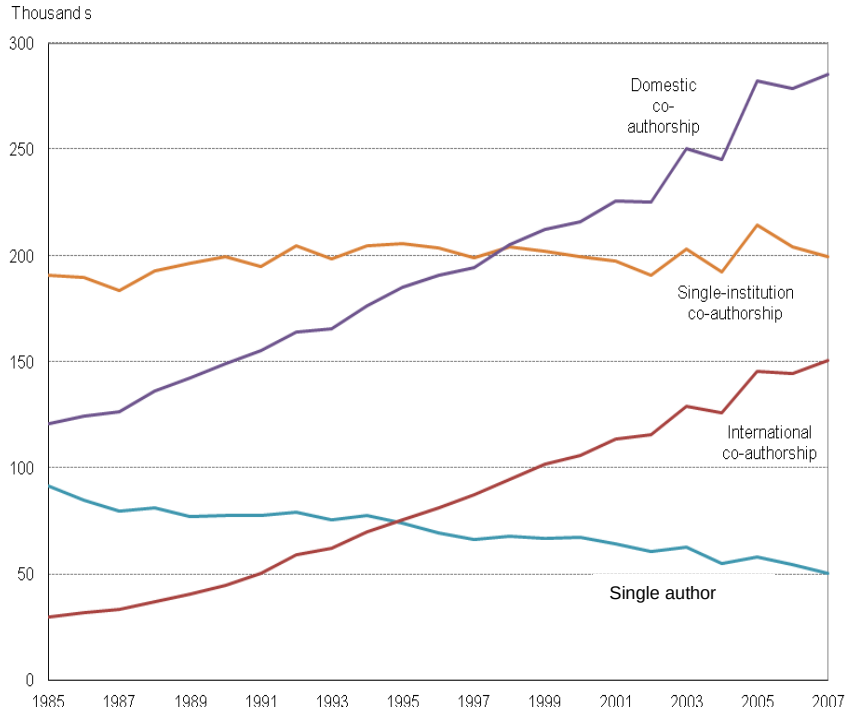
[3] This report funded by the governments of Denmark and Finland was prepared as a contribution to the OECD Innovation Strategy.

[4] As shown by Von Hippel (2005) in developed economies 10 to 40% of users engage in developing and/or modifying goods and services they purchase.

and, at regional levels, the importance of strengthening "regional innovation systems" to better reap the opportunities opened by the development of local knowledge assets.

Figure 1. Growth in scientific collaboration

Trend in the co-operation of scientific articles 1985-2007



Source: STI Scoreboard, OECD, 2009g

The *availability of skilled human capital* has always been a prerequisite for the successful development of innovative activities. The importance of this factor is however still on the rise and goes beyond the mere supply of skilled personnel in science and engineering.[5] It encompasses the variety of skills that are increasingly required to foster the absorptive capacity of firms the diffusion of technology such as those related to the management of innovation or the brokerage of knowledge. Two other issues deserve a special attention because the do impinge on the dynamics of innovation. The first one concerns the mobility of high skilled personnel across institutions and especially between public research organisations and the private sector. Obstacles to such mobility – in both directions – restrain the flows of knowledge and dampen collaborative prospects. The second is more general as it relates to the broader notion of social capital and society's ability to generate and boost demand-driven innovations responding both to evolving and more sophisticated consumer tastes and to social or collective needs in areas such as environment, health, energy and water.

[5] Although this issue remains an important one in many countries where the relative –and sometimes absolute– enrolment in S&T studies has been declining and the proportion of women in graduate S&T curricula remains weak.

2.2. Main policy challenges implications

Evolving trends in the patterns and dynamics of innovation have implications on policy challenges that should be reflected in the ways policies are designed and implemented at national and regional levels.

- Innovation policy should not remain the sole concern of administrations responsible for science and technology and higher education. This policy increasingly requires a whole-of-government approach. Only such an approach can ensure coherence framework conditions underpinning a successful innovation strategy. At national levels, these conditions essentially pertain to financial systems, tax, competition, intellectual property and regulation regimes, openness to foreign direct investment, and international mobility of highly skilled human resources. At regional level, corresponding framework conditions should also apply to the extent defined by constitutional arrangements regarding the sharing or devolution of policy and associated budgetary responsibilities.

- The broadening of the notion of innovation involves more complex relationships with stakeholders. This implies an adapted governance mechanism that allows the management of these relationships to achieve some consensus in the design of S&T and innovation policies, but also efficiency in its implementation. Instruments in support of S&T and innovation should not be subject to drastic changes for the sake of keeping some medium term stability of the decision environment in which public and private stakeholders have to program their investment in knowledge assets. However the policy-mix of financial and more qualitative instruments and measures in support of S&T and innovation must be progressively adapted to the new conditions that determine innovation performance at national and regional levels and encourage the emergence of lasting dynamic interactions among stakeholders as regards the production, diffusion of knowledge. The main purpose of policy is to provide the knowledge infrastructure and the incentive system that address not only the market failures related to sub-optimal R&D investment but also, and possibly mainly, the systemic failures that hinder the development of these dynamic relations.

- The scope of the targets of innovation policy has also broadened. One the one hand to encompass non-technological sectors that are either the source of innovation in firms' intra-muros or outsourced services (e.g. organisation, design, training), or contribute to foster innovation across the economy, such as the wide array of KISA activities, innovation financing services or knowledge diffusion brokers. On the other to respond to new social challenges and the expanding demand to satisfy or collective needs through more efficient modes of provision that call for the development and application of new knowledge. Hence the increased role of public procurement in innovation policies mentioned above notably through regulatory frameworks and the stimuli given to the formation of public/private partnerships for the provision of collective goods and services.

2.3. Regional innovation policy challenges

Regional innovation policy challenges deserve a particular attention in this monograph devoted to Catalonia. In effect, at regional level, governments must not only take into account the evolutions

highlighted above to frame their policies. The improvement of their governance structure and the implementation of policy mixes better adapted to the specificities of the region's innovation system must be achieved in coordination or complementarity with national government policy frameworks that often have to strike a balance between considerations of efficiency and equity among regions. In fact, in many instances the basic elements of a regional innovation system underpinned by the existence of a local S&T infrastructure, performing regional stakeholders in the public and the private sectors who share a common interest in knowledge transactions supported by appropriate institutions and incentives is not ubiquitous among regions of OECD countries.

There is a large and growing body of literature that focuses on the relevance the notion of regional innovation systems not only as an analytic tool to better understand the spatially determined drivers of innovation, but also as a policy concept (Cooke, 2001; Fritsch and Stephan, 2005). But as emphasized in a number of studies reviewing actual regional innovation policies or the conditions that underpin their definition and/or implementation, the determining factors of policy relevance are (i) the good accounting of the specificities that characterise a particular region's innovation system – including the possible lack of or obstacles to relationships among actors of the system, (ii) sufficient budgetary means and regulatory or legislative power to provide support instruments and institutional frameworks to policy measures and (iii) the evolving governance arrangements across levels of governments (Bilbao-Osorio, 2009; Sanz and Cruz Castro, 2005).

Across OECD countries the system by which innovation is managed across levels of government remains challenging. As stressed in the OECD review of regional innovation in Catalonia (OECD, 2010a) using a typology developed by Perry and May (2007): "The distinction between national and regional roles should be based on which factors that support innovation are most susceptible to be of influence at the sub-national level. This is a kind of subsidiarity exercise applied to innovation policy. While this approach seems quite basic, policy experience so far is limited and is not grounded in a clear model of what regional innovation policy should look like…. [There] is no optimal distribution of responsibilities across levels of government with regard to innovation. There are currently different approaches to organising and managing innovation policy, largely dependent on more general institutional and constitutional frameworks. Across OECD countries, there are examples of regions playing a passive role (as stages and implementers) or an active role (as partners and independent policy makers)". Catalonia is an active region, acting as an independent policy maker in this field, but increasingly recognising the need for working as a partner with the Spanish government.

2.4. Innovation policy in the context of the current crisis

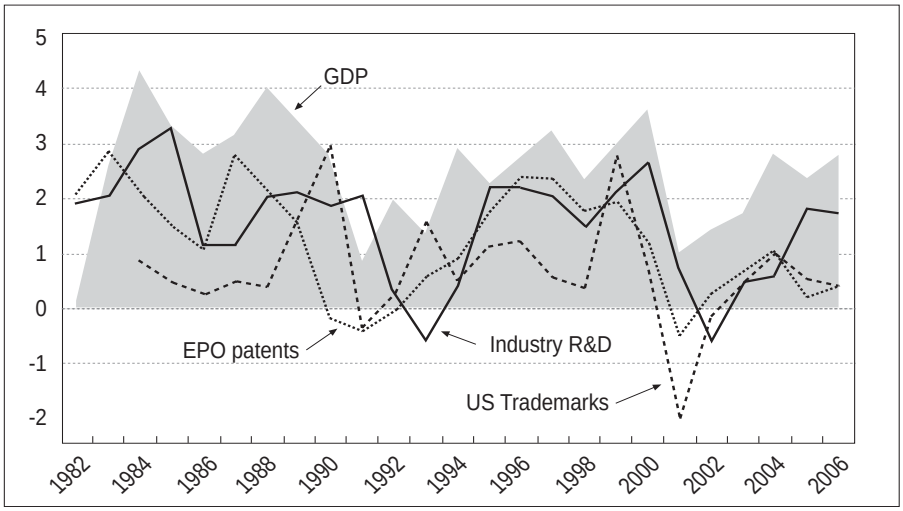
At the macro-economic level innovation expenditures tend to be correlated with the business cycle (Figure 2). Indeed, across OECD countries there is evidence that the current financial and economic crisis has already affected innovation through a slower growth or stagnation – or in certain cases decline – of business R&D expenditures and the filing of patents.

As highlighted in a recent study on policy responses to the crisis (OECD, 2009c) the reasons are many and affect firms' innovative behaviour as well as the overall innovative climate:

- R&D is declining because it is mainly financed out of cash flow which contracts in downturns. Banks and institutional or individual investors are becoming more risk-averse reducing potential flows of external financing.

Figure 2. The impact of business cycles on innovation

Business funded R&D, patent applications to EPO, trademarks filed at USPTO[1]



[1]Annual growth rates for the total of OECD countries divided by standard deviation

Source: OECD, 2009c

- Small and medium-size innovative enterprises are particularly affected since their development is very often based on intangible assets and conditioned by availability of external capital. Exit rates increase and the number of new entrants falls.

- Facing a contracting effective demand, firms also generally become more risk-adverse and favour low-risk and short term incremental innovation over higher risk and longer term ventures involving higher R&D costs and recruitment of new high skilled personnel.

- Slowing down of international trade and investment flows as well as diminishing access adversely affects the resilience of global value chains that underpin technological diffusion and knowledge transfers.

- This bleak innovation climate has also a negative impact on the job market for highly skilled personnel and risks affecting the stock and diffusion of knowledge respectively embodied in, and transmitted through, these human resources.

However as it often happens in crisis periods, new opportunities are open to firms willing and able to take risks and invest in research and innovation to expand their market shares at the expense of more cautious competitors.[6]

In such a depressed context anti-cyclic policy measures developed both at national and regional levels can have a strong impact of firms' innovation-related investment in R&D, equipment, organisation and human resources. In fact since 2008, and notwithstanding strong budgetary constraints, a number of governments have innovation support measures in their fiscal stimulus packages leading to a volume increase of their R&D expenditures including the share financing business R&D. In some countries, the crisis has catalysed efforts to engage R&D efforts around new so called strategic priorities such as green technologies in energy, environmental protection or the construction industry. In some cases, the degree of generosity of R&D tax incentives has been raised and/or new incentives have been made available to sustain technological development in industries where demand has been drastically falling (e.g. the automobile industry) or to encourage innovation in lagging low-tech sectors and SMEs.

Counter-cyclical budgetary or tax measures are more difficult to implement at regional levels, often because regional fiscal and budgetary prerogatives are limited, or at any rate more limited that at national levels regarding deficit spending and targeted tax incentives. In the case of many regions, including Catalonia, absolute or relative increases of public investment in S&T and innovation related infrastructure and intangible assets have been implemented through recognised priorities in the budgetary exercises of 2008 and 2009, and sectoral priorities for public investment in R&D have been identified (Generalitat de Catalunya, 2008c).

3. The economic and industrial structure context of innovation in Catalonia

Catalonia's record in terms of its innovation performance is mixed. As has been highlighted in recent reports such as the *Informe Annual de l'R+D I la Innovació a Catalunya* (ACC1Ó, 2009) and the *Memòria Econòmica de Catalunya 2008* (Garrido and Duch (2009) in terms of traditional quantitative indicators Catalonia's performance over the last decade looks quite impressive. However, when one examines more closely the evolution of other aspects of the Catalan economy over which the public and private efforts towards the development of innovation should have borne fruit, such as productivity gains or the diffusion of technology in traditional sectors and a large fraction of the SME population, this performance is less manifest. The main question is therefore the extent to which the innovation policy pursued by the government provides the necessary infrastructure and incentives to underpin a structural evolution of the Catalan economy in which innovation is not only a driver of microeconomic performance in some sectors, but also a key to productivity gains throughout the economic fabric.

The contribution of innovation to economic growth is well documented both at macro and microeconomic levels (OECD, 2008b; OECD, 2009f). Along with the recognition of market failures that lead to underinvestment in knowledge assets and systemic failures that hinder the efficiency of such investment, evidence of this contribution to economic growth provides one the main rationales for innovation policies at country and regional levels.

[6] It is to be noted that some of the leading firms in the ICT sector such as Microsoft or Nokia were born or transformed through innovation during the creative destruction climate of economic downturns, and that others such as Google and Samsung strongly increased their R&D expenditures after the "New Economy" bust of 2001 (OECD, 2009c).

At the micro economic level, the main channels through which innovation drives economic performance are its impact on productivity and competitiveness, as well as on the creation of new sources of wealth related to the development of new firms and markets that have positive effects on job creation and income.[7]

The translation of the positive microeconomic effects of innovations at the macro level is more problematic. They depend on a series of factors having to do with the initial conditions of the industrial structure, the framework conditions that impinge upon the successful development of innovative activities by enterprises, the nature of the relationships among the actors of the innovation system involved in the processes of creation, diffusion and commercialisation of knowledge, and of course the government policies aiming at strengthening the elements of the system and the relationships among the actors. It is in this light that the performance of Catalonia's innovation system has to be analysed.

Over the last 15 years prior to the economic crisis. Catalonia's economy experienced a strong growth, on par with that of Spain and higher than the OECD average. This growth was largely due to expanding external markets related to the adhesion to the EU but also to favourable wage conditions in an expanding labour market. These conditions explain the concomitant slowdown in labour productivity also suffered in the majority of Spanish regions. During the period 1995-2005, the absolute levels of Catalonia GDP per worker dipped in the beginning of the decade, when the productivity of the Catalan and Spanish economy suffered a stronger shock than other European countries, and has yet to reach the same absolute levels as 1995. The relative deterioration with respect to OECD countries is notable: while in 1995 Catalonia was at 115% of the OECD average, it had dropped to only 91% by 2005. It should be noted, as will be seen below that this weak productivity performance at the macro level needs to be nuanced at the micro level (Segarra-Blasco, 2010).

Catalonia has retained a large manufacturing base, larger than that of Spain and the EU in terms of its share in gross value added (GVA),[8] but the productivity of its manufacturing sector as measured by GVA per worker remains slightly below the region's average and has even experienced an average annual decrease of 0.1% annually between 2000 and 2006.

Catalonia's manufacturing is more technology-intensive than the rest of Spain, but about average for OECD regions generally. Employment in the manufacturing sector is 4.5% in high-technology (1.0% of all employment), but 32.1% in medium-high technology (7.3% of all employment) —the remaining 63.5% being in medium-low or low technology industries. Catalonia is specialised in high-tech and medium high-tech manufacturing relative to Spain (1.6 and 1.3 respectively in 2006). Relative to the Spanish average Catalonia has increased its specialisation high-technology industries since 1994 with a parallel decrease in medium-high technology ones (Figure 3). R&D expenditures are highly concentrated with two thirds of the total incurred in four industries: pharmaceuticals, automobile, chemicals and software. In recent years knowledge-intensive

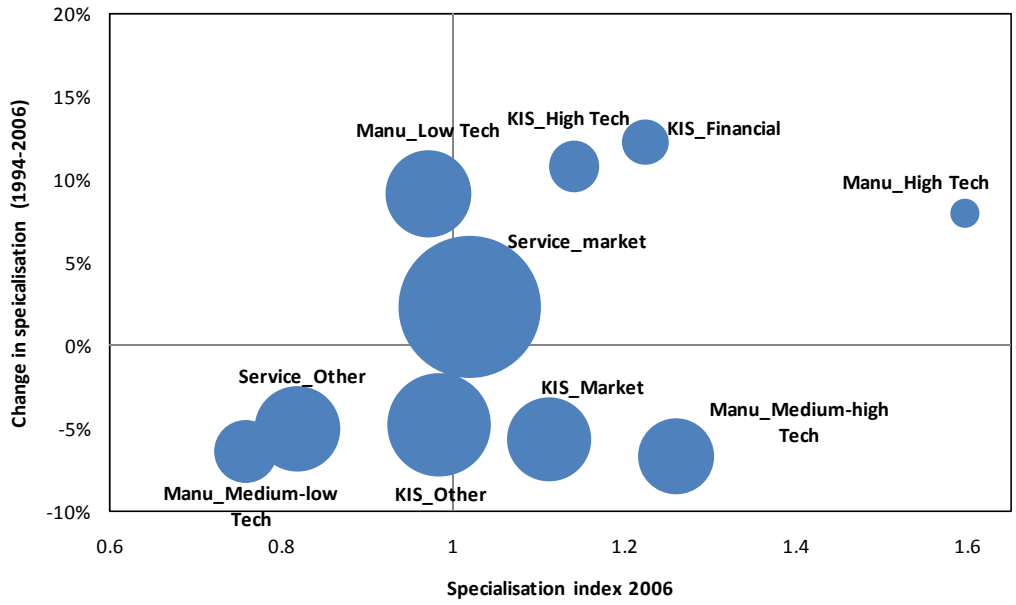
[7] As highlighted in Schumpeter's pioneering work (Schumpeter, 1975), provided the existence of sound framework conditions related to competition and property rights regimes, innovation drives a process of creative destruction that weeds out uncompetitive firms and fosters the development of innovative ones as well as the diffusion of technology throughout the industrial fabric. The conditions that facilitate the development of knowledge and innovations in the first place and the efficiency of the diffusion process determine the performance of the innovation system.

[8] In 2007 the shares of the manufacturing sector in gross value added in Catalonia, Spain and the EU were respectively around 18.2, 15.9 and 17.5 percent.

services (KIS) have grown quite rapidly (Segarra-Blasco, 2010)[9] but in this sector Catalonia –as Spain in general– still stands below EU averages.

Figure 3. Sectoral dynamics by technology level: Catalonia relative to Spain

Change in specialisation, 1994-2006



Note: (1) Manu=manufacturing, and KIS=Knowledge Intensive Services, (2) Bubble size denotes sector size in terms of employment in 2006. (3) Specialisation is measured as the quotient of employment in the sector in Catalonia in relation to employment in the sector in Spain, corrected for total employment shares in Catalonia. A score of 1 means that a sector in Catalonia has a similar employment share as would have been expected on the basis of working population (that is: not specialised); a higher score indicates a sector in which Catalonia is specialised; a lower score indicates under specialisation.

Source: (OECD, 2010a), calculations based on Eurostat data and classification by technology level.

Catalonia's industrial structure, as that of Spain, is characterised by an overwhelming proportion of very small firms and SMEs. Of all firms in Catalonia, 99.8% are firms under 250 employees, of which 92.5% are firms with no salaried employee or fewer than 10 salaried employees (Table 1). Catalonia's SMEs employ 74% of the workforce, with 31.1% in firms with fewer than 10 or no salaried employees (PIMEC, 2008). Large firms continue to register a significantly higher average –although declining– level of labour productivity (GVA per worker), albeit that of SMEs has grown over the last few years. This skewed industrial structure raises the important issue of the promotion of innovation across the SME industrial fabric and of the incorporation of SMEs into innovation networks or platforms.

[9] While the number of high and medium tech firms in the manufacturing sector has remained stable between 2004 and 2007, the number of KIS firms has almost doubled during the same period (ACC1Ó, 2010).

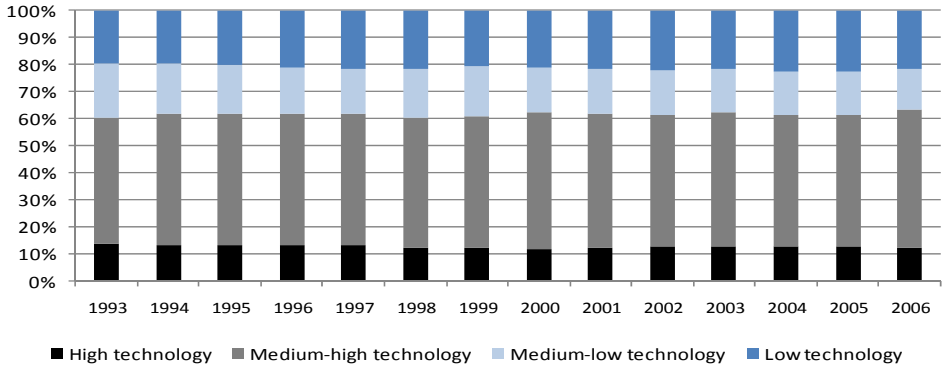
Table 1. Characteristics of firms by size 2006

	SMEs without employees	Micro-enterprises (1-9)	Small firms (10-49)	Medium-sized firms (50-249)	Total SMEs	Large firms	All firms
Firms	284,923	209,183	34,050	5,203	533,359	858	534,217
% of total	53.3%	39.2%	6.4%	1.0%	99.8%	0.2%	100.0%
Employees	284,923	576,780	676,877	508,297	2,046,877	719,936	2,766,813
% of total	10.3%	20.8%	24.5%	18.4%	74.0%	26.0%	174.0%
Productivity per worker	51,624	54,059	56,448	53,291	48,195	68,383	53,448
Annual change in productivity 2002-2006	3.1%	0.1%	0.3%	-1.1%	0.2%	-1.5%	-0.2%

Source: PIMEC (2008), *Anuari de la pime catalan: Resultats economics i financers*: 2002-2006, PIMEC, Barcelona.

As highlighted in the monograph chapter of the 2008 issue of the "*Memòria Econòmica de Catalunya"*, the Catalan economy has experienced significant internationalisation since the incorporation of Spain to the European Union. Traditionally Catalonia has been one of the main Spanish regions in terms of emission and receipt of Foreign Direct Investment (FDI), but this varies from year to year. This investment was and continues to be associated with the industrial and entrepreneurial base of Catalonia, its well-developed system of transport and communications, its locational advantages within in the European Union, the social and cultural components found in Barcelona (Bacaria *et al.*, 2004) and, increasingly, the attractiveness of its knowledge base in some specific areas such as health related technologies. Flows of foreign direct investment benefit from this attractiveness but, in principle, should also contribute to technology transfers that raise the innovation potential of the Catalan economy.

Figure 4. Catalan exports by technological level of products 1993-2006



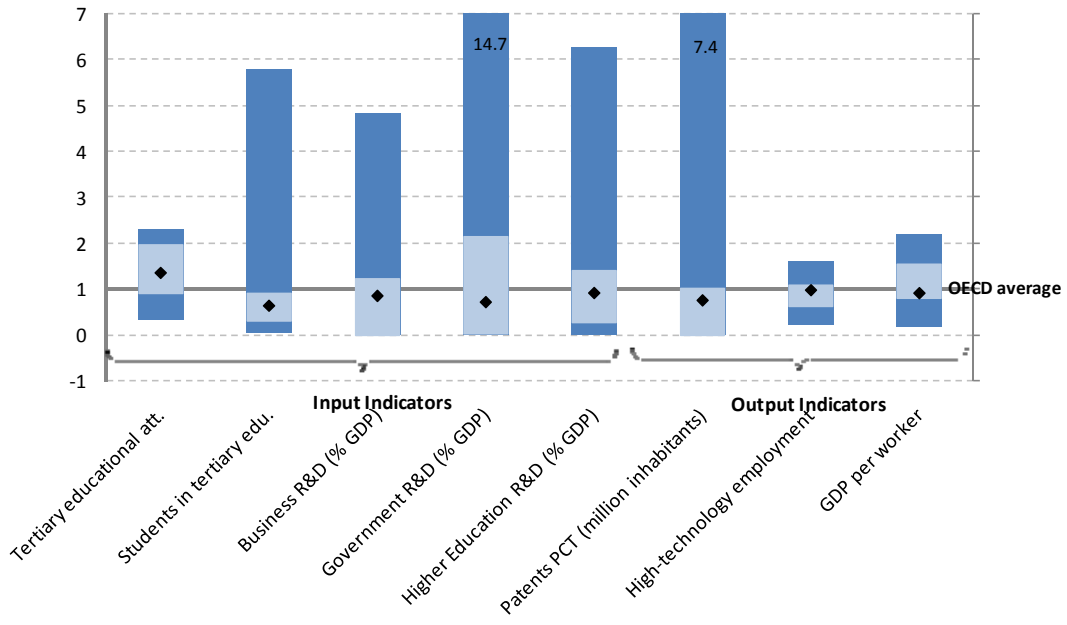
Source: OECD (2010a), based on data from IDESCAT as reported in ACC1Ó (2009), *La situació de la innovació a Catalunya.*

However, it is to be noted that notwithstanding the growing internationalisation of the Catalan through increasing external trade and FDI flows, the technological content of Catalan exports has practically not varied since the early '90's (Figure 4).

4. Performance of Catalonia's innovation system

Although in the last two decades much progress has been made in improving the understanding of the determinants of innovation performance and the influence of policies over that performance, the development of appropriate indicators remains a moving target. As highlighted in endogenous and evolutionary growth theories (Aghion and Howitt, 1998) R&D activities and technological progress are at the same time an outcome of socio-economic development and a driver of change of economic structures and potential growth. Moreover, the ways this dialectical relationship operate in any given country depend to a large extent on initial conditions such as physical and human resources endowments, industrial specialisation, business environment conditions, international openness, as well as on its S&T and institutional infrastructure (OECD, 2005). Measuring the performance of an innovation system is therefore a challenging task that cannot be reduced to a mapping of standard indicators and international benchmarking exercises.

Figure 5. Catalonia's innovation performance summary 2005



Notes: The outer band in dark blue represents the range of values for OECD regions. The inner band in light blue represents the range for regions in Spain. The diamond ♦ represents the value for Catalonia. The values of each variable were normalised to the OECD regional average for available regions. Information on all OECD regions is not available for each indicator.

Source: (OECD, 2010a), Calculations based on data from the OECD Regional Database.

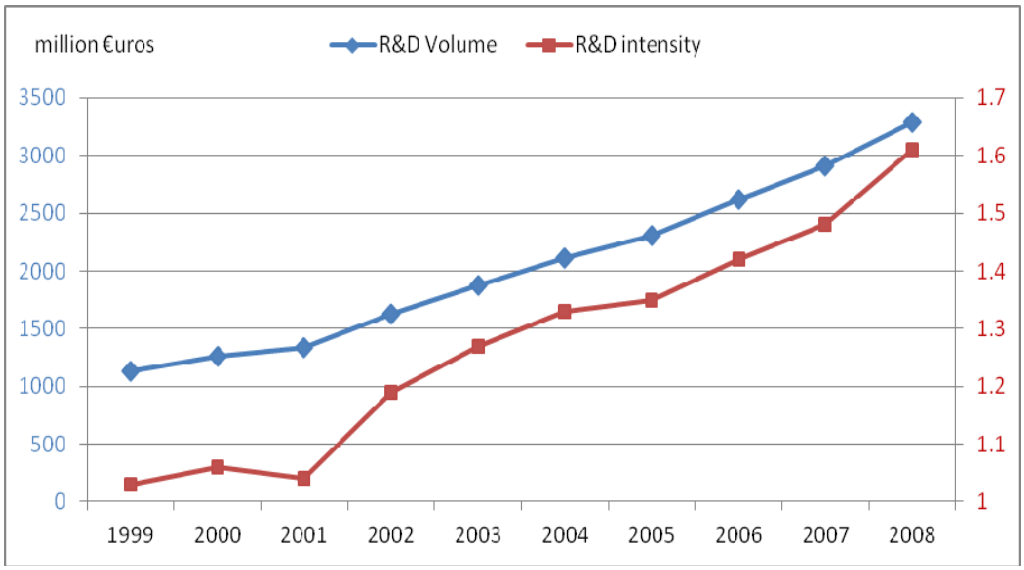
This being said internationally comparable input, process and output indicators such as those developed in the OECD and Eurostat remain indispensable –albeit partial tools– to measure innovation performance and monitor the impact of innovation policy on that performance. What do such indicators tell us about Catalonia's performance?

From an international viewpoint, and on the basis of standard internationally comparable input and output indicators commonly used for benchmarking purposes Catalonia is a leading region in a country –Spain– that is still lagging within the OECD area. As illustrated in Figure 5, in 2005, while for some indicators Catalonia was near the top of the range among Spanish regions, for most of them Catalonia was still below OECD average.[10]

4.1. R&D expenditures

Over the last decade Catalonia's total R&D expenditures[11] have grown rapidly and regularly with a threefold increase between 1999 and 2008 This growth has substantially outpaced that of the regional GDP resulting in significant increases in the R&D intensity[12] of the Catalan economy which reached 1.61% in 2008 (Figure 6). This level of R&D intensity nevertheless remains far below the EU Barcelona objectives –set at country level– of 3%.

Figure 6. Catalonia's R&D expenditures (GERD) and R&D intensity (GERD/GDP) 1999-2008

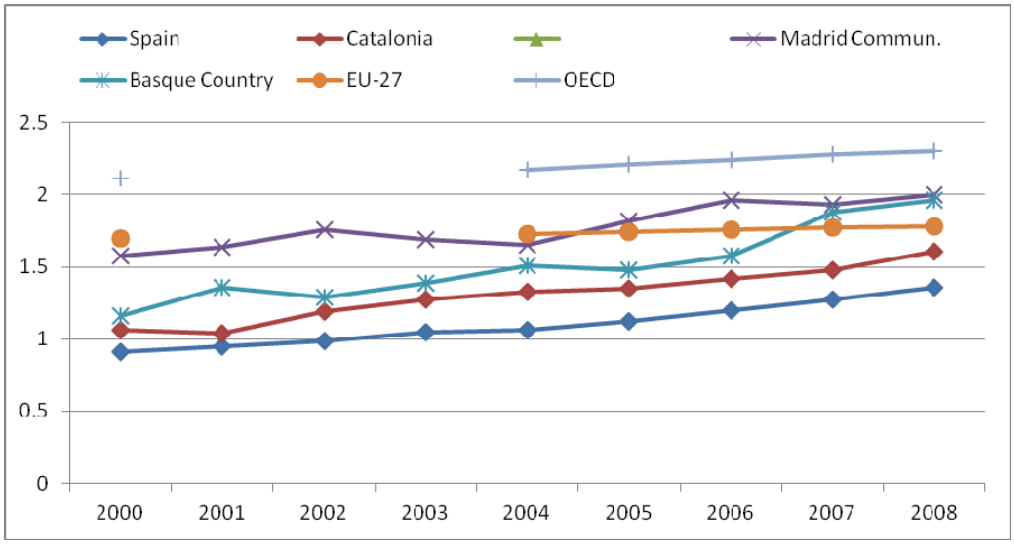


Source: Calculations based on INE data.

[10] 2005 is the latest date for which such comparisons can be made using the OECD Regional Database. Preliminary estimations indicate that the relative position of Catalonia has marginally improved up to 2008.
[11] Gross Expenditures in R&D or GERD in the OECD terminology
[12] Ratio of GERD over GDP.

Figure 7. Evolution of R&D intensity (%), 2000-2008

(OECD, EU-27, Catalonia, Spain and selected regions)



Source: Calculations based on INE and OECD data.

Catalonia accounts for close to 25% of Spain's total R&D expenditures, with a slight decrease in 2008. However, as illustrated in Figure 7, in terms of R&D intensity Catalonia still fares less well than the EU and OECD average, the Basque country, the Madrid Community, two other high performing regions in the Spain (Table 2)[13].

Beyond total R&D expenditures trends, the structure and evolution of these expenditures by sectors of performance and sources of financing need to be detailed to deepen the understanding of the innovation system the focus of research and innovation efforts.

In Catalonia by far the largest share or R&D expenditures is performed by enterprises (Figure 8). Together with non-for-profit institutions the enterprises sector, with over 2 billion Euros, accounted for more than 61% of total R&D expenditures in 2008. This share is much larger than that of Spain as a whole (55.5%) but still lower than the EU average or the OECD. Yet, if non-R&D innovation expenditures were added, Catalonia would be more than fulfilling the EU Lisbon structural objective of more than two thirds of innovation expenditures originating from the enterprise sector. With a share of 22.0% of total R&D in 2008 expenditures the Higher Education sector comes in second position followed by the government sector –essentially public research centres– with 16.9%.

[13] With an R&D intensity of 1.92 in 2008 Navarra also performs better than Catalonia.

Table 2. Evolution of R&D expenditures: Volume, annual growth rates and intensity 2000-2008
Spain, Catalonia and select autonomous communities

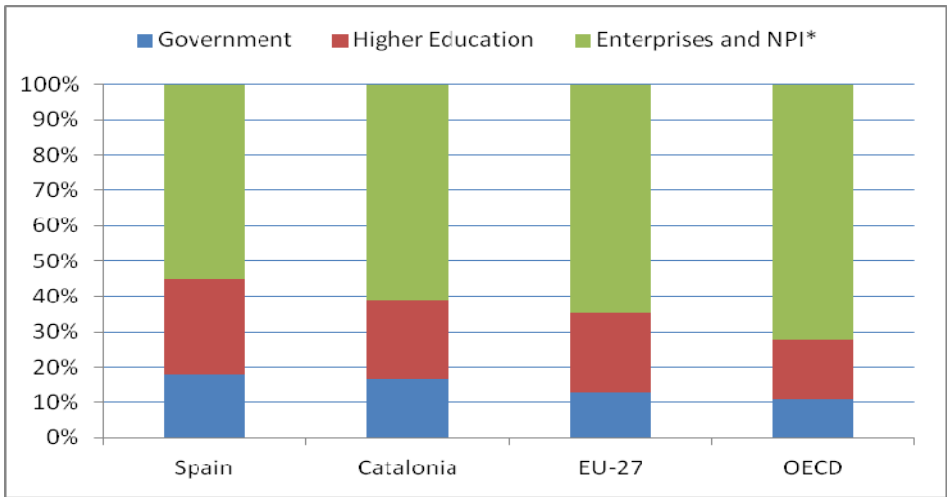
	GERD[1]					GERD rate of growth				R&D intensity[2]			
	Spain	Catalonia[3]		Madrid Commun.	Basque Country	Spain	Catalonia	Madrid Commun	Basque Country	Spain	Catalonia	Madrid Commun.	Basque Country
2000	4.995	**1.262**	**25.3%**	1.752	0.460	6.16	**11.72**	10.26	10.00	0.91	**1.06**	1.58	1.16
2001	5.719	**1.334**	**23.3%**	1.974	0.561	14.49	**5.68**	12.67	21.96	0.95	**1.04**	1.64	1.36
2002	6.227	**1.628**	**26.1%**	2.278	0.582	8.88	**22.05**	15.40	3.74	0.99	**1.19**	1.76	1.29
2003	7.194	**1.876**	**26.1%**	2.346	0.667	15.53	**15.22**	2.99	14.60	1.05	**1.27**	1.69	1.39
2004	8.213	**2.107**	**25.7%**	2.447	0.778	14.16	**12.32**	4.31	16.64	1.06	**1.33**	1.65	1.51
2005	8.946	**2.302**	**25.7%**	2.913	0.829	8.92	**9.28**	19.04	6.56	1.12	**1.35**	1.82	1.48
2006	10.197	**2.614**	**25.6%**	3.416	0.959	13.98	**13.55**	17.27	15.68	1.20	**1.42**	1.96	1.58
2007	11.815	**2.909**	**24.6%**	3.584	1.217	15.87	**11.26**	4.92	26.90	1.27	**1.48**	1.93	1.88
2008	14.701	**3.286**	**22.4%**	3.892	1.346	24.43	**24.43**	8.59	10.60	1.36	**1.61**	2.00	1.96

[1] Gross domestic expenditures on R&D.
[2] GERD over GDP ratio
[3] The second column under Catalonia gives the share of Catalonia's R&D expenditures in Spain's total.

Source: Calculations based on INE data.

This overall structure has been rather stable over the first half of the decade. However, as of 2005, stepped up efforts in favour of investment in research and innovation by the Catalan government have mainly benefitted the development of public research centres. In effect, since that date, the annual growth rates of expenditures related to R&D activities performed in government research institutions have been systematically higher that in other sectors: 33.8% in 2005, 18.3% in 2006, 27.9% in 2007 and a high 39.2% in 2008 (Table 3). As will be highlighted further this trend, reflects de facto bias for public research centres over university research partly due to governance issues in the higher education sector and is probably not sustainable.

Figure 8. R&D expenditures by sector of performance 2008



* Non Profit Institutions

Source: Based on INE and OECD data.

In fact, as illustrated in Table 3, among the three Catalan R&D performing sectors, higher education is the only one whose annual rate of growth between 2007 and 2008 has been lower that its counterpart for Spain as a whole (6.9% vs. 11.8%).

Table 3: R&D expenditures by sector of performance, Spain and Catalonia 2007 – 2008

(Million Euros)

	Spain				Catalonia			
	2007	**2008**	**Growth rate**	**Shares 2008**	**2007**	**2008**	**Growth rate**	**Shares 2008**
Total	13342.4	14701.4	10.2%	100	2908.7	3286.4	13.0%	100
Government	2348.8	2672.3	13.8%	18.2%	398.3	554.6	39.2%	16.8%
Higher Education	3518.6	3932.4	11.8%	26.7%	677.4	724.4	6.9%	22.1%
Enterprises +NPI	7474.9	8096.7	8.3%	55.1%	1833.0	2007.3	9.5%	61.1%

Source: Own calculations based on INE.

4.2. Human capital and S&T personnel

Human capital is a core input of an innovation system. Catalonia does have a share of the workforce with tertiary education higher than the OECD region average. However, within Spain, with a share of 32% Catalonia is only the 8th ranked region, the top ones being the Basque Country (48%), Navarra (40%), and Madrid (38%).

In Catalonia, as in Spain in general but even more so, the volume of human resources in S&T has grown quite rapidly in recent years due to large scale investments in graduate and post-graduate training in the higher education system.

Table 4: Evolution of number of R&D personnel[1] per 1000 employment 2002 - 200

Catalonia, Spain, EU-27 and OECD

	R&D personnel per 1000 employment			Researchers per 1000 employment		
	2002	**2004**	**2006**	**2002**	**2004**	**2006**
Spain	7.7	8.7	9.5	4.8	5.5	5.8
Catalonia	9.8	11.0	12.0	5.4	6.7	7.2
EU 27	9.7	9.9	10.3	5.5	5.8	6.1
OECD	n.a.	n.a.	n.a.	6.9	7.2	7.6

[1]In Full time equivalent

Source: Author's calculations from OECD and INE data.

As illustrated in Table 4 in Catalonia the shares of R&D personnel and researchers in total employment are well above those for Spain; they stand higher than that of the EU 27 average and are currently growing at a faster rate.

Table 5. Respective shares of R&D expenditures and personnel by sector of performance 2008

	R&D expenditures		R&D Personnel		Researchers	
	Catalonia	**Spain**	**Catalonia**	**Spain**	**Catalonia**	**Spain**
Government	16.9	18.2	14.6	19.1	16.4	17.2
Higher education	22.0	26.7	32.1	36.6	42.3	47.1
Enterprises and NPI	61.1	55.1	53.3	44.4	41.3	35.6
TOTAL	100.0	100.0	100.0	100.0	100.0	100.0

Source: Own calculations from INE data

In general terms the distribution of R&D personnel and researchers among the three R&D performing sectors follows the ranking of the distribution of R&D expenditures but with important nuances on actual shares that reveal organisational differences and wage or productivity variations among R&D personnel of these sectors (Table 5). The share of the higher education

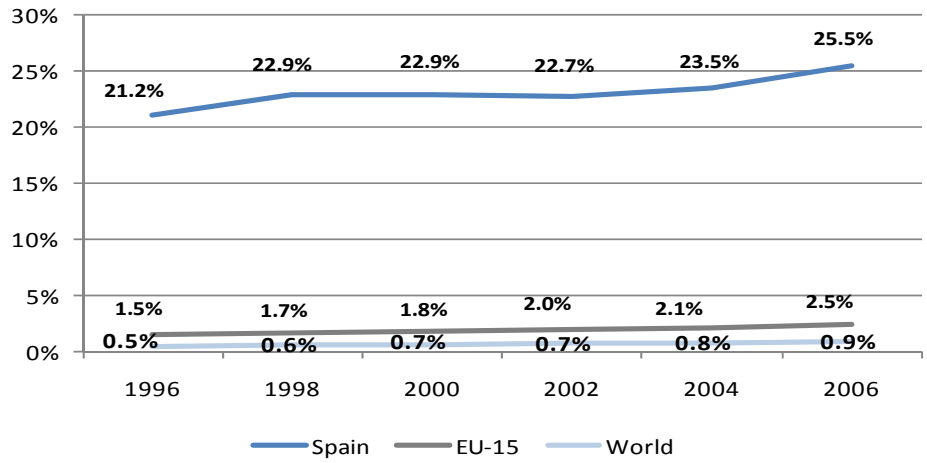
sector in the total of R&D personnel is larger than its share in expenditures reflecting a lower level of expenditures in equipment and/or a cap on wages or a lower productivity level than in other sectors. Table 5 also shows a notable discrepancy between the shares of the higher education sector in total researchers and total R&D personnel. This seems to point to a suboptimal researchers/technician in academic research. The reverse seems to hold true for the enterprises sector whereas in the government sector the respective shares are of the same magnitude.

4.3 Output performance

Scientific publications

Catalonia has made notable progress in scientific publications over the last decade. From 1996 to 2006, its share of publications within Spain has grown from 21.2% to 25.5%, of the EU15 from 1.5% to 2.5%, and of world production from 0.5% to 0.9% (Figure 9). In absolute terms, that is a 70% increase over the period. Within Spain, Madrid is the only region that exceeds Catalonia in the absolute value of scientific publications, helped by the concentration of CSIC public research centres in the capital. The university sector accounts for 74% of publications during the period with the health sector publications having the highest visibility (over 13 citations per document). There are indications of an incipient trend towards increasing co-publications between academic and enterprises' researchers.

Figure 9. Catalonia's scientific production 1996-2006



Source: Rovira, L., R.I. Méndez-Vásquez, E. Suñén-Pinyol and J. Camí (2007), "Caracterització bibliomètrica de la producció científica a Catalunya, 1996-2006". *Informe AGAUR-PRBB.* Barcelona, 2007. http://bibliometria.prbb.org/ncrcat06

Con formato: Español (España - alfab. internacional)

Patents

With close to 60 PCT patents[14] per million population in 2007 Catalonia's patenting propensity[15] is lower than the than OECD countries' average (112) or even the OECD region's average.[16] In 2008, with 31.6% of Spanish total PCT patents (and around 0.3% of the world total) Catalonia was by far the best performing region in Spain. According the Spanish patent office data for 2007, in high-tech sectors, Catalonia's patenting accounted for 27.2% of Spain's biotechnology patents, 30.7% of ICT patents, and 37.4% of nanotechnology.

Table 6 and 7 illustrates some of Catalonia's specificities among other regions as regards the growth and structure of its PCT patents by filing institutions. While Catalonia lags behind the Basque Country, Navarra and the Madrid community for the growth of total and enterprise patents, the patenting record of its public research system (universities, public research centres and hospitals) is quite high in comparison with other regions and has been improving in recent years as highlighted in ACUP (2010).[17] On the other hand, the growth rate of enterprises patenting has been much slower in absolute and relative terms.

4.4. Patterns of innovation in the enterprise sector

In Catalonia, the main patterns of enterprise innovation show features that are also to be found in other developed European regions. Catalan firms in high-tech manufacturing and services are more likely to have higher values on a range of innovation-related indicators. For example, firms in high-tech industries are more likely to have innovation projects (71.5%) than those in low-tech industries (49.8%). In services, high-tech knowledge intensive services (KIS) are also more likely to do so (71.1%) relative to other KIS (37.8%) (Table 6).

[14] The patenting performance is better accounted by PCT patents that have a higher international value.
[15] Number of patents per capita or per unit of R&D expenditures
[16] According to data from the OECD regional database in 2005 the OECD regional average in PCT patents per million population was 72.3.
[17] The Polytechnic University of Catalonia is the Spanish university with the highest number of patent applications.

Table 6. Number of PCT applications filed by Spanish applicants and institutional sectors, 2000-2007
(Selected Autonomous Communities)

	Individuals[1]			Companies			GOV.			Univ. + Hospitals			PNP[2]			Total[3]		
	2000	2004	2007	2000	2004	2007	2000	2004	2007	2000	2004	2007	2000	2004	2007	2000	2004	2007
Catalonia	35	87	94	138	266	254	1	6	4	7	14	29	0	5	11	187	388	411
Madrid Community	21	43	111	49	85	126	0	5	5	13	15	47	1	5	5	126	216	310
Navarra	3	9	11	7	22	42	0	0	0	1	1	2	1	2	2	11	39	55
Basque Country	8	11	17	16	28	42	0	1	0	0	3	9	1	2	9	27	46	81
TOTAL Spain	129	274	398	287	532	614	1	13	10	39	84	177	4	17	32	524	1028	1299

[1] Includes patents filed by owners of small enterprises
[2] Private non-profit organizations
[3] Includes patents filed by unregistered applicants
Source: OECD, REGPAT database, January 2010

Table 7. Share and growth rates of PCT applications by institutional sectors
(Selected Autonomous Communities)

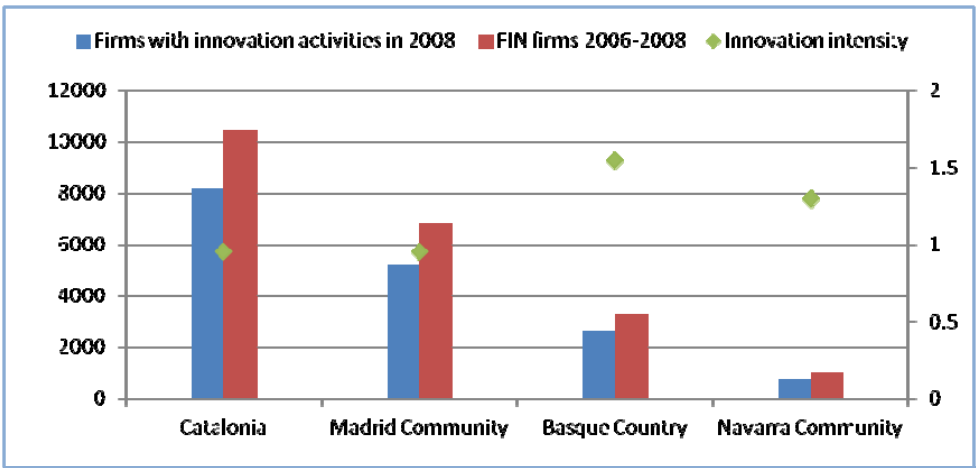
	Individuals		Companies		Government + Univ. + Hospitals+ PNP		Total	
	Share 2007	growth rate 2000/2007	Share 2007	growth rate 2000/2007	Share 2007	growth rate 2000/2007	Share 2007	growth rate 2000/2007
Catalonia	23.5	63.0	41.3	83.9	19.9	403.3	31.6	119.3
Madrid Community	27.9	81.4	20.5	155.1	26.2	338.2	23.9	146.8
Navarra	2.8	266.6	6.8	500.0	1.9	200.0	4.2	400.0
Basque Country	4.2	54.1	6.9	159.2	8.0	1650.0	6.3	198.2
TOTAL Spain	100	67.6	100	114.4	100	387.8	100.0	147.9

Source: OECD, REGPAT database, January 2010.

The 2008 innovation survey shows that within Spain Catalonia is an average performer in terms of the share of innovative firms over total enterprises. The Basque country and Navarra fare much better in terms of innovative intensity which measures innovation-related expenditures as a proportion of turnover.

Figure 10. Innovative firms[1] and innovation intensity[2] 2006-2008

Selected regions



[1] FIN firms: firms that have engaged innovative activities in the 2006-2008 period.
[2] Innovation intensity: Innovation expenditures over turnover x 100

Source: Own calculations from INE data.

In terms of financing of innovation expenditures Catalonia also shows some specificities. While in all regions the share of own resources is preponderant, the share public funds provided by the Spanish State and the Community's government in the framework of programmes and incentives in support of innovation is much smaller in Catalonia than in both Navarra and the Basque country. The same is true for funding from other enterprises which reflects a weaker cooperative approach to innovation and a lesser degree of inter-enterprise knowledge spillovers (Table 8).

Table 8. Structure of innovation financing by sources of funds 2007

Selected regions

	Own funds	Other firms	Public funds[1]	Foreign funds
Catalonia	68.6%	2.2%	8.8%	20.4%
Madrid	73.4%	5.6%	8.7%	12.3%
Basque country	55.0%	14.9%	26.0%	4.1%
Navarra	71.5%	4.8%	21.2%	2.5%

[1] From Spanish state and autonomous community

Source: ACC1Ó (2010), Calculations based on the INE Innovation Survey 2007.

In terms of *type* of innovation, again, the higher the technology level, the greater the share of firms engaging in different forms of innovation, with high-tech KIS being by far the most likely to engage into organisational ones. The relationship between firm size and R&D/innovation activity is not always linear and depends on sector and technology level. Smaller firms in both manufacturing and services at different technology levels tend to spend more per employee on R&D and innovation than larger firms. However, while in manufacturing the share of innovative firms and those with permanent R&D activities raises with firm size in (both high and low-tech) the reverse is true in service industries (Segarra-Blasco, 2010).

Table 9. Innovation trends of firms in Catalonia

	High-tech industries	Low-tech industries	High-tech KIS	Other KIS
R&D and innovation activities in 2004 (share of firms %)				
Innovation projects	71.50	49.75	71.11	37.78
Permanent R&D	66.28	39.63	67.14	26.84
Sporadic R&D	12.47	10.94	7.22	7.24
Public support in R&D	26.99	19.26	43.32	16.61
Co-operative agreements in R&D	25.66	12.19	28.88	13.21
Patents	23.00	11.85	21.66	4.54
Innovative firms by type of innovation in 2002-2004 (share of firms %)				
Innovative firms	60.00	34.58	53.42	20.88
Product innovation	58.84	36.93	54.87	25.42
Process innovation	51.32	44.76	41.15	32.38
Organisational innovation	48.14	38.39	58.84	42.32
Market innovation	26.28	19.81	24.18	13.06
Product or process innovation	70.97	52.94	62.81	38.35
Product and process innovation	39.20	28.75	33.21	19.46
Process product (1)	66.61	77.86	60.52	76.53
Product process (1)	76.37	64.24	80.70	60.08
Product permanent R&D (1)	78.23	69.75	72.04	57.14
Process permanent R&D (1)	65.55	73.60	51.61	65.07
Output product innovation				
New for the firm (% sales)	11.73	7.98	11.11	6.40
New for the market (% sales)	6.33	3.22	14.07	3.19
Average size (workers)	160.14	114.18	161.32	320.15
Average size (sales, millions EUR)	51.23	27.59	31.65	39.28
Export over sales (%)	26.06	16.49	9.05	3.03
Number of firms	1 130	1 443	277	704
R&D and innovation expenditures by firm				
Research personnel (% total workers)	7.62	2.19	24.53	4.39
Innovation expenditure per worker (EUR)	6 764	3 748	19 118	4 719
Intramural R&D	4 559 (67.4)	1 470 (39.2)	15 590 (81.6)	3 463(73.4)
External R&D	1 346 (19.9)	173 (4.6)	2 571 (13.4)	406 (8.6)
Machinery and software	462 (6.8)	1 159 (30.9)	233 (1.2)	586 (12.4)
Other sources	396 (5.8)	943 (25.2)	721 (3.8)	262 (5.6)

Note: (1) Conditional frequencies. KIS=Knowledge-intensive services, R&D=research and development.

Source: Segarra-Blasco, A. (2010), "Innovation and productivity in manufacturing and service firms in Catalonia: a regional approach", *Economics of Innovation and New Technology*, Vol. 19-3, pp.233–258; based on data from the Catalan sample of the CIS-4.

Firms that innovate show much higher levels of spending on innovation and R&D by several multiples than those that did not report an innovation (high-tech innovators 3.5 times more, low-tech innovators 5.4 times more, and KIS 11.3 times more) (Table 10). Of that spending, the share devoted to R&D as opposed to other sources of innovation is also much higher among innovating firms. Firms that report an innovation are also those with higher shares of exports. The share of innovation output in sales is also notably higher, especially for KIS firms (38.7% for innovators versus only 5.6% for non-innovators).

As was noted above, over the last decade and at the macroeconomic level, total investment in R&D and innovation in Catalonia was not correlated to aggregate productivity gains. However, as shown by Segarra-Blasco (2010), the correlation is positive at the micro-economic level: "R&D intensity presents positive marginal elasticity on labour productivity in all estimations: 7.9% in high-tech manufacturing industries, 6.0% in low-tech manufacturing industries, 11.7% in high-tech KIS and only 2.5% in other KIS. However, firm size has a positive effect on productivity in manufacturing industries but not in services. In addition, when firms export their productivity level increases, particularly in low-tech manufacturing and service industries".

Table 10. Characteristics of innovative vs. non innovative firms by technology intensiveness

Type of firms	High-tech manufacturing	Low-tech manufacturing	Knowledge Intensive Services (KIS)
Innovative firms			
Export by sales (%)	41.7	26.3	1.3
R&D and innovation expenditure per employee (EUR)	15 553	6 019	10 671
Expenditure on R&D per employee (%)	31.1	36.4	43.0
Expenditure on other sources of innovation per employee (%)	58.9	63.6	57.0
Innovation output in sales (%)	26.1	22.5	38.7
Non-Innovative firms			
Export by sales (%)	29.5	16.9	1.5
R&D and innovation expenditure per employee (EUR)	4 420	1 116	946
Expenditure on R&D per employee (%)	10.3	3.4	3.0
Expenditure on other sources of innovation per employee (%)	89.7	96.6	96.9
Innovation output in sales (%)	9.6	7.0	5.6

Note: The criteria for classification into high-technology and low-technology manufacturing were not specified.

Source: Segarra-Blasco, A. *et al.* (2008), "*Barriers to innovation and public policy in Catalonia*", International Entrepreneurship Management Journal, Vol. 4 pp: 431-451; based on data from the Catalan sample of the CIS-4.

Beyond the cost of innovation-related investment which is often quoted as the main barrier to innovative activities, the weak macroeconomic effect may be due to various obstacles in the technology diffusion process, limited absorption capacities of large segments of SMEs in low-tech industries and low levels of inter-industry spillovers. In effect according to the results of the recent innovation surveys, in Spain as a whole as well as in Catalonia a rather low percentage of

SMEs report sourcing information for their innovation activities from institutions that offer technological transfer activities.

4.5 Higher education institutions and public research centres

The high priority given by the Catalan government to the development of the S&T infrastructure since in its first research and/or research and innovation plans since the beginning of the '90s have resulted in the building of a strong public research system.

By international standards, Catalan publicly funded research institutions have achieved a high level of excellence in several areas such as biomedical research. They play a key role in the Catalan innovation system. Higher education institutions (HEIs) and public research centres (PRCs) are the main players in the generation of new knowledge, as well as in the training of qualified human resources not only in science and technology but also in the management of innovation. They are increasingly involved in so-called "third mission" activities devoted to knowledge transfers to individual enterprises or clusters, as well as in research and innovation partnerships with the private sector.

Together, the HEIs and PRCs (including Spanish CSIC centres) perform close to 40% of total R&D activities carried out in Catalonia (respectively 22% and 16.9%) with a high share of such activities funded on a competitive basis by the Spanish state and EU programmes.[18] They employ over 25,000 researchers which represent more than 58% of the region's total (respectively 42.3% and 16.4%). With the creation of the ICREA[19] programme in 2000 they have been given the means to attract high-level scientists from around the world.

The contribution of HEIs and PRCs to innovation is supported by various types of Spanish or Catalan support instruments or incentives and can take several forms highlighted in ACUP (2010). The main ones are:

- The technological transfer offices (OTRI)[20] in all Catalan universities with the support of funds Spanish government[21] to promote cooperation with enterprises in R&D activities through contractual arrangements;

- The participation in the Spanish government sponsored CENIT[22] strategic programmes that support public research in the framework of medium to long term partnership with the private sector;

- The development by CIDEM, in cooperation with CIRIT[23] and the nine universities, of networks of support centres for technological innovation (XIT) founded on an

[18] The share of Catalan research institutions in the total amount of funding received by Spanish institutions from the successive EU S&T framework programmes has steadily increased over time from15% in the 3rd framework programme (1990-1994) to 23.5% in the 6th one (2002-2006). Moreover, more than 60% of the starting grants received by Spain from recently created European Research Council were awarded to Catalonia.
[19] Institució Catalana de Recerca i Estudis Avançats
[20] Oficinas de Transferencia de Resultados de la Investigación.
[21] This support is available to all Spanish universities that have research activities.
[22] Consorcios Estratégicos Nacionales en Investigación Técnica.
[23] Comissió Interdepartamental de Recerca i Innovació Tecnològica.

accreditation system of its members who can benefit from incentives in engaging in transfer activities;

- The relatively recent development of University-linked science and technology parks that provide physical and knowledge infrastructure in support of incubators and sectoral clusters.

- New modes of intellectual property management by public research institutions that provide increased incentives to individual and/or team of researchers to engage in patenting activities, and for institutions to develop licensing practices;

- The development of spin-off enterprises originated in university research is encouraged through support provided by the Network of Technological Springboards (XTT).

Table 11. Catalan universities' transfer and innovation activities 2008

University	R&D contracts (thousand Euros)	S&T Services (thousand Euros)	PCT patents	Licences (thousand Euros)	Spin-offs
UAB	14,200	4,745	9	100.0	5
UdL	2,276	452	3	2.5	1
UdG	3,531	610	0	2.0	0
UPC	39,863	3,473	12	133.0	9
UPF	6,475	0	2	165.9	1
URL	7,816	750	2	0	0
UB	15,621	1,816	11	0	0
URV*	8,140	304	1	118.0	0
Total	97,922	12,150	40	521.4	16

* Figures from 2007
Source: Report of the survey RedOTRI 2008 and URL. Reproduced from ACUP (2010)

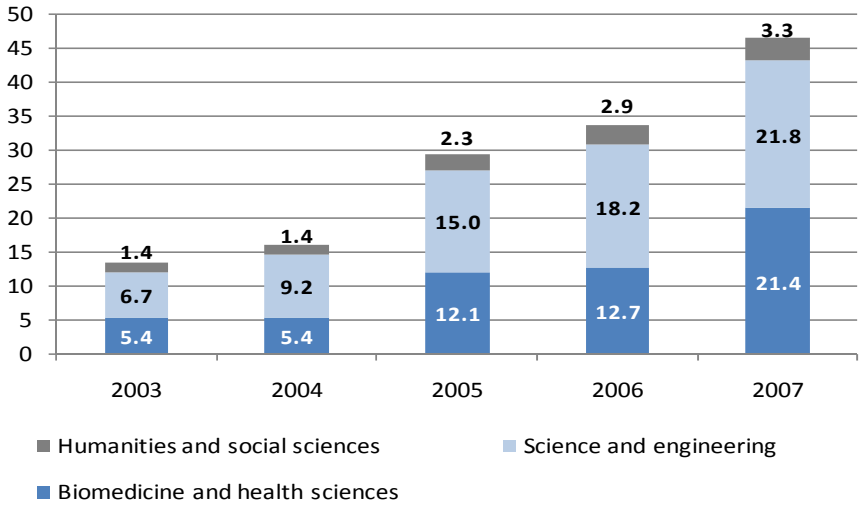
On the whole, all these channels aimed at transferring knowledge and fostering knowledge-based innovative activities have produced some positive results (Table 11) but it is argued that they have not all met with the expected outcomes for several reasons that have to do with remaining rigidities in the governance of public universities, critical mass of the resources devoted to transfer activities as well as management issues.

The system of public research centres was developed by the Catalan government partly in response to governance rigidities in universities –due to a regulatory framework that applies for all Spanish public HEIs, partly to ensure the development of research capacities in strategic areas. Since their creation in the mid eighties, their number has increased rapidly up to 37 in 2008. The Catalan government financed on average approximately 42% of the Centres operating expenditures in 2006. The region's budget for institutional funding of PRCs has more than tripled between 2003 and 2007 from 13 million to 46.5 million Euros annually (Figure 11) and PRCs are encouraged to increase the share of their self-financing through research contracts and the provision of technological services.

By essence, as compared with that conducted in HEIs, the research activity developed in PRCs is of a more targeted and operational nature. Therefore PRCs should in principle be more active in knowledge transfer and/or innovative activities, the more so as the share of self-financing is bound to increase. However, as will be argued later, the recent multiplication of research centres and the moving balance with HEIs raises some efficiency issues as well as some having to do with the management of interdisciplinary research.

Figure 11. Financing of the Catalan Research Centres network

Millions Euros (current prices)



Source: (CIRIT, 2008).

4.6 Intermediary institutions

The development of a sound and dynamic innovation climate is predicated upon the existence of various public and private intermediary institutions that foster not only the diffusion and technical application of knowledge but also to the development of commercial applications of this knowledge into new products, processes and services that will respond to existing market opportunities or open new ones. Among such institutions figure prominently (i) those dedicated to technological information and transfer, (ii) those that facilitate the financing of innovation projects, and (iii) those that aim at improving the management of such projects and the related organisational changes.

Large firms are often in a better position than SMEs to internalise the services offered by such intermediary institutions. Among the reasons of the relatively low innovative performance of the SME fabric in Catalonia is the weakness of such institutions, the fact that their recent development has been more supply than demand oriented, or the fact that their frequent public nature has crowded out private initiatives for the provision of intermediary services. Public provision can usefully serve as a catalyst, but at some point it should be complemented or substituted by private initiatives. In Catalonia, there are two cases in point.

Table 12. Technological centres in Catalonia: scale and type 2008

Technology Centres	Staff	Total revenues in EUR millions (0 to 1.5, 1.5-3, >3)	Share of revenues from R&D (<50%, >50%)
Advanced Technology Centres			
ASCAMM (The Foundation of the Catalan Moulds and Matrices Companies Association)	89	>3	<50%
CTM (Cerdanyola del Vallès, Vallés Technology Parko Manresa Technology Centre)	73	>3	>50%
LEITAT (Terrassa Textile Conditioning Research and Test Laboratory)	123	>3	>50%
CETEMMSA (the Mataró-Maresme Business Technology Centre Foundation)	63	>3	<50%
BM-CI (Barcelona Media Innovation Centre)	148	>3	>50%
Technology Centres			
AIICA (Association for Research in the Fertiliser and Related Industries)	27	1.5-3	<50%
CTAE (Aerospace Technology Centre)	25	0-1.5	>50%
IMAT (Construction Technology Centre)	23	1.5-3	>50%
CENTA (Agrofood Industries Technology Centre)	8	ND	ND
BDCT (Barcelona Digital Technology Center)	30	>3	<50%
CTNS (Health and Nutrition Technology Centre)	ND	ND	ND
CTQC (Chemical Technology Centre of Catalonia)	ND	ND	ND
Technology Dissemination Centres			
Eduard Soler Technology Centre	51	>3	<50%
INCAVI (Catalan Vine and Wine Institute Centre)	44	>3	<50%
Fund CECOT	15	1.5-3	<50%
FITEX (Igualada Foundation for Textile Innovation)	7	1.5-3	<50%
Fund ITL (Lleida Technological Institute)	19	0-1.5	<50%
CENFIM (Wood and Furniture Technology Dissemination Centre)	5	0-1.5	<50%
INNOPAN (Bakery Sector Technology Dissemination Centre)	2	0-1.5	<50%
Cam. Grafica	7	0-1.5	<50%
TCM Audiovisual (TecnoCampusMataró Audiovisual)	6	0-1.5	<50%
CATIC (ICT applications Centre)	3	ND	ND

Note: ND = no data available

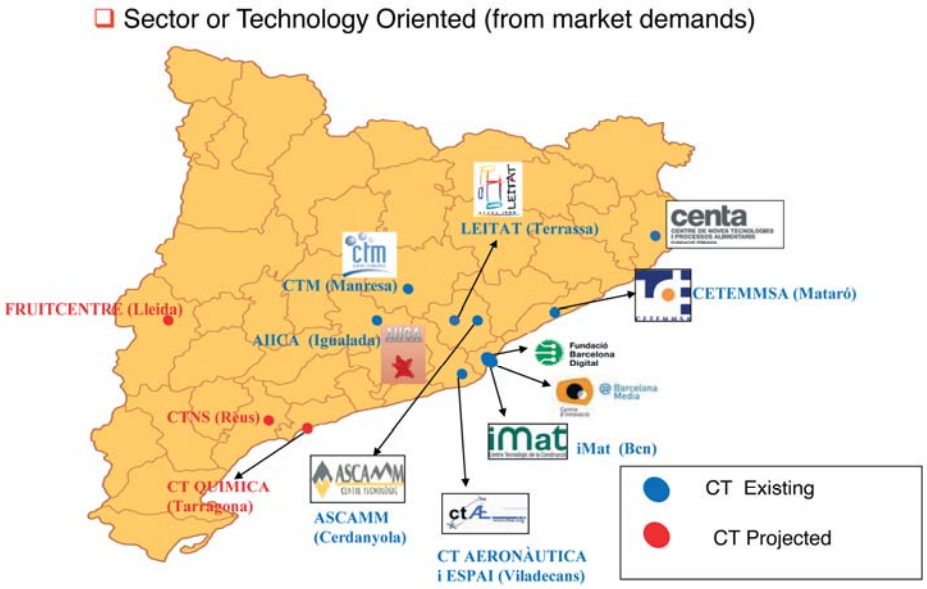
Source: OECD (2010a), based on ACC1Ó data.

The first one is the complex system of technology transfer services principally organised under the aegis of CIDEM.[24] Technology Centres are relatively new to Catalonia, as compared to other regions in Spain, such as the Basque Country. Over time, through CIDEM funded programmes, the Catalan Government promoted the development of three types of centres: Advanced Technology Centres, Technology Centres and Technology Dissemination Centres (Table 12). While each was type was to function as a network, they were actually performing as individual centres without much synergistic effects expected from being part of a network. Recognising the shortcomings linked to the proliferation of such technology centres funded with successive instruments and their resulting different sizes and quality of services, the Catalan government is

[24] Now merged into ACC1Ó.

now seeking to rationalise the existing offer (Figure 12). The new Network of Technology Centres, TECNIO, should bring together all the different centres under a single oversight entity. This incipient reorganisation should also recognise the importance to strike a good balance of incentives and support between the offer and demand of such technology transfer services and avoid crowding out the development of private technology brokers.

Figure 12. Catalonia's technological centres



Source: CARI (2009)

The second one is related to the financing of innovative projects and more particularly the availability of venture capital. While Catalonia is typically the second leading receipt of private equity investment and venture capital in Spain after Madrid and often first in terms of transactions this outcome should be more attributed to a size effect than to the vitality of the local venture capital market. In effect, one can argue that the Catalan Institute of Finance (IFC) has been relatively timid in its venture capital activity where it could have had more of a catalyst role to mobilise private funds, especially when projects were eligible to benefit from subsidised guarantee schemes such as AVALIS.

5. Catalonia's early approaches to S&T and innovation policies

In the early 1980s, Catalonia was already one of the Spanish regions with the highest concentration of research and innovation activities. Although it accounted for more than 16% of the country's R&D expenditures, the intensity of that investment was much lower than that of other major European regions. The share of business in total regional R&D expenditures was already larger than the public share. Catalan enterprises outperformed those of other Spanish regions in terms of patents applications, even if the major source of technology remained embodied in imported capital goods and designs. S&T infrastructure was relatively well

developed, with three public universities and a number of Spanish public research institutions operating under the aegis of the Spanish Research Council (CSIC). There were also incipient research and technological centres created by the newly formed Catalan government and operating either in collaboration with universities or under the aegis of sectoral departments.[25] This infrastructure contributed to a relatively good record in terms of scientific production as compared to the other Spanish regions, and in particular that of Madrid (Cruz Castro *et al.*, 2003).

Over the last three decades, Catalan approaches to S&T and innovation policies have evolved under the influence of several factors whose interdependence may continue to orient these policies and the innovation performance of the region in the future:[26]

- ***Constitutional/devolution issues:*** Sharing of responsibilities and co-ordination between the Spanish State and Autonomous Communities over S&T policy and resources;

- ***Stakeholder issues:*** Relative balance of power between the academic and business communities –as well as growing importance of civil society concerns– for policy orientations and their consequences in terms of resource allocation;

- ***Political issues:*** From 1980 to 2003, the Coalition and Union party led the Catalan government. Since 2003, there has been more political turnover leading to frequent ministerial and institutional changes reflecting more complex political coalitions;

- ***Governance issues:*** Evolution of government structure and responsibilities as regards priority setting for the design, funding and implementation of S&T policy, including the growing importance of accountability of public action;

- ***External sources of funding:*** Catalonia's access to the European Union (EU) Framework Programme and Structural Funds following Spain's adhesion to the EU in 1986 as well as increased capabilities to benefit from Spanish support programmes;

- ***Increasing emphasis on innovation as tool to address socio-economic challenges:*** Growing recognition at all levels of the key role of innovation for sustainable development and international competitiveness across economic activities, including public and private services, as well as of the threats and opportunities brought about by globalisation; and

- ***Changing approach to innovation policy:*** Progressive diffusion of the innovation system conceptual framework into the policy-making process at EU, Spanish and Catalan levels.

5.1. Evolving institutional and international contexts

In the first year of the new Autonomous Community legislature after the 1980 elections, the Inter-ministerial Research and Innovation Commission (CIRIT) was created under the chairmanship of the region's President but could not effectively carry out its mission. It was entrusted with the

[25] Such as the Agrofood Research and Technology Institute (IRTA) created in 1985 under the aegis of Catalonia's Department of Agriculture following the transfer of responsibility for the agrofood sector from the State to the *Generalitat* (Catalan government) in 1981, including the *Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria* (INIA), the State research facility in the sector.

[26] Quoted from OECD (2010a).

allocation of Catalan public investment in and support of, S&T related activities. The creation of this institution at inter-ministerial level seemed to already indicate a willingness to address in a co-ordinated fashion the demand and supply sides of R&D and technology, the strengthening of scientific capacity of public research institutions, and the technological absorptive capacities of the productive sector - mainly in industry and agriculture (Bacaria *et al.*, 2004).

CIRIT immediately faced resource constraints due to the nascent conflict between the Spanish State and the *Generalitat* over the transfer of responsibilities and resources in the S&T area.[27] These transfers, that would have contributed the largest share of the CIRIT budget, were not approved at State level.[28] CIRIT resources therefore remained minimal, peaking at EUR 3.18 million in 1983. The academic constituency gained the upper hand in the decision-making process regarding policy priorities for the allocation of scarce resources and the funding of programmes (Cruz Castro *et al.*, 2003). Thus, the lack of devolved Spanish government resources resulted in a shift in the balance of S&T and innovation policy towards the academic side, mainly in the areas of S&T infrastructure and human capital development through scholarships, at the expense of support to innovation and technology transfer.

To compensate for this policy imbalance towards the academic side, in 1985 the Ministry of Industry created a new agency to strengthen S&T infrastructure for industry: the Centre of Entrepreneurial Information and Development (CIDEM). This agency started with actions focused on the development of sectoral technological centres, the provision of technological services such as metrology and certification, and the dissemination of information through networks (*Xarxas*).

This dual or "silo" approach to S&T and innovation policy continued and was institutionalised during the second legislature (1984-1988). With the 1986 devolution of the responsibility and related resources over the public higher education sector to the regions, and the contrary decision regarding the S&T sector taken in the same year, the pressure of the academic community to take a *de jure* control over the CIRIT became stronger. This institutional change became effective in 1988 when the CIRIT passed under the direct responsibility of the Ministry of Education. The attempt at a more integrated, or at least co-ordinated, approach was unsuccessful as a narrow academic vision of a Catalan S&T policy prevailed with the institutional consolidation of a silo organisational and governance structure.

The academic constituency's pressure for resources to develop their research activities (mainly related to infrastructure and human capital) became more acute during the stalemate over the S&T devolution issue. Anticipating a negative outcome – after an appeal from the Catalan government was rejected by the Spanish constitutional court in 1992 – CIRIT managed to substantially increase the budget appropriations for research activities under its control, as well as those coming from other bodies of the Ministry of Education. Indeed, between 1988 and 1992 the R&D budget of that Ministry (CIRIT and the Directorate General of Research) increased more than tenfold to reach EUR 33.3 million at the end of the period, with more than half allocated to CIRIT

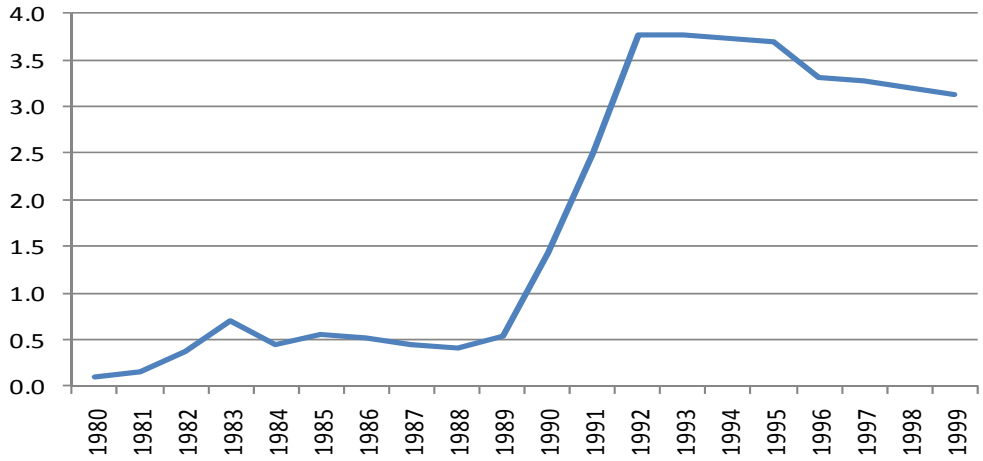
[27] The budget shortage was due in part to the Catalan government's unsuccessful attempt to press the central government for devolution of S&T resources. Other Spanish regions did not seek devolution of S&T resources at the time.

[28] Contrary to what happened for public funding of agricultural research.

programmes (Figure 13). Despite this substantial increase in absolute terms, budgetary resources remained quite small for an economy of Catalonia's size, but this was partly compensated by the strategic choice to leverage funding sources external to the region –mainly from Spain and the EU– by allocating internal resources to strengthen the HEIs and PRCs research capacity allowing these institutions to reach the best possible competitive level to access external funds (Cruz Castro *et al.* (2003).

Figure 13. Catalan public R&D expenditure 1980-1999

Billions of pesetas (constant prices 1986)



Notes: This includes spending under the remit of CIRIT as well as in some years the Directorate General for Universities and/or Research. It excludes funds under the remit of IRTA, the Catalan Research Centre for agriculture, aquaculture and the agrofood industry.

Source: OECD calculations based on data from the *Gabinete Técnico de Investigación (GTR) y Comisionado para las Universidades y la Investigación, 2000* as cited in Cruz Castro, L. *et al.* (2003).

In the meantime, resources devoted to the promotion of innovation and transfer activities remained minimal. Programmes focusing on the development of universities' "third mission" were quasi inexistent. There were few, if any, incentives or institutional arrangements aimed at fostering the transfer of scientific knowledge to the productive sector and the collaboration between science and industry. The only actions explicitly devoted to foster firm innovative or technological capacities were carried out through the provision of support services by CIDEM for manufacturing industries or by the Ministry of Agriculture for the agrofood sector. There were no financial instruments such as grants, loans or guarantees in support of research and innovation projects in or by enterprises.

5.2. The first research and innovation plans

Formally, the first Research Plan (1993-2000) developed by the Catalan government was intended to promote increased synergies between the research and innovation pillars of S&T policy. This was supposed to be achieved through an improved balance between support to supply factors

(essentially support to public research infrastructure and the development of human capital), and demand factors (incentives to R&D and innovation investment as well as support to technology transfer). This view was of course inspired by the increased concerns for the competitiveness of Catalan industry and the agrofood sector in the open European market and the premium to be gained in productivity through innovation. Moreover, since the overwhelming share of the financing of the research projects was coming from outside, more resources could be invested in innovation-related activities. However, this vision proved difficult to obtain due to institutional inertia, as while CIRIT had responsibility for Plan design and implementation this Committee was overseen by the Commission for Universities and Research (CUR) which was strongly dominated by academic interests.

The bulk of resources were devoted to strengthening research groups to capture outside competitive project funding. Priority lines of action were only pursued through the creation of the so-called Reference Centres Network aiming at strengthening S&T capabilities in areas such as biotechnology, food technology and advanced production technologies. Conceived as a means to facilitate technology transfer, these Centres were financed on a contractual basis. Their performance was at best mixed as their governance lacked efficient co-ordination mechanisms between the supply and demand sides. The Plan did not include specific programmes or instruments for direct financial support to firm innovative projects. However, towards the end of the period covered by the Plan, CIDEM started to provide such type of support, essentially to SMEs, with the launching of a joint CIRIT/CIDEM grant programme in 1995.

In terms of resource allocation, the *de facto* policy mix of the Plan was heavily tilted towards the scientific base. There was not much concern with either the demand side or the articulation between latent demand and the orientations of supply. Less than 7% of the 1995 budget for research in a broad sense was devoted to firms' innovation projects. The bias in the policy mix was due in part to the governance setup, with Plan development by CIRIT acting under the authority of the Commission of Universities and Research and not reflecting a true inter-ministerial approach. Another bias stemmed from a confusion of roles for CIRIT as a body involved both in policy making and policy implementation.

The second Research Plan (1997-2000) whose preparation was still led by CIRIT under the authority of the Commission for Universities and Research marked a certain evolution over the preceding one. Its general policy orientations and programmes evolved –albeit slightly– towards an improved balance between the strengthening of the knowledge base, innovation support and development of more efficient between science and industry in terms of technological transfers and collaboration. While the main emphasis of the 2nd Plan remained on research infrastructure and human capital,[29] there are significant new initiatives that highlight this incipient evolution. Among them one can mention:

- The creation of a Network of Centres for Technological Innovation Support (XIT) in 1999. The purpose of this network co-financed by CIRIT and CIDEM with the collaboration of Catalan universities was to provide incentives to academic research groups to engage in knowledge transfer activities as well as to the creation of spin-offs by individual researchers. A system of accreditation of Centres was developed to provide some quality guarantees to

[29] With the creation of ICREA (Catalan Institute of Advanced Research and Studies) an important initiative was taken to promote the hiring of top level international scientists in Catalonia's public research institutions with contracts not bound by University contractual regulations.

both enterprises and research groups engaged into collaborative activities. It is to be noted that public resources invested in this network by CIRIT and CIDEM served as a catalyst to leverage private financing from firms engaged in collaborative activities with the Centres revealing a latent but effective demand; the number of accreditated Centres grew rapidly from 9 in 1999 to 24 in 2000 (CIRIT, 2003). This network structure which represents the "touchstone of the Catalan technology transfer system" (Defazio and García Quevedo, 2006), is at the origin of the creation of other similar initiatives in subsequent years.

- The consolidation programmes in support of enterprise innovation projects co-financed by CIRIT and CIDEM and engaged in the last years of the previous Plan. Close to 300 enterprises, mainly but not only SMEs were supported during the period covered by the Plan. Here again there was a leverage effect built into the programme with 1 peseta of grant inducing an investment of 9 pesetas in innovation related activities (CIRIT, 2003).[30]

Table 13. Catalonia's second Research Plan budget, 1997-2000

Million pesetas

Programmes		Volume	Percent
1. CIRIT and DGR			
	1.1. Research Promotion Programme		
	HRST (Human Resources for Science and Technology)	5 623	24.4
	Research Support	9 402	40.8
	Research Projects	617	2.7
	Research Centres	4 050	17.6
	International Co-operation	699	3.0
	Others	1 213	5.3
	Total	21 604	93.8
	1.2 Technology Transfer Programme		
	HRST (Human Resources for Science and Technology)	308	1.3
	Support to XIT Network	351	1.5
	Support to Technology Transfer Networks	16	0.1
	Support to Projects	591	2.6
	International Co-operation	152	0.7
	Total	1 418	6.2
	Total CIRT/DGR	**23 022**	**100.0**
2. Transfer DURSI for Academic Research Personnel		**93 136**	
3. Total DURSI[1]		**122 451**	
4. Thematic Areas[2]			
	Health	34 556	
	Industry (including CIDEM)	6 675	
	Agriculture	5 197	
	Others	10 683	
Grand Total Research Plan		**179 562**	

[1] DURSI is the Ministry of Universities, Research and Information Society which replaced the Commission for Universities and Research in 2000.
[2] Funded by sectoral ministries.

Source: CIRIT (2003), "Informe d'Avaluació del II Pla de Ricerca de Catalunya

[30] Note that this ratio does not measure the additionality effect but the relative proportions of public and private financing of the supported enterprises' total innovation related investment.

- Programmes focusing on mobility of human resources aiming at facilitating the insertion of R&D personnel in enterprises such as scholarships to facilitate the undertaking of doctoral work in enterprises, or subsidies to the temporary recruitment of public research centres' staff into enterprises.

Beyond the fact that they highlight an increased attention to innovation performance in Catalan S&T policy, these initiatives also reflect an incipient systemic view of the research/innovation nexus that emphasises the articulation between generation and diffusion of knowledge and the importance of capacity building and learning processes in the innovation performance.

However, one should also submit these welcome initiatives to the reality check of actual resources allocation. Qualitatively they represent a conceptual shift and recognition of complementarities between S&T policy pillars. Quantitatively they remained rather poorly endowed vis-à-vis those focusing on the strengthening of the research infrastructure (see Table 13), even when the CIDEM resources from the Ministry of Industry that contribute to technological transfers and grants to innovative projects are added to the "Technology Transfer Programme" CIRIT budget line of the Plan.

5.3 The institutionalisation of separate and complementary research and innovation policy areas at the beginning of the decade

In the final year of the second Research Plan pressures mounted to devote a greater attention to the promotion of innovation in the formulation of policies and the allocation of resources. The comparison with other Autonomous Communities such as the Basque country where the promotion of innovation as the main axis of the S&T policy more responsive to industrial interests had led to stronger economic performance (Sanz *et al*. 2005) contributed to a policy shift. This shift was underpinned by the evaluation of the Plan that explicitly recognised that the promotion of innovation and in particular the technology transfer programmes had been too weak in terms of scope and resources (CIRIT, 2003).

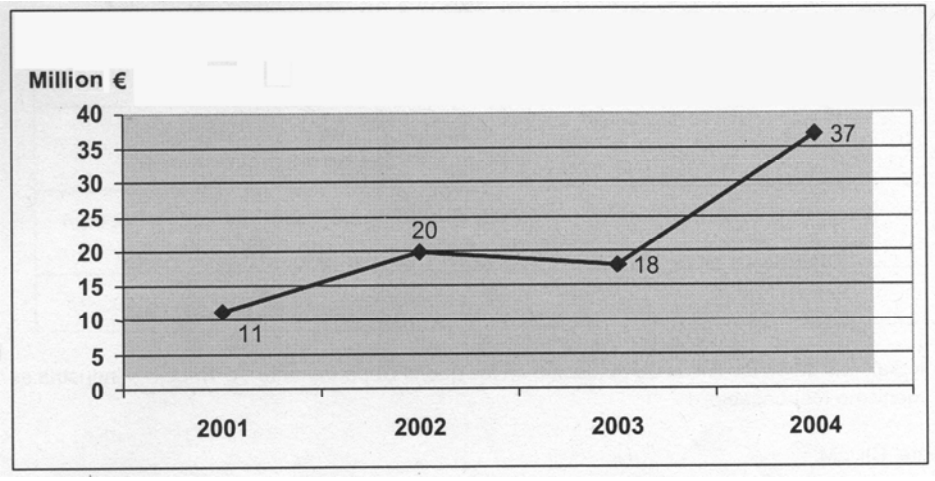
However, and despite the pervasive influence of the systemic approaches in S&T and innovation policy fostered *inter alia* by the European Union and the OECD and their implications in terms of policy governance, institutional changes did not lead to a unified governance structure with an organic link between the research and innovation pillars of S&T policy. The choice was then made to elaborate in parallel two separate Plans: one on Research entrusted to CIRIT, and another on Innovation entrusted to CIDEM. Both bodies had also managing functions in the implementation of these Plans and formal mechanisms were set up to ensure some coordination in policy design, complementarities in support programmes and joint funding mechanisms.

The third Research Plan basically pursued the same objectives of the previous one, with a primary focus on the strengthening of the Catalan research system to attract outside competitive funds. In this plan there was a greater emphasis on the support to the creation of research groups on the basis of excellence criteria (managed by the newly created Agency for Management of University and Research Grants (AGAUR)) and on the development of public research centres through either expansion or creation of new facilities. One of the major achievements of the Plan was the very rapid development of the ICREA programme, whose budget resources to hire prominent international scientists grew by over 600% during the Plan period. ICREA played a determining role in Catalonia's performance in accessing external competitive sources of funding of research

projects. As was the case in earlier Plans, the only resources devoted to thematic research programmes were allocated through institutional funding of research centres overseen by DURSI, and other sectoral ministries, primarily health and agriculture. Over the four years covered by the third Plan, Catalan public resources devoted to R&D and innovation increased by over 34%. Compared with the prior Plan, the share of resources devoted to the direct promotion of firm technological innovation were among those that grew the fastest, especially over the last years of the period (García Quevedo, 2005). [31]

The Innovation Plan was designed following the approach promoted by the European Commission Regional Innovation and Technology Transfer Strategies (RITTS) initiative.[32] This approach highlights the importance of market and non-market processes of knowledge diffusion among public and private agents for innovation performance and puts a premium of the roles of institutions and incentives that enhance diffusion, appropriation and valorisation of knowledge. As illustrated in Figure 2, resources devoted to the promotion, including direct support to enterprises increased significantly over the duration of the Innovation Plan.

Figure 2: Resources devoted to innovation promotion in the Innovation Plan 2001-2004



Source: Parellada Sabata (2005), elaboration from CIDEM data

Borrowing from this approach within the framework of Catalan institutional specificities, the Innovation Plan is articulated around six main programmes financed and implemented by CIDEM, some of which had already been initiated in the context of the collaboration with CIRIT in the second Research Plan (Busom, 2006):

[31] From 12.5 million Euros in 2003 to 33 million in 2004. It should be underlined however that in 2001, the first year of the Plan the Catalan government financed only 2.7 percent of business R&D expenditures whereas, in average the governments of the other Autonomous Communities of Spain, this share amounted to 4 percent (García Quevedo, 2005)

[32] In the framework of this initiative the Catalan Government received support from the EU to develop its Innovation Plan.

- Development of technology markets (*Mercado tecnológico*), mainly through the support of technology transfers, collaboration activities and human resources mobility between enterprises and public research institutions in the framework of the Network of Centres for Technological Innovation Support (XIT) initiated in 1999 in collaboration with CIRIT. This programme - which also included the provision of services in innovation supporting activities such as the management of intellectual property rights - accounted for close to 50 percent of the total resources of the Plan.[33]

- Innovative entrepreneurship *(Esperit emprendedor)*, mainly through support to the creation of spin-offs from academic research through the provision of specialised services and financing facilities. In 2004 this programme will be consolidated through the creation of, and support to, the Network of "technological springboards" (XTT) located in all universities (and some business schools);

- Digititalisation of SMEs *(Digitalització de la empresas)*;

- Provision of financial services for the development of innovative projects *(Finançament)*;[34]

- Provision of capacity building services to SMEs in the area of access to technological information and knowledge management *(Gestió de la innovació)*;

- Provision of support services and financing to improve access to information on, and implementation of advanced process technologies and logistical infrastructure *(Producció i logística)*

CIDEM introduced another programme in support of innovative projects in the form of financial incentives granted to firms on a competitive basis. Although in principle open to firms of all sectors, this programme was in fact mainly targeted at priority sectors deemed to be strategic (e.g. pharmaceuticals or aerospace), or experiencing a rapid transformation due to increasing international competition (e.g. textile, automobiles and consumer electronics). In 2004 public support extended in the framework of this programme amounted to close to 30 million Euros but eligible expenditures covered more than those typically related to innovation. On the other hand, actions aiming at fostering technological transfers were further developed in 2004 through the creation of two new networks: the Technological Centres Network (XCT) and the Technology Dissemination Network (XCDT).

The decision to develop a separate Innovation Plan apart from the Research one had mixed effects. On the positive side, it may be argued that an initial "autonomisation" of innovation policy under the Ministry of Industry and CIDEM probably facilitated a better identification of the market and systemic failures that impaired the development of enterprises' innovative capabilities, notably in terms of access to, and costs of, technological information and financing investment. It also allowed for larger budgetary appropriation for innovation related programmes. On the negative side, it seems that the Innovation Plan contributed to the current multiplicity of initiatives that tend to reflect a "one problem-one instrument" syndrome. The rationale behind the definition of the different programmes and the boundary of their scope is not entirely clear. This is particularly the case for the numerous networks that now exist in Catalonia, all created to address

[33] 137.41 million Euros for the duration of the Plan.
[34] Managed jointly with the Catalan Finance Institute (ICF).

particular aspects of the chronic technology diffusion weaknesses of the Catalan S&T and innovation system (Table 14). Moreover, the network label may be a misnomer as it refers only to a certification credential of a private or public technological transfer institution. Starting in 2009, there is an effort to better integrate these different networks under a common label of TECNIO.

Table 14. Catalan technology transfer networks

Technological Innovation Network (XIT)	Created in 1999, the XIT is formed by units and groups of researchers with the capacity to offer innovation services to Catalan companies. It offers the services of researchers who are most experienced in working with companies and who recognise the need to respond quickly to market opportunities. All the universities and relevant government units (it is mainly an initiative of CIDEM but includes CIRIT) are involved as providers and managers.
Network of Technological Springboards (XTT)	Launched in 2000, the objective of the XTT is to create a network of units located in universities and business schools across the region to encourage the establishment of knowledge-based companies from within the universities. Network staff help identify projects that could be exploited by firms, give courses on entrepreneurship and hold competitions for the development of business plans, etc. In 2002, this took a general approach with local advisors in different organisations. In 2005, these advisors began taking a sectoral approach. In 2008, the advisors became part of CIDEM/ACC1O and began a technological approach.
Innovation Centres Network (XPIC)	The XPIC is composed of several intermediate organisms acting as strategic allies of the CIDEM, in a type of cluster approach. Their function is to design and carry out the innovation policy, and to provide SMEs with the essential information needed for their business activity. Moreover, it designs programmes according to the needs of the territory in which the network is acting, and creates synergies among the members of this industrial sector.
Technology Advisers Network (XAT)	The XAT is focused on the management of technological innovation in companies. The network is organised into 13 sectoral nodes and is delivered by chambers of commerce, specialised foundations and technology centres. They provide specialised advice to companies in project definition, information searches, and partner searches.
Business Angels Network (XIP)	The XIP is a programme designed by CIDEM to promote the growth of high potential innovative companies. It is a network of different existing investor networks which share a common code of good practice and work together to finance, advise and work with newly created companies during their early phase growth.
Technology Centres Network (XCT)	Created in 2004, XCT is the network that regroups all technology centres. The objective of this network is to map and rationalise the existing offer of technological services and fill any gaps. The participating centres focus on applied research, pre-competitive development and services. They are grouped according to their specialisation and national or international level of excellence so that depending on their size, level of knowledge and specialisation, they are able to supply continuous support to their customers' innovation activities. There are seven major technology centres in the network, including both private and public not-for-profit structures.
Technology Dissemination Centres Network (XCDT)	Also launched in 2004, XCDT was created to promote technology transfer to help overcome an infrastructure deficit and organisational problems in the Catalan innovation system. This network is based around a Registry that brings together information about the region's science and technology organisations, including their services and objectives. The XCDT centres are characterised by their geographical proximity to their client base. Services include: promotion and dissemination of technology; information and assistance with innovation; training; and advanced technology services. There are six centres in the network dedicated to local business activities and located in proximity to those firms in sectors such as wine making, textiles, furniture making.

Source: Generalitat de Catalunya, (2008a), with additional information from ACC1Ó.

Fostering networking among S&T institutions is a right approach as it facilitates dissemination of information and the pooling of skills in support of technology transfer activities.[35] But a multiplicity of specialised single-purpose networks – although it may indeed reflect the diversity of problems faced by specific constituencies– can be counterproductive because of lack of critical mass, loss of comprehensiveness in the approach and weak complementarities in addressing technology transfer issues. In this respect, an evaluation of CIDEM's initiatives taken in the context of the Plan or continuing those already implemented in the framework of its contribution to the second Research Plan would have been in order before launching the integrated 2005-2008 Research and Innovation Plan.[36]

It had been argued that at the beginning of the decade Catalonia's innovation system lacked some of the essential features deemed characteristic of effective regional systems and in particular organic relationships between regional enterprises and research institutions in the development of scientific and technological knowledge leading to innovation output (Riba and Leyersdorff, 2001).[37] This view only partially reflects a reality that is more complex. True, in comparison with more advanced European regions the density and intensity of knowledge flows are weaker in Catalonia and this is a reason why they were emphasised in the third Plan. But there are also constraints imposed by division of power and responsibilities with the Spanish State, notably as regards the national regulations that limit Catalonian academic institutions' ability to develop their "third mission". In response to real regional deficiencies and to overcome regulatory constraints due Spanish State/Autonomous Community relationships, Catalonia has taken a number of institutional initiatives aimed at overcoming systemic weaknesses. In the course of the third Research Plan the number of Catalan Research Centres grew from 12 in 2000 to 20 by 2005, and the number of ICREA researchers from 2001 to 135 in 2004.

The experience of separate but complementary research and Innovation Plans certainly facilitated the recognition of the systemic nature of the S&T and innovation system and paved the way for the decision to merge research and innovation policies in the new planning exercise initiated in 2005. In a sense, with hindsight, the pros and cons of separate Plans may also have facilitated the ministerial restructuring that took place a few years later in 2007 with the creation of the Ministry of Innovation, Universities and Enterprise (DIUE) entrusted with a more comprehensive oversight over the implementation of R&D and innovation policy.

6. Towards a more integrated approach to research and innovation policy[38]

6.1. The Research and Innovation Plan 2005-2008

Approach and priority programmes

[35] This point had been highlighted in the Chapter on Innovation of the 2007 OECD Economic Review of Spain (OECD, 2007a).

[36] Garcia Quevedo *et al*. (2007) have evaluated the effects of financial support to innovative firms. Their study concludes on positive effects of the various types of financial support on R&D input and output additionality but does not find any significant impact on behavioural additionality which is in fact the real test of lasting structural impact measures of support.

[37] The intensity of relationships being measured by the relative share of co-publications, co-patenting or citations of regional research institutions in regional enterprises' patent applications.

[38] This section largely draws on the author's contribution to the OECD review of Catalonia's Innovation Policy (OECD, 2010a, Chapter 2).

The 2005-2008 Research and Innovation Plan (PRI) reflects a shift in the balance of power among business and academic stakeholders, laying the framework of a comprehensive and systemic approach. Its lines of actions focus in an integrated way on the factors that impinge on the performance of the Catalan S&T and innovation system as a whole and, more generally, on the competitiveness of the Catalan economy. In contrast with the preceding plans, and in line with the findings of many analyses of the performance of innovation systems,[39] the PRI recognises that fostering firm capacity to invest in R&D and innovative activities enhances their ability to effectively engage in co-operation with research institutions. Hence the view that the development of a virtuous dynamics in which the strengthening of the scientific and technological knowledge base and the innovative capacity of firms are mutually reinforced is predicated upon a rebalancing of efforts towards support to enterprises.

The ten objectives determined by the PRI indeed reflect an integrated approach and a balance in policy priorities of different constituencies (Box 2).

Box 2. Objectives of the Research and Innovation Plan (2005-2008)

1. To expand the research and development base by attracting new talent and facilitating the entry of young researchers into the system.
2. To build up universities, educational centres and infrastructures to the level required of advanced and high-quality research and development activities.
3. To continue fostering improvements in the quality of research conducted in Catalonia as a prerequisite for attaining full integration in the European research area.
4. To foster the entrepreneurial spirit and the creation of technology-based enterprises by increasing the number of joint programmes between universities, research centres and businesses and by promoting the transfer of technology and knowledge.
5. To promote the entry of researchers and qualified human capital into the private enterprise sector.
6. To consolidate and unify the research, technology transfer and innovation system in Catalonia.
7. To augment the innovation capabilities of businesses established in Catalonia and to foster internationalisation projects.
8. To draw up specific sectoral and technological strategies that will drive both the development of the economy and structural modifications in productive activities.
9. To improve co-ordination between Catalan research and development policies and economic, social and cultural policies, thereby making Catalonia a reference as far as co-ordinated research and innovation support policies are concerned.
10. To promote communication and public awareness of developments in science and technology so that society as a whole becomes fully aware of the importance of research, development and innovation.

Source: CIRIT (2005), "*Pla de Recerca i Innovació de Catalunya 2005-2008*", Government of Catalonia, Barcelona.

[39] There is a large body of academic and policy-related literature that emphasises this point. See in particular OECD (2002), Miotti and Sachwald (2003) and Segarra-Blasco and Arauzo-Carod (2008).

These objectives are supported by two sets of programmes aimed at strengthening the S&T and innovation system as a whole, as well as promoting an innovative culture across the Catalan society. There is also a set of strategic actions aimed at fostering the Catalan capacities in key technologies or sectors deemed to have large spillover effects in the regional economy (Table 15).

Table 15. Research and Innovation Plan budget: 2005-2008[1]

Priority Actions	Ministry	Agency	2005-2008		2007	
			Budget (EUR millions)	Percent	Budget (EUR millions)	Percent
Transversal Actions			**649.0**	**75.5**	**184.5**	**77.3**
Support to research	DURSI	AGAUR	169.0	19.6	30.0	12.6
Support to research personnel	DURSI	AGAUR/ ICREA	138.5	16.1	38.1	16.0
Research centres and infrastructure	DURSI	DGR	213.3	24.8	69.8	29.2
Technology and knowledge transfer	DTI	CIDEM	77.3	9.0	30.1	12.6
Innovation promotion	DTI	CIDEM	48.0	5.6	11.8	4.9
Financing support	DTI/DEIF	CIDEM/ICF/ Avalis	2.9	0.3	4.7	2.0
Complementary Actions			**88.2**	**10.2**	**10.6**	**4.5**
Mobility, co-operation and internationalisation	DURSI		19	2.2	3.5	1.5
Promotion of S&T culture	DURSI		4.3	0.5	1.2	0.5
Promotion of entrepreneurship	DTI	CIDEM	23.4	2.7	2.8	1.2
Innovation in public administration	All		40.5	4.7	2.2	0.9
Co-ordination and attraction of Spanish and EU funds	All		0.9	0.1	1.0	0.4
Sectoral and technology strategy	DTI	CIDEM/SIE	**122.8**	**14.3**	**43.5**	**18.2**
Total PRI			**860.0**	**100.00**	**238.5**	**100.00**

[1] Estimated budget for the duration of the Plan. It only covers the "direct" budget to finance the actions and programmes explicitly included in the Plan. It does not cover the so called "indirect" budget expenditures that incude other government expenditures devoted to R&D and innovation such as DURSI's contribution to the salaries of Universities' personnel devoted to R&D activities (800 million Euros) and Sectoral Ministries' financing of R&D activities undertaken by institutions unde their authority, mainly the Health and Agriculture ministries (400 million Euros). Same definitions for budget executed in 2007

Source: CIRIT (2005), *Pla de Recerca i Innovació de Catalunya 2005-2008*, Government of Catalonia, Barcelona.

The first set of programmes grouped under the label *"Transversal Actions"* focuses on the core of the innovation system. It consolidates and refines the major policy orientations of the previous Research and Innovation Plans, albeit with a more balanced approach between the support of supply and demand factors. The salient transversal actions are articulated around the following main elements:

- ***Public research capacity.*** Support to public research capacity building such as infrastructure, incentives for the creation of research groups, and human resources development continues to receive the largest share of budgetary appropriations (more than 60% of the total budget). This includes ICREA and, to a lesser extent, endowment of scholarship programmes. As in previous plans, most of the financing of public research is institutional. There are practically no budgetary resources devoted to targeted research programmes or competitive research projects. Catalonia has adopted a "subsidiarity principle": the Catalan government finances the

development of public research and academic capacities so that these institutions are better placed to attract competitive funding from Spanish and European sources.

- ***Expansion of Catalan Research Centres***[40] to overcome the institutional rigidities that hinder the academic research system's ability to engage in collaboration with the private sector and invest in new scientific disciplines requiring the accreditation of new doctoral programmes. By 2008, the number of Catalan Research Centres had reached 37 with six others in development. Such an evolution goes against the trends observable in the majority of OECD countries and regions where the role of specialised research centres declines vis-à-vis that of multi-disciplinary university research groups.

- ***Substantial increase of resources devoted to support business investment in R&D and innovative activities***. Support is essentially provided through competitive grants to individual or collective projects and, to a lesser extent, through subsidised loans and guarantees and public venture capital (Table 16). Increasing resources had already started in the last years preceding the launching of the PRI, from EUR 12.5 million in 2003 to EUR 33 million in 2004 and 36 million in 2005 (García-Quevedo, 2005). This trend was due to continue over the duration of the Plan.[41] The Plan is not always clear on the types or portfolio of support instruments deemed more efficient to promote private investment in R&D and innovation activities according to the various types of market and systemic failures faced by different categories of firms.[42]

- ***Financing***. For the first time there is an explicit recognition that, beyond direct support to projects through grants or loans, specific instruments were needed to ease the financing constraints faced by innovative enterprises and due to financial markets imperfections. Hence, some timid initiatives were initiated to facilitate the development of venture capital funds by the Catalan Institute of Finance (ICF), the subsidisation of guarantee schemes (Avalis) and the provision of services to facilitate access to diversified sources of capital.

- ***Increased effort devoted to technology transfer programmes.*** Support is mainly supply oriented as it finances the organisation of the provision of technological services by networks of transfer institutions (see Table 14 above). Limited resources are made available directly to SMEs to undertake technological assessments of actual production processes or potential innovative projects. As noted above, while technology transfer programmes must cater for various types of needs, the rationale for such a diversity of support networks may be questionable (Ballart, 2007). Moreover, it seems that a more efficient balance could be have been struck between instruments that focus on fostering the demand for technological services and knowledge inputs through the enhancement of absorptive capacities (*e.g.*, subsidising the recruitment of high-skilled personnel, supporting technological diagnostics, or a cluster-type approach), and those that focus on the strengthening of supply of technological services.

[40] These Centres are under the authority of sectoral ministries from which they receive their institutional funding. Universities may be associated to their creation. Catalan Research Centres are induced to increase their share of self financing over time.

[41] This figure includes the amount of support to investment in R&D and innovation granted to firms in priority sectors or technologies under the PRI "Sectoral and Technology Strategy" (Table 15).

[42] The vast literature on evaluation of R&D support programmes illustrates the fact that their outcomes highly depend on these variables rather than on the mere volume of granted support (OECD, 1997).

Table 16. Summary of CIDEM instruments in support of business R&D+i activities

	Subsidisable projects	Beneficiaries	Subsidisable expenses	Maximum subsidy	Budget
By CIDEM (R+D+i)	Industrial research	Companies with establishments in Catalonia	External consultancy: To SME's, which are related with intellectual and industrial property registration. The projects should have a minimal Subsidizable expenses of 25,000 €	Until 50% (big company) Until 60% (mid-size company) Until 70% (small company)	**3,5 million €**
	Experimental development	SME's with establishments in Catalonia		Until 35% (mid-size company) Until 45% (small company)	
	Innovation		External consultancy: The projects should have a minimal subsidisable expenses of 25,000 €	Until 35%	
By the Industry and Enterprise Department (R+D)	**Individual projects of:** Industrial research Experimental development	Industrial companies or services to the industry with establishments in Catalonia Total minimum subsidisable expenses - 60,000 € to SME's - 200,000 € to big companies	- Own and contracted staff - External collaborations - Equipment, instrument and inventoriable material acquisition. (To SME's, as well as the expenses relating to intellectual and industrial property registration. - Other expenses relating to acquisition of non inventoriable material, supplies, and other similar products. - Consultancy expenses	Industrial research projects: Until 50% (big companies) Until 60% (mid-size companies) Until 70 % (small companies) Experimental development projects: Until 25% (big company) Until 35% (mid-size company) Until 45% (small company)	**First announcement: 15 million €**
	Collective projects of: Industrial research Experimental development	Groups of companies (It is necessary to be 2 private companies that develop the project) Total minimum subsidisable expenses: 500,000 €		Industrial Research projects Until 50% Experimental development projects Until 25% To projects suggest by groups of companies, increase of the intensity of the help until 15% if: - At least one SME is involved in the project and any participant bear no more than the 70% of the subsidisable expenses. - Collaboration with one research organism which bear a minimum of 10% of the subsidisable costs.	

Source: CIDEM (2007)

The second set of programmes of the PRI regroups *"Complementary Actions"* that aim at generating or consolidating "an environment that sustains a culture of science, technology and innovation in all walks of society and facilitates the emergence of innovating initiatives". In fact, this set looks like a mixed bag of actions that may all be important in their all right and the rationale for having two separate sets of programmes looks somehow artificial. This is notably the case for two programmes that could have been incorporated in the so called "transversal actions" as they are related to issues that belong to the core of the innovation system: on the one hand the institutional mobility of HRST personnel and, on the other, the promotion of entrepreneurship.

The third set of programmes concerns actions in support of priority areas of research related to economic or social demand (e.g. health sciences and biomedicine, ICT, agrofood, socio-cultural development, environment) and so called strategic sectors (e.g. aerospace, biotechnology, pharmaceuticals, agrofood, renewable energy**)**, both to be financed by CIDEM and the Department of Industry. No indication is given as to the process that led to the selection of priority research areas or industrial sectors.

Ambitious quantitative targets have not been met

The Plan had set ambitious quantitative targets. On the basis of available information it can be said that most of these targets have not been met (Table 17). One of the global objectives of the PRI was to increase the ratio of R&D expenditures in Catalonia over its GDP from 1.33% in 2004 to 2.10% by 2008, with two-thirds financed by the business sector. Although this objective has not been reached, the Catalan government has indeed stepped up its own investment in R&D+i[43] in the first years of the PRI.

This increase led to growing shares of Catalan public investment in R&D+i in the Community's budget and GDP (from 2.8% in 2004 to 3.5 in 2007) as well as in total Spanish State public investment in R&D in Catalonia (from 60.2% in 2004 to 79.8% in 2007). This trend has continued over the last two years, albeit at a slower pace than anticipated in the Plan. Similarly, innovation inputs and outputs have fallen short of set targets even if the ratio of private sector investment in R&D over GDP has experienced a robust increase at the beginning of the PRI. This ratio has since declined. Reflecting the implicit priorities of the PRI, the areas in which the achievement exceeded the Plan target is that of the number of full time equivalent researchers (FTE) as that figure reached 24 500 in 2006, surpassing by 500 the objective set for 2008. The region also surpassed set objectives regarding the volume of funding received from EU Framework and other research programmes.

For most of the output indicators the achievements have fallen short of the set targets, notably as regards those pertaining to the productive sector.

[43]Budgetary figures compiled by CIRIT include government expenditures in support of innovation (CIRIT, 2008). Although CIRIT claims that it draws on the definitions of the OECD/Eurostat Oslo Manual, this accounting poses some problems as the Oslo Manual provides definitions of innovation activities undertaken by enterprises.

Table 17. Research and Innovation Plan 2005-2008: key performance indicators

	INDICATOR	Latest figures available when the PRI was elaborated		Target 2008	Actual 2007
		Catalonia	EU15	Catalonia	
RESEARCH, DEVELOPMENT AND INNOVATION RESOURCES					
1	R&D spending as a percentage of GDP	1.38 (2003)	1.99[7] (2002)	2.10	1.48
2	Business innovation spending as a percentage of GDP	2.42 (2000)	3.70[6] (2002)	5.20	2.00
3	R&D spending by private sector enterprises as a percentage of GDP	0.91 (2003)	1.30[7] (2002)	1.26	0.93
SCIENCE AND TECHNOLOGY HUMAN RESOURCES					
4	Number of researchers (full time equivalent)	18 387 (2003)	--	24 000	25 063
5	Number of researchers per 1000 labour market participants	6.42 (2003)	5.60[7] (2000)	7.5	7.2
6	Private sector researchers as a percentage of the total number of researchers in Catalonia	37.51 (2003)	50.9[7] (2001)	45	41.3
7	Number of in-company researchers per 1000 labour market participants	6.29 (2003)	5.83[7] (2001)	8	6.55
PRODUCTIVE STRUCTURES					
8	Innovative businesses (10 or more workers) as a percentage of all businesses	25.80 (1998-2000)	44 (1998-2000)	40	27.4
9	Industrial GVA for high-technology sectors as a percentage of total industrial GVA	7.50 (2002)	13.7 (2000)	10	8.15
10	Employment in high-technology industries as a percentage of labour market participation	2.68 (2002)	3.57 (2002)	4	3.0
SCIENCE AND TECHNOLOGY RESULTS					
11	Number of indexed scientific publications	10 967 (99-00)	622 499	12 000	8 443 (avg. annual 02-06)
12	Quality of scientific publications (citations during the two years subsequent to publication as a percentage of the number of articles published in a specific period)	5.33 (1999-2000)	6.04 (1999-2000)	6.04	Not avail.
13	Number of doctoral theses submitted	1 200 (2003)	--	1 500	1 359 (2008)
14	Number of patents registered at the European Patent Office per million inhabitants	62 (2002)	161 (2002)	160	Not avail.
15	High-technology industrial exports as a percentage of total industrial exports	12.07 (2003)	--	18	15.1 (2008)
SCIENCE AND TECHNOLOGY POLICIES					
16	Catalan researcher success rate in Spanish State open calls	27 (2002)	--	30	16.8
17	Value of Catalonia participation (million of Euros) in the EU Framework and other research programmes[5]	51 (2003)	--	75	103

Source: CIRIT (2005), "*Pla de Recerca i Innovació de Catalunya 2005-2008*", Government of Catalonia, Barcelona, except for the last column, provided in 2009 by CIRIT.

6.2 An unbalanced policy mix

It can be argued that the integrated approach that underpinned the conception of the Plan was at best weakly reflected at the levels of policy implementation and budgetary allocation. Despite a proclaimed improved coordination between government bodies that managed support programmes aimed at nurturing the linkages between the research and enterprises communities, this coordination was rarely, if at all, implemented through joint management and financing procedures between responsible departments from different ministries or agencies. This suggests

that the integration process pursued by the Plan was not completely achieved, possibly due to inertia in governance structures and budgetary allocation procedures. Moreover, the ministries concerned by the budgetary allocations for the Plan implementation were only DURSI and the Ministry of Trade and Industry (DTI) and did not include other sectoral ministries such as those of Agriculture and Health under the aegis of which are conducted important S&T activities in public research institutions. This, compounded by the coordination issues with the Spanish State resulted in an unbalanced policy mix that could consolidate the strengths Catalonia's innovation system of but only partly address its structural weaknesses.

Consolidating the strengths of the research system remains a de facto high priority

The early priority given to the strengthening of Catalonia's public research system (universities and the now large number of Catalan Research Centres) has not been fundamentally modified in the budget or in the PRI. The volume of resources allocated to research and universities accounts for the largest share of the Catalan R&D&I budget (see Table 18). Close to 60% of the total budget goes for this purpose, and that figure reaches more than 80% if the research supported by the Departments of Health and Agriculture is added.[44] This priority reflects the importance of the academic community in the policy and the deliberate choice to ensure the competitive strength of the Catalan public research in national and EU-level competitive calls.[45] This choice has been successful in terms of its stated objectives but has probably impaired the achievement of other objectives related to the promotion of business innovation.

However, even in the framework of this budgetary priority given to public research one can raise the policy mix question of the relative roles of HEIs and PRCs. One can infer that the share of institutional funding allocated to Catalan Research Centres increased relative to that of universities. Beyond the autonomy status enjoyed by universities, the national regulatory framework applied to Spain's public universities (personnel status, career and wage management) imposes some constraints hindering a flexible and efficient mobilisation of resources on priority research programmes or projects. It may therefore seem easier to palliate perceived weaknesses of the university system with the creation of dedicated public research centres. Such a strategy has pros and cons. It preserves the research autonomy of universities but does limit their research funding since the Catalan government does not currently offer competitive research funding. This strategy does not promote interdisciplinary research, which can be more efficiently undertaken in a university context than in dedicated research centres.[46] By international and regional standards, the number of Catalan public research centres is quite large and, as noted above, this raises questions of critical mass and efficiency. While the contract programmes that encourage self financing to which the centres are submitted can alleviate this problem, it is practically always easier to create a new centre than to close an existing one.

Another imbalance in the research system support is the way thematic research priorities and specialisations are handled. This is partially addressed through the support given to university

[44] If the compensation for research duties of university professors is not counted, the respective shares are still high, respectively 35% and over 70% of the total

[45] For example, during the period of the 6th EU Framewok Programme (2002-2006) Catalonia's share in Spain total awards of FP grants was 23.2%. This share rose to 25.3% in 2007 (Moreno Amich, 2008).

[46] The recent development of "mixed" research groups associating researchers from Catalan Research Centres and universities is reducing, but not overcoming, this shortcoming.

research groups, but the relative amounts are probably insufficient. Given the size and the excellence level reached by public research in Catalonia, the quasi exclusive reliance on project funding by Spain and the EU may becoming inadequate to ensure a better contribution of the Catalan research system to the region's socio-economic needs. In this regard, the Catalan government should probably consider launching thematic research programmes focusing on regional priorities and open to competitive funding of projects presented by or in association with Catalan institutions. These programmes could encompass public/private partnerships and act as leverage for private investment in R&D activities related to meeting collective needs.

Table 18. R&D+i expenditures by area 2006

Department/Areas	EUR Million	%	Without professor compensation[1] %
UNIVERSITY AND RESEARCH (Commission of Universities and Research)	**396**	**58.58**	**35.19**
Professors (% of salaries in research duties)	244	36.09	-
Universities: investments	12	1.78	2.78
Universities: research groups programmes	32	4.73	7.41
Fellowships (including ICREA)	34	5.03	7.87
Research Centres	45	6.66	10.42
Research Infrastructure	10	1.48	2.31
Co-operation with other institutions[2]	10	1.48	2.31
Other	9	1.33	2.08
INNOVATION AND INDUSTRY (CIDEM and SIE)[3]	**65**	**9.62**	**15.05**
Technology Centres	16	2.37	3.70
R&D+I projects	36	5.33	8.33
Support to enterprise innovation	13	1.92	3.01
HEALTH	**131**	**19.38**	**30.32**
Personnel (% of salaries in research duties)	120	17.75	27.78
Health Research Centres	11	1.63	2.55
AGRICULTURE	**25**	**3.70**	**5.79**
OTHER GOVERNMENT DEPARTMENTS	**59**	**8.73**	**13.66**
TOTAL	**676**	**100.00**	**100.00**

[1] This refers to the compensation of university professors for research duties.
[2] In Spain and abroad.

Source: Government of Catalonia, Inter-ministerial Research and Innovation Commission (CIRIT).

Business R&D and innovation activities: scope and efficiency issues

With approximatively two-thirds of total R&D investment performed by its business sector in Catalonia is on par with European standards. However across practically all sectors of the economy the R&D intensity of Catalonia's industries is lower than that of the European countries' average in the same sectors. Apparently, this gap was not much reduced during the PRI which means that the R&D+i support programmes have only incidental effects on bringing Catalan firms

closer to the technological frontier. Overall, and at the aggregate level, this reflects an adaptive behaviour of firms in their innovation related investment, a bias towards incremental innovation and weaker relationships with global sources of knowledge.

The relative importance of support to business R&D and innovation (including technology transfer programmes) has increased in the Catalan policy mix over the present decade. This is true particularly in the framework of the PRI 2005-2008. Resources devoted to this support amounted to 37% of the PRI budget in 2007 and over 15% of total government expenditures on RDI in 2006 (Tables 15 and 18). This evolution, which reflects a welcome rebalancing, calls for some remarks.

Notwithstanding the diversity of support schemes, the PRI has not fully succeeded in broadening the scope of firms that undertake such activities as part of their development strategy. The distribution of firms that do undertake them remains skewed. An overwhelming share of business R&D is still concentrated in larger firms and specific sectors such as chemicals, pharmaceuticals and transport equipment with a high proportion of foreign affiliates, although the more recent development of new technology based firms in the agrofood sector, ICT and design industries is beginning to reduce this distribution skewness. Overall the support programmes developed by CIDEM (now ACC1Ó) suffer from a fragmentation into numerous support measures that may generate inefficiencies due to lack of critical mass and management costs. The financial instruments, essentially grants may not always be the ones most suited to the needs of the enterprises, especially those SMEs that have the most difficulties to access the Spanish government CDTI support programmes.

Lessons drawn from analyses of the effect of programmes in support of business R&D+i activities on innovative behaviour of firms that have benefitted from such support should help improve policy efficiency in terms of spillover effects and scope of impact. As highlighted by García Quevedo *et al*. (2007) firms that have the highest probability to get support are: (1) those that have already received support; (2) larger firms; (3) firms that have an R&D laboratory; (4) firms that have a high export/production ratio. It seems that, with the exception of new technology-based firms, the overwhelming majority of SMEs do not share these characteristics and are therefore excluded from the benefits of these programmes. So far, its seems that programmes aiming at fostering the absorptive capacity of SMEs do not yet act as a springboard to bring a substantial number of them to the standards allowing to benefit from R&D+i support programmes. The same study has also highlights that although existing support programmes had globally positive effects in terms of input and output additionality[47] their effects in terms of "behavioural additionality"[48] remained at best very limited. Behavioural additionality is an indication that support programmes have a positive effect on the dynamics of the innovation system, notably as regards the interactions and knowledge flows among agents and institutions, and that they catalyse the development of virtuous circles between generation, dissemination and application of knowledge in innovation systems.[49]

[47] Meaning that public support had a positive multiplier effect of private R&D expenditure and led to positive outcomes in terms of e.g. market shares, patents or productivity.

[48] Meaning that public support enhances a learning process through which firms improve and diversify their modes of knowledge acquisition and broaden their modes of innovation, notably trough increased cooperation (OECD, 1997).

[49] Innovation surveys are a key source of information to assess behavioural additionality effects. The survey carried out in 2003 by the Catalonia's Statistical Institute (IDESCAT) showed that the share of Catalan firms that developed process or product innovations in collaboration with other firms or institutions was significantly lower than the EU average. There is no indication that this gap has been significantly reduced. Countries are increasingly relying on the

Financial support instruments also need to be better articulated with other policy actions so as to increase their behavioural additionality effects. This is true for enterprises that already have a long practice of R&D+i investment. It is even more the case for lower-technology-intensive enterprises, where behavioural additionality is predicated upon ensuring that financial support instruments reduce the costs of R&D+i investment. For such firms, the financial support instruments need to be complemented by other support measures or incentives that will foster firm absorptive capacity, such as the strengthening of human resources capacity and cluster-type policies in the case of SMEs (OECD, 2010b).

Another lesson relates to the duplication or complementarity between Catalonia and the Spanish State support programmes. At present, it seems that an important share of Catalan support goes to projects that could be eligible to CDTI programmes. It would seem more appropriate to concentrate Catalan support either to address specific weaknesses related to the regional industrial structure (and the regional factors that account for the disparities in firm propensity to innovate) or on funding research and innovation projects in the priority areas of the region.

Technology transfer and programmes: design and implementation shortcomings

While the various technology transfer networks have reached a relatively large number of enterprises, it seems that with the exception of XIT and XTT the benefits of the services they provide have often been short-lived in the sense that they have not really succeeded in jumpstarting an innovation culture in the majority of Catalonia's enterprises. Technology transfer programmes have certainly helped the improvement of production processes and the introduction of new products, but they have not generated sustained knowledge relationships between the majority of beneficiary firms and knowledge production institutions. This partly reflect the supply side bias of most of the transfer programmes and the lack of complementarity with measures aimed at increasing firms' knowledge absorptive capacity that generates demand and nurtures collaboration with Research and/or Technological Centres.[50] Even the technological springboard network (XTT) which by essence fosters the creation of technology advanced firms or academic spin-offs has met with mixed success. While the number of new technology-based firms has increased quite rapidly,[51] the growth of these new firms has in general been very weak. Here again, one can suspect a policy complementarity failure as this company growth may have been constrained by shortages of available venture capital or obstacles affecting the interinstitutional mobility of researchers.

Additionally, Catalan cluster policy has up to now been isolated from the mainstream of innovation policy. Here again, fragmentation and the lack of complementarity with the provision of technological and other business services that strengthen the absorptive capacity of firms belonging to the same cluster can be seen as detrimental to efficiency of business support programmes. Innovation-related cluster policy need not be re-designed from the beginning, as it could draw on the initiatives taken by dynamic local institutions that may play a leading role in innovative clusters (OECD, 2001).

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behavioural additionality concept to asses the efficiency of their programmes of support to business R&D (OECD, 2006b).

50 The second phase of the CIDEM cluster programme initiated in 2005 aiming at promoting new tools for the "management of strategic change" should have an incidence on the demand side.

51 60 start-ups created in 2007.

Blind spots in the PRI policy mix

The PRI 2005-2008 policy mix suffered from "blind spots". They were rightfully acknowledged in the CARI exercise and taken into account in the design of the current research and innovation plan. It is to be hoped that policy initiatives underpinned by appropriate programmes and/or institutional reforms will address these blind spots among which one can highlight the following ones:

- ***Thematic priority setting.*** Catalonia funding of public research institutions scarcely included any competitive financing of projects, either so called bottom up "blank projects" or projects presented in the framework of top down defined research programmes. As acknowledged in the CARI, Catalonia can no more stand aside from trends that are observable across countries at both national and regional levels. In the policy making process prioritisation responds to necessities that are increasingly recognised by governments, scientific and business stakeholders, and the public at large. Scientific excellence cannot last without the build up of a critical mass. While at the same time the costs of infrastructure are rising, therefore the dispersion of funds would lower the levels of excellence. Nurturing Catalonia's strongholds in research calls for a dose of thematic prioritisation. Moreover, publicly funded research activities should help respond to socio-economic concerns expressed by Catalonia's civil society, and the priorities among these concerns are local-specific.

- ***Public/private collaboration.*** The PRI does not include any explicit programmes devoted to supporting public/private collaboration or partnerships in research and innovation bottom up projects or top down programmes. A number of countries, including some that are comparable in size and economic development with Catalonia have promoted this type of programme to strengthen industry/science relationships and facilitate technology transfers and in some instances as a means to foster synergies among public and private research capacities in the implementation of national priorities. The existence of the Spanish CENIT programme should not preclude Catalonia to emulate such an initiative.

- ***Innovative clusters.*** Contrary to the experience over the last decade of many OECD countries and regions, Catalonia has not explicitly integrated a cluster approach in its innovation policy as laid out in the PRI. The cluster programme promoted by CIDEM was essentially devoted to the improvement of the strategic management capabilities of firms belonging to a same sector, even if it has recently given more attention to the technological aspects of these capabilities (Pezzi, 2008). The cluster approach to innovation policy goes much further than this (OECD, 2001; OECD, 2007b). It is founded on the provision of common S&T infrastructure and intangible services to firms to enable them to increase their collective knowledge absorption and exchange capacities allowing them to put innovation at the core of their development strategies.

- ***Public procurement.*** Public procurement is becoming an important policy tool in national and regional innovation policies (Edler and Georghiou 2007). It illustrates the evolving balance between supply and demand policies in innovation policy mixes. Following EU recommendations (Aho *et al.* 2006), a wide array of OECD countries and regions are increasingly using public procurement as an integral part of their policy mix to foster

business R&D and innovation activities and promote industry/science collaboration.[52] While the volume of goods and services procured by Catalonia's government in areas where technological change is rapid and its applications can substantially improve the delivery and quality of public services is rather high, up to now this does not seem to have been the case in Catalonia. In practice however, the development of innovation-related public procurement policies as highlighted in CARI's recommendations may raise some legal and/or regulatory issues with at the Spanish state level.

- ***Innovation in services*.** The development and widespread provision of knowledge-intensive services do contribute to technology diffusion growth and productivity growth (OECD, 2006a). Segarra-Blasco (2010) provides evidence that this is the case in Catalonia Yet, although Catalonia has a large and growing services sector, notably in the areas of tourism, design, health, ICT, financial services and logistics the PRI pays practically no attention to the promotion of innovation in services activities or to the role of knowledge-intensive services in technology diffusion. This shortcoming reflects an implicit manufacturing bias in the policy mix which was acknowledged in the CARI exercise.

6.3. Governance issues

Governance structures affect the policy mix in various ways. Their role in the definition of policy orientations and priorities is reflected on budgetary allocations across and within policy areas. They affect the coordination among implementing agencies that may or may not belong to the same ministerial departments. Good governance also implies the development of evaluation and accountability practices that should feed back on policy mixes.

Although CIRIT was entrusted with a co-ordination authority to ensure collaboration among agencies involved in the preparation of the Plan and its subsequent implementation, this co-ordination often remained superficial at least until the creation of the new Ministry of Innovation, Universities and Enterprises (DIUE) in 2007. Indeed, the University and Research Commission (CUR) oversaw public research policy and CIDEM innovation and technology transfer. The fact that these two areas are included under the same "transversal" line of action does not necessarily imply a prior reflection on policy complementarities at the level of CIRIT or implementing agencies. In a systemic view, efficient management of such complementarities is at least as important as ensuring the efficiency of individual policies because it often conditions the sustainability of the outcomes.[53] Another example of limited co-ordination is the apparent lack of CIRIT oversight on research activities carried out by research institutions under the aegis of other ministries, and in particular those of Health and Agriculture. This is a delicate matter as these ministries' institutions may have their own supply and demand driven research agenda and should probably retain a large margin of autonomy. On the other hand, given their weight in the Catalan R&D&I system, their research and technological transfer activities cannot be entirely left out of the purview of the main governance body and the inter-ministerial budgetary allocation process in which this body is involved.

[52] Procurement for innovation was incorporated as an element of the European Commission's Research Investment Action Plan to raise R&D and innovation expenditures to the 3% Barcelona target.

[53] A case in point is the complementarity between measures of direct support to business R&D and innovation and policies that consolidate firm propensity to innovate, in areas such as those that foster the recruitment of human resources in S&T or strengthen relationships with outside sources of knowledge.

The scope of the Spanish state and Catalonia's respective prerogatives over S&T and innovation policy impinge upon the nature co-ordinating mechanisms between the two governments and Catalonia's own governance structure. As long as Catalonia was able to benefit from a sizeable share of Spanish support programmes to R&D and innovation, the political motivation to re-open co-ordination issues may not have been sufficiently high. Funds to Catalan actors are those provided to enterprises by the Spanish Centre for Industrial Technology Development (CDTI), and to the Catalan public research system through national competitive research funds. There were, however, clear cases where a closer look at such issues would have benefitted the design and implementation of the PRI. One can mention in particular the dual role of the Spanish and Catalan governments in the development and financing of technological parks, the fine tuning of innovation support programmes funded by CIDEM in view of the alternative (or complementary) support provided by CDTI, and the possible Catalan participation in the CENIT public/private R&D programmes.

7. Responding to the challenges ahead

7.1. The CARI exercise: purpose, ambitions and limits

Catalonia has a long standing practice of consensus building processes leading to agreed commitments among government and political and civil society stakeholders on medium to long term objectives and policy orientations in socio-economic areas deemed as strategic for the development of the region and where agreed orientations should transcend the political cycles. The Catalan Agreement on Research and Innovation (CARI), signed on 21 October 2008, is the latest of such agreements.[54]

CARI represents the outcome of a high visibility and ambitious process to mobilise the main actors of the Catalan S&T and innovation system around a common vision of the challenges ahead. The ambition underpinning CARI was to forge a consensus not only on long term objectives regarding the performance of this system and its contribution to the region's competitiveness and social welfare in a global environment, but also on the actual commitments that the actors have to make to reach these objectives.[55] In most OECD countries that engage in consensus building exercises, these provide a compass to reach stakeholders' agreements on common objectives and priorities. They usually stop short of detailing performance related commitments underwritten by stakeholders. CARI's ambition does not go without risks: reaching quantitative targets may prove elusive as illustrated by the expected difficulties for a number of European countries in reaching the EU target of a 3% ratio of R&D+i expenditures over GDP. Actors may fail to comply with their own commitments and resources may be lacking. Such risks must be managed to ensure that the mobilisation of actors remain high even in case the course is not stayed as anticipated. In principle the CARI monitoring process allows to learn from experience and to periodically revise the course of actions that underpin the commitments.

[54] The four previous Agreements signed since the beginning of the decade pertain to education, housing, infrastructure and immigration.

[55] For an overview of experiences on mobilisation of actors in the design and governance of innovation policy, see the section on "Mobilisation of actors and resources" in OECD (2009d).

Table 19. Catalan Agreement on Research and Innovation: challenges and objectives

Strategic Challenges		Objectives
1. Talent	To have the best scientific, innovative and entrepreneurial talent, with the necessary abilities and a critical mass	-To have an education system and a professional environment that provides, promotes and maximises scientific, innovative and entrepreneurial abilities. -To attain a critical mass of qualified professionals with the right profiles for innovation (creative, scientific, technical and management skills). -To recruit, recuperate and retain more and better scientific and innovative talent in the research and innovation system and to promote the mobility of this talent.
2. Push	To develop and maintain a high capacity for generating and valuing knowledge	-To strengthen the public research system. -To attain and profit from leading scientific and technological infrastructures. -To reinforce the capacity of research agents to value knowledge.
3. Pull	To innovate systematically as a base for productive activity and public and social action	-To facilitate the development of the different types of innovation. -To generate favourable contextual conditions for innovation. -To encourage the growth of an innovative and knowledge-intensive business ecosystem. -To have an innovative public sector as well as public administration that drive innovation.
4.Internationalise	To think, be and act globally in research and innovation	-To direct and implement a joint co-ordinated action to internationalise research and innovation. -To strengthen the role of Catalonia as an international player in research and innovation. -To establish international strategic alliances and platforms for research and innovation.
5. Socialise	To ensure that Catalan society be infused with science, technology and innovation	-To direct and implement a joint co-ordinated action of socialisation of science, technology and innovation. -To introduce science, technology and innovation into close contact with the public. -To place science, technology and innovation in the foreground of the political, social and economic arenas in Catalonia.
6. Focus	To focus and prioritise research and innovation where there is the greatest value	-To design and develop the regional strategy for specialisation in science, technology and innovation. -To specify the fields selected as strategic priorities for research and innovation in the coming years. -To direct instruments and resources towards the areas focusing on and prioritising research and development.
7. Facilitate	To adopt a governance of the research and innovation system that is intelligent, efficient and effective	-To establish a solid organisation and link among agents in the Catalan research and innovation system and to strengthen their co-operation. -To develop a dynamic model of governance that strengthens strategic capacity and coherence in decision making and in the design and implementation of research and innovation policies. -To maximise the efficiency, the effectiveness and the learning capacity of the research and innovation system.
8. Invest	To make more and better investment into research and innovation in the public and private sectors	-To increase spending on R&D to 2% of GDP and business spending on R&D&I 3.75% of GDP in 2010, with the aim of reaching 3% and 4.5%, respectively, in 2017. -To focus public spending on R&D and in supporting innovation on the objectives of the Catalan Agreement on Research and Innovation. -To improve the economic and taxation framework for R&D&I spending in Catalonia.

Source: Government of Catalonia (2008), Catalan Agreement on Research and Innovation, Barcelona.

The result is that very often the CARI commitments agreed by agents read like a wish list or a readiness to work out a plan or a strategy that should facilitate the achievements of objectives related to a specific challenge. Too often the level of specificity of commitments coupled with the general character the actions to comply with them reduces their credibility. So does the sheer number of commitments (131) and the frequent absence of indication on the resources required to fulfil them, in particular as the question of compliance costs –required resources to meet the commitments– has often been left aside, more particularly as concern non-governmental actors.

In brief, one can argue that CARI went probably too far in its attempts to steer the behaviour of the actors of the system through agreed commitments that could prove difficult to respect individually, and more so collectively. The numerous commitments form a set that seems "wired" to the achievements of the CARI objectives in the sense that if one commitment is not complied with the fulfilment of the objectives seems in danger of jeopardy. Given agreed priorities, a more realistic approach for the preparation of the Plan could have focused on the nature of incentives, regulatory changes and support systems that the actors would have to respond to in order to fulfil the agreed upon objectives.

This being said, both as a process and as an outcome to be used in the preparation of the 2010-2013 Plan, CARI undoubtedly served a useful purpose in facilitating a consensus on (i) the main innovation related challenges facing the Autonomous Community economy and society, (ii) a diagnosis of the strengths and weaknesses of Catalonia's S&T and innovation system, (iii) the strategic priorities and policy orientations aiming at strengthening of the system. As no thorough evaluation of the 2005-2008 PRI had been performed CARI remains the main basis for the preparation of the following Research and Innovation Plan for 2010-1013.

7.2. Policy orientations: Improving the policy mix and policy effectiveness

Policy shifts or new policy orientations aimed at improving Catalonia's innovation performance are defined against the background of the diagnosis of the strengths and weaknesses –and blind spots– of Catalonia's S&T and innovation system highlighted in the preceding sections and summarised in the SWOT analysis presented in Table 20. Beyond the rationale of specific policies responding to market and systemic failures, these orientations should reflect a more efficient overall policy mix and be implemented through improved governance structures.

Policy mix

No explicit attention is given to policy mix issues in the CARI document. However new initiatives or better designed existing support policies should reduce prevailing policy mix imbalances across and within S&T and innovation policy areas:

Table 20. SWOT analysis of the Catalan Innovation System

Strengths	Threats
• High political commitment to STI (CARI) • Poles of scientific excellence in the public sector (HEIs, hospitals and research centres) • Sizeable pool of qualified researchers • Recognised international excellence in some sectors (e.g. biotech and design) • Good technological specialisation within Spanish State • Existence of leading enterprises in R&D intensive sectors • Regional and local dynamism (including HE institutions) • Good infrastructure, including in S&T • International attractiveness (FDI and top international scientists: ICREA)	• Growing competition from emerging economies • Growing competition to attract EU Funds • Concerns related to alleviation of effects of current crisis (e.g. priority support to labour intensive traditional sectors) • Accelerated pace of expansion of the scientific and technological frontier • Intensifying global competition to attract talents
Opportunities	**Weaknesses**
• Growing demand for knowledge-intensive social goods (health and environment) • Insertion in global knowledge networks and technological platforms (EU and beyond) • High level of creativity • Good localization in Euro-Mediterranean markets • Diversification of production and trade towards goods and services with higher knowledge content • Engaging SMEs in more innovation-driven strategies (clusters) • Technology diffusion around multinational enterprises in line with the development of innovation-based global value chains • Attractiveness (FDI, foreign scientists and students) • Increased contribution of Catalan innovation system to meeting local social needs (thematic research programmes and public procurement) • Increased contribution of KIS to technology diffusion and productivity gains	• Rigidities in HE sector (e.g. mobility, competitive remunerations, accreditations, contractual arrangements for cooperation) • Relative scarcity of high and middle level human resources in S&T in the private sector • Low technological absorptive capacity of the vast majority of MSMEs (dual industrial structure) • Weak IPR culture and low patenting level • R&D intensity across industry lower than most EU counterparts • Too many PRCs and TCs (problems of critical mass and performance) • Complex governance (e.g. priority setting, coordination among implementing agencies, weak evaluation) • Policy fragmentation/glut (critical mass and "1 problem/1 instrument " syndrome) • Coordination/complementarity with Spanish State policy, priorities and support instruments; • Financial markets ill-adapted to innovation-related investment • Low level of public/private cooperation; low mobility of human resources in S&T • Fuzzy policy mix and lack of priority focus (strategic priorities)

Source: Author's compilation for the OECD Review of Catalonia's innovation policy (OECD, 2010a)

- Continue to pursue *excellence in Catalonia's public research system* in order to maximise external financing from the Spanish government and EU programmes but also devote budgetary resources to finance contractual and competitive research projects proposed in the framework of regional priority programmes to which Universities can apply, thereby increasing the competitive funding for their research activities, notably through collaboration with research centres. This should contribute to improving the balance between HEIs and PRCs with positive effects on multidisciplinarity;

- Engage *thematic prioritisation* aiming at ensuring that Catalonia's innovation system better respond to the region socio-economic challenges and opportunities; foster the region's capacities in priority areas and strengthen public/private partnerships with leverage effects on private RDI expenditures;[56]

- Along with a streamlining of programmes portfolio, *step up R&D and innovation support for the business sector* with a wider reach to SMEs;

- *Improve outreach of technology transfer programmes* between public research institutions and enterprises, as well as among enterprises;

- Increased emphasis on *demand driven innovation policy* (e.g. innovation clusters, demand driven technology transfer, procurement policy).

Public research institutions

In this area, policy orientations pertain to the criteria for institutional funding, the broadening of the base of competitive funding, the strengthening of the collaboration between universities and research centres, the development of public/private partnerships in research and innovation and the mobility of researchers:

- Increasingly *link institutional funding of universities and hospitals to regular assessments* of research activities in the context of multi-year programme contracts, similar to those developed with public research centres. Engage a process of consolidation of PRCs;

- *Promote collaborative agreements between PRCs and HEIs*; negotiate a framework agreement with CSIC to foster co-operation and policy alignment with Catalan institutions

- *Promote public/private partnerships* (P/PPs) in research and innovation based on international best practices (OECD, 2002). The development of P/PP programmes should increase the funding base of research institutions and leverage private investment;

- In the framework of its prioritisation of research and innovation activities, *develop thematic priority research programmes* within which projects presented by public research institutions and /or private enterprises will be funded on a contractual or competitive basis;

[56] In the framework of the CARI follow up, apriority setting exercise has been launched at the end of 2008 under the oversight of the CARI Steering Committee. This exercise based on foresight approach developed in collaboration with an international panel of experts, has involved a large number of stakeholders representatives. The PRI 2009-2013 will take into account strategic priorities identified by the foresight exercise.

- Encourage the *interinstitutional mobility* of HRST through incentives and removal of regulatory constraints and fostering their hiring by enterprises in ACC1Ó support programmes.

Private sector innovation and technology transfer

As noted above in section 6.2., Catalonia's present system of support to private innovation and technology transfer is suffering from inefficiencies and weak behavioural additionality effects. The forthcoming should contribute to improve this situation, provided appropriate precautions are taken in the design and management of the support programmes:

- *Rationalisation of support programmes* financed and managed by ACC1Ó should be undertaken to remedy their excessive fragmentation;

- Large enterprises should continue to be encouraged to apply to and participate in Spanish and EU programmes (e.g. CENIT and Eureka) and but increased budgetary resources should be devoted to the *support of high-technology projects* with a premium given to those developed in cooperative ones;

- *Streamlining of the various schemes developed to provide support to SMEs* to give rise to a fewer number of more comprehensive ones that will cover a larger scope of innovation related expenditures. However, given the wide variety of SMEs, support policies should be diversified and customisation should not be a victim of the necessary streamlining efforts;

- *Rationalisation of the technology transfer networks* to reduce overlap, improve quality of services through accreditation and give a greater emphasis to demand driven actions supported by business associations;

- Broaden the presently limited scope of industrial cluster to give rise to *a more comprehensive innovation clusters policy* developed in collaboration with initiatives promoted locally by research institutions and business associations on the basis of local opportunities and specialisations; the innovation cluster approach should underpin SMEs and technology transfer support programmes;

- Implement specific incentive or support programmes –with a mix of supply and demand measures– to foster the *development of knowledge-intensive services* (KIS) and strengthen their role in innovation diffusion;

- In line with practices implemented at both national and regional governments in a number of EU countries (Edler and Georghiou, 2007) develop an innovation-related action plan for *the procurement of technology- intensive public goods and services*; this plan should ensure the participation of SMEs and not hinder the involvement of public research institutions;

- Mobilisation of public resources to leverage private ones for *venture capital funding* of technology-based business projects.

7.3. *Governance, monitoring and evaluation*

Efficient and transparent governance involving the functional relationships among institutions entrusted with policy design, funding and monitoring, those in charge of policy implementation and management, and those that undertake R&D and innovation activities is an essential component of performing innovation systems. The governance principles highlighted in the CARI by New Public Management best practices followed by a number of OECD countries with degrees of diversity reflecting institutional specificities.[57] This is particularly the case for the "principal agent" principle which distinguishes between the functions of policy advice, policy setting and monitoring, programme funding and policy implementation, as well as for the contractual arrangements between funding agencies and institutions performing research and innovation activities benefitting from public funding.

The new governance structure promoted by the CARI typically improves upon those that have prevailed up to the latest Research and Innovation Plan. The most salient improvements are:

- Creation of the Catalan Research and Innovation Council (CCRI), a high-level advisory body made up of independent experts from the academic and business sectors chosen by the Government, entrusted with making recommendations to the Government on policy orientations that may have an effect of the policy mix and budgetary orientations. It would be advisable to entrust the CCRI with an advisory responsibility over the governance and funding of the system of public research institutions;

- The confirmation of CIRIT recent transformation into an inter-ministerial research and innovation committee chaired by the President entrusted with policy design and budgetary allocations proposals to be submitted to Parliament. CIRIT is also responsible for conducting the priority setting exercise in concertation with stakeholders from the academic and business sectors as well as others representatives from civil society;

- The creation of new Agency for Research Funding of Catalonia entrusted with the design, funding and management of competitive research funding of public research institutions. It would be advisable to also associate this Agency with the oversight over cooperation arrangements between University and public research centres and with the monitoring of programme contracts with these institutions. The Agency would also be responsible for the funding of programmes in support of research personnel and S&T infrastructure under the authority of the Director for Research;

- The confirmation of ACC1Ó as the main agency entrusted with the design, funding and management of support programmes to business R&D and innovation projects as well as technology transfer programmes;

- The consolidation of the Catalonia Research Centres Agency (CERCA) mainly responsible for the institutional funding of public research centres and oversight over programme contracts (com. 109). The fulfilment of this responsibility will involve interministerial coordination as the funding of some research centres is provided by sectoral ministries (e.g. Health and Agriculture);

[57] See the section on Governance and public policy in OECD (2009d).

- Although the CARI is not explicit on this point, it is to be stressed that the governance system should retain some margins of flexibility, at least more than presently envisaged. For instance the Agency for Research Funding and ACC1Ó should be left free to join forces in the support given to public/private partnerships for research and innovation.

To a large extent innovation policies are still in a learning process stage that benefits not only from best practices implemented elsewhere but also from domestic monitoring and evaluations exercises Such exercises are indeed essential functions of efficient governance systems(Arnold, 2004).. In Catalonia, up to now and apart from annual reports such as those prepared by ACC1Ó and which essentially present a mapping of innovation performance and a description of support instruments, these functions have not been adequately pursued by Catalonia's government in the area of S&T and innovation policy. The effectiveness of the policies and support instruments of the recent Research or Research and Innovation Plans has not been assessed either; as a consequence, their micro or economy-wide impacts have remained uncertain and lessons could not be learned to improve policy design and implementation. In Catalonia, the too few policy evaluations that were made have been carried out by the academic sector either in the framework of its independent research activity or as commissioned work. Time has come to consider evaluation as an intrinsic part of the policy-making process.

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