March 2011

Emerging forms of cross-sector collaboration in the Spanish innovation system

Science and Public Policy, 38(2), March 2011, pages 135–146
DOI: 10.3152/030234211X12924093660552; http://www.ingentaconnect.com/content/beech/spp

Emerging forms of cross-sector collaboration in the Spanish innovation system

Manuel Fernández-Esquinas and Irene Ramos-Vielba

The Spanish innovation system has grown since the 1980s following a predominantly supply-side model where R&D capacities have concentrated in universities and public research organizations. Since then efforts have been made to stimulate cross-sector linkages. These have relied on university–industry projects, various forms of interface organizations, technology centres and programmes to encourage mobility. However, initiatives have encountered some significant drawbacks. Due to a lack of progress, a range of centres and other collaborative arrangements have emerged since 2000 to try to foster greater collaboration and firm based innovation. The process of policy change and their institutional structure are examined in the context of current and potential impact on the national innovation system.

IN RECENT YEARS one of the key assumptions of innovation policy has been the need for cross-sector cooperation and interactive learning. Innovation is characterized by reciprocity and feedback mechanisms through which actors produce new combinations of ideas, capabilities, skills and resources. If these interactions are poor, it has been argued, they will have a negative impact on the pace of innovation activities (Lundvall *et al*., 2002). Because research capabilities in many countries are heavily concentrated in the academic and government sectors, the emphasis is often put on improving cross-sector research collaboration (CSRC) between public science and proprietary regimes, a trend that Bozeman (2000) calls the 'collaboration paradigm'.

Given the large number of instruments available to promote collaboration, such as project grants, cooperative centres, human resources programmes, financial aid, tax incentives, and legal reforms, the task of designing the most effective mechanisms to enhance links between sectors has attracted much policy attention. Governments face the problem of trying to promote collaboration from a wide set of tools that need to be adapted to the specific conditions of their innovation system. However, there is little in the way of policy guidelines concerning the design of policies for different contexts. As a consequence, interventions for promoting collaboration usually develop as a process of learning through trial and error.

Some important questions follow for public policies: Are CSRC tools equally effective for different configurations of innovation systems? What are the appropriate measures for systems at different stages of development?

Moreover, given that innovation policies are taken from multiple levels of government, there is an ongoing discussion on the instruments that national or regional administrations should use to support private innovation (Fernández-Ribas, 2009; Laranja *et al*, 2008). In this multi-level governance context how should be the division of work be best allocated for promoting collaboration?

The Spanish innovation system is an illustrative example of this situation. In the last 25 years scientific capacity has grown considerably alongside the economic development of the country. Public

Dr Manuel Fernández-Esquinas (contact author) is at the Institute for Advanced Social Studies (IESA), Spanish National Research Council (CSIC), Campo Santo de los Mártires, 7, 14.004 Córdoba, Spain; E-mail: mfernandez@iesa.csic.es; Website: <http://works.bepress.com/manuel_fernandez_esquinas/>; Tel: +34 957 760528. Irene Ramos-Vielba is with the Ideas Foundation, Gobelas 31, 28023 Madrid, Spain; E-mail: iramos@fundacionideas.es.

The authors thank Professor Tim Turpin, two anonymous referees and the participants at the Córdoba workshop on Cross-Sector Research Collaboration for their constructive comments.

Manuel Fernández-Esquinas is a senior researcher at the Institute for Advanced Social Studies (IESA), a centre of the Spanish National Research Council (CSIC). He holds a PhD in sociology and political sciences from the Complutense University of Madrid. He worked for 10 years as an applied sociologist, leading numerous studies on public opinion, public policy analysis, social problems and programme evaluation. His research interests lie in the intersection of science policy and the sociology of science and innovation. His current projects explore the socioeconomic impacts of public research organizations, the emergence of collaborative research centres between science and industry and the practical uses of the social sciences. He is currently Vice-president for Research of the Spanish Sociological Association (FES) and Spanish Delegate at the OECD Committee for Science and Technology Policy.

Irene Ramos-Vielba has a PhD in political science and sociology, and is currently Head of Politics, Citizenship and Equality at the Ideas Foundation in Spain. Her main areas of research are the Spanish science policy, university–industry relationships and knowledge transfer processes, on which she has published some scientific articles. She was a Visiting Fellow at the Centre for Industry and Innovation Studies, University of Western Sydney, Australia; at Indiana University, USA, under the direction of Dr Elinor Ostrom, 2009 Nobel Prize in Economic Sciences; and at Harvard University, USA. She worked as a Postdoctoral Research Fellow at the Institute for Advanced Social Studies, Spanish National Research Council.

expenditure and the numbers of universities, academic researchers and scientific publications have increased continuously.[1] At the same time, governments have implemented policies to promote knowledge transfer to firms following a supply-side model. A wide range of tools has been launched, including grants, loans for collaborative projects, and several interface organizations. However, innovation capacity, reflected in patents, spin-offs, private expenditure on R&D, researchers in firms and the number of innovative firms, have not increased at the same pace (ICONO, 2008). So CSRC incentives appear to have achieved little so far.

Some specific features of the Spanish innovation system impede both collaboration and knowledge transfer. The concentration of R&D in the academic sector, the complexity of the multi-level policy framework, the special characteristics of industries (with a predominance of small to medium-size enterprises [SMEs] and low-technology sectors), plus the difficulties for cross-sectoral mobility of researchers, are all important limitations (Muñoz, 2001; Sebastián and Muñoz, 2006). Several reports have provided descriptive overviews of interface mechanisms and public–private partnerships, describing an 'implementation gap' between science and innovation (FECYT, 2006; OECD, 2005b). However, explanations of the causes that hinder collaboration as well as the rationale for emerging trends are lacking.

This article analyses the mechanisms and impact of cross-sector collaboration policies. Our main goal is to explain the dynamics of policies as a result of two important forces: the elements shaping the national innovation system and the actions by which stakeholders try to overcome the limitations of previous arrangements. The diversified set of procedures and organizational structures in the Spanish innovation system provides a suitable setting for developing some more general insights about the factors that shape public policies and, more importantly, their implications for interventions to promote collaboration.

Our analysis reveals a trend consisting of a shift from mainly project-based cooperation to more structured and stable forms of collaborative endeavours and partnerships. Taking into account such a trend we confront two questions:

- What is the policy rationale driving the trend toward new forms of collaboration dynamics? And
- Does organizational stability contribute to improvements in cross-sector research linkages?

The argument we put forward is that for many years an 'implementation gap' has been caused by the barriers that hinder collaboration, but also by a 'lock-in' of the main policy actors. This lock-in is caused by the implicit division of work resulting from the institutional building of the innovation system. Only the rise of new structural conditions since the 2000s has enabled actors to follow a different path. New forms of CSRC tools emerging in a bottom-up fashion are the result of actions by new actors that try to overcome the failures of traditional policies, which in turn pose unresolved issues concerning the division of work.

As an analytical strategy we use the evolutionary perspective of policy-making applied to the governance of innovation systems (OECD, 2005a). For our purposes, we combine this perspective with the concept of system failure. The evolutionary aspect of policies suggests that public interventions result from exchanges of interest in the context of prevailing opportunities. Collective policy-making consists of bargaining behaviour and negotiated outcomes among interested actors (March and Olsen, 1996). But at the same time, it is acknowledged that social choices are shaped and mediated by institutional arrangements. Actors situated in different domains have different motivations when engaged in knowledge production and utilization. The institutions play a major role in how people and firms learn and use their knowledge, which affects the final outcome (Edquist and Hommen, 1999).

Therefore, policy analysis in the innovation field should consider two processes. First, a country's institutional set-up, which typically experiences its 'defining moment' in the design of ministries and agencies, allocation of resources, competences of actors and stakeholder participations (OECD, 2005a). In evolutionary terms, this creates conditions for path dependency. Second, innovation systems are subject to tensions, therefore new actors are pushed to meet stakeholders' requirements to compete in the

knowledge economy. For this reason new developments are often the result of perceived failures of former situations.

System failure and research policy

The concept of system failure provides a useful tool for looking at specific mechanisms that affect the evolution of research and innovation policies. This concept can be helpful for explaining why some CSRC policies do not interact effectively with existing practices and organizational forms. The notion of failure has often been used to accounts for factors affecting innovation processes. Several studies have identified barriers induced by a lack of basic infrastructure (Edquist and Hommen, 1999), firm competence (Lhuillery and Pfister, 2009), government shortcomings (Komninos and Tsamis, 2008; Svarc, 2006), regulations that hinder scientific excellence (Bonaccorsi, 2009) and social configurations of norms that shape creative processes in key productive sectors (Anchordoguy, 2000). The framework suggested by Woolthuis *et al*. (2005) is especially useful for integrating different types of barriers and identifying actors in each of them. The main types of processes creating systemic failure are:

- *Capability failure*, concerning the competences, resources, and skills of both firms and science organizations;
- *Network failure*, concerning the barriers to cooperation and flow of information between actors; and
- *Regulation and institutional failure*, concerning institutions norms and non-predicted evolution of regulatory arrangements.

For the purpose of this article we use the different failures as analytical devices to identify the mechanisms that hinder the effective networking of system components. In addition to the macro perspective that is usually privileged by institutional policy analysis, we argue that it is necessary to descend to the micro level and observe the dynamics of specific measures. Taking the building of the modern research system as the starting point, we consider both the results of traditional tools that have been running for the last two decades and the emergence of a new set of policies and organizations. For empirical illustration we use previous evaluations that have focused on performance, and analysis of a selection of new programmes.

Our methodological approach has two components. First, we focus on the social mechanisms that shape the results of cross-sector dynamics in projects, human resources programmes and interface organizations. The analysis highlights several drawbacks that can be considered as failures. Second, we focus on the emerging trend from mainly project-based and short-term links to new organizations and more stable forms of CSRC. We investigate this trend through successive waves of CSRC policies in terms of the rationale and the interests of the actors involved. The latest wave of tools, consisting of more structured means of collaboration, is explained by the emergence of new actors in a multi-level political system that tries to overcome the failure of traditional policies.

For the purpose of this article we use the different failures as analytical devices to identify the mechanisms that hinder the effective networking of system components

Spain's political and economic context

The construction of a 'mode 1' research system

The transition to democracy that started in 1978 presented a departure from the old model of industrial support based on strong public research organizations (PROs) close to the corporate capitalism of the dictatorship. The emerging goals of science and technology policy in the 1980s were to develop R&D practices and institutional forms that were commonplace in most western democracies. The policy trend can be labelled as an effort to build a 'mode 1' research system (Gibbons *et al*., 1994). The 'right institutions' at that time were considered to be a modern structure for science support based on the Mertonian reward system, together with a technology policy detached from political and corporate influences.[2] In the case of science, the aim was to create research-based universities and advanced institutes by establishing funding schemes encouraging competitive projects, properly evaluated publications and research training. For industry, the priorities were to establish a new framework for the development of dynamic firms, where the restructuring of public conglomerates and highly subsidized industrial sectors were necessary steps to overcome the autarkical economy.

As a result, state[3] R&D policy was based on a dual system for priorities and funding: a group of programmes and mechanisms for academic science (mainly under the *National R&D Plan* of 1987 and the associated evaluation agency — ANEP — which specialized in academic science) and a set of economic incentives and promotion schemes for firms operated by another specialized agency (the Centre for Industrial Technological Development). In fact, explicit policies frequently claimed to align public support of science with the technological and

innovation strategies of the industrial sectors (Dorado and Oro, 1991). The practical implementation of tools for very different needs resulted in science policy (directed toward researchers in universities and public research institutes) disconnected from technology and innovation policy, managed by industry policy-makers.

System failure in the Spanish policy system

Three sets of factors arising from this arrangement generated barriers that hinder CSRC: industrial innovation capabilities; rules governing the academic sector; and the bifurcated nature of public policies.

Industrial innovation capability

Most accounts of the Spanish industrial base point to the structural conditions that hinder innovation (OEP, 2005): the specialization in low and medium technological content, with a notable presence of construction and services, especially tourism; the small size of firms; labour force productivity; and, consequently, scarce private investments in R&D. Few corporations in Spain have a strong technology base and the larger national firms are concentrated in the service sector. Other bigger firms resulted from the off-shoring process of international corporations that retain their R&D divisions in other countries. This industrial structure has created few incentives for interest groups to create large public–private partnerships. Instead, smaller firms prefer one-to-one projects and avoid investments in joint ventures.

Regulation of the academic sector

Universities and PROs are public bureaucracies governed by state laws, where tenured researchers and professors are public servants. Hiring and mobility of personnel are subject to rigid administrative procedures. Part-time appointments of researchers are very restricted and temporary cross-sector mobility for professors usually means the loss of career advantages. Moreover, contract research between sectors is also highly regulated, especially the exchange of economic resources in both directions. Until very recently universities were not allowed to invest in innovative business or to be official partners in new firms. These arrangements have to be overseen and approved by several external bodies and pose management constraints on creating new organizational forms (Sebastián and Muñoz, 2006).

Bifurcated public policy

The dual public policy consisting of science agencies versus technology and innovation agencies has meant they are governed by different rationales. In science agencies the aim has been to strengthen the once-precarious research base of universities using management tools that favour individual scientific merit. In technology and innovation agencies, management procedures in the agencies distributing funds for innovation have been detached from scientific peer-review practices. Innovation policies have placed an emphasis on accountability and the increase of firm turnover (Fernández-Esquinas *et al*., 2011). Collaboration tools have been one-sided only, coming from one of the policy domains. In sum, public bodies in charge of both funding agencies have seen few strategic advantages in adopting policy innovations that overcome rigid boundaries, especially those that are high-risk and costly such as collaborative centres.

The combination of these factors has produced a system failure in terms of both promoting interaction across the sectors and supporting the interest of actors in doing so. The limitation in firms' technological capability has been an important barrier to establishing strategic links with universities, since the activities they are eager to engage with are driven by the need for technical assistance leading to immediate productive and commercial outcomes. On the university side the regulations have been highly restrictive and collaboration has not been part of the recognized formal mission for academics. For academics the incentives to collaborate with industry have not been consistent with indicators for career development or recognition.

Finally, in the absence of coordination there has been a lack of horizontal integration between ministerial departments (Muñoz, 2001). More recent developments have sought to overcome this by funding bigger projects and adding multiple stakeholders to the partnerships, but the orientation toward different constituencies has handicapped the possibilities of spanning boundaries between organizational forms or creating hybrid organizational arrangements.

The rise of a multi-level governance system

Another resilient feature of the Spanish innovation system is its multi-level character. The reconstruction of the science system coincided with the emergence of the regions as new active agents. A devolution process started in 1978, enabling regional governments to establish their own science, research and innovation policies. The *Constitutional Act* considers R&D as a 'concurrent competence', meaning that both levels of government have the capacity to implement policies, although the state retains the competence for coordination (Tortosa, 2006).

Regional governments' policies have been growing steadily. Priorities were first focused primarily on agricultural research, but later moved toward innovation and development more generally. Regional governments were also given responsibility for funding and the management of universities and research facilities in hospitals. However, the pace and direction of change has differed considerably across the

regions. With few exceptions, such as in the Basque Country, the early trend during the 1980s and 1990s was to support academic science because of the need to strengthen the scientific capacities of an expanding university sector. Later developments have resulted in heterogeneous regional systems in terms of the specific combination of resources. A comparison of regions shows significant differences in the status of universities in Navarra and Catalonia, firm associations in the Basque Country or PROs in Madrid (Buesa *et al*., 2006).

Currently R&D expenditure by regional governments is about 50% of total public expenditure, although the main regional programmes are concentrated in the bigger regions. Madrid, Catalonia, Andalusia, the Basque Country and Valencia combined account for more than 80% of R&D (ICONO, 2008). At the same time, European agencies have also started to play an important role, both as a source of funding for academic research and for the development of firm-based infrastructures, especially in regions and suburban areas with a lower GDP. This situation has given rise to a complex system. Spain has the dynamics of a federal state, but lacks the institutions and mechanisms for coordination that are generally found in countries with a federal structure. This has resulted in a fragmented policy framework, with only an implicit division of policy responsibility.

An overview of traditional cross-sector research collaboration

The more recent wave of Spanish CSRC policies contrasts with earlier policies in a number of ways: earlier initiatives were directed more toward one-to-one, short-term and small-scale arrangements, with an orientation towards activities with relatively low levels of scientific content. Other important features are the difficulties for vertical policy integration; although the state is the main political actor for regulation and funding, a common trend has been the predominance of bottom-up initiatives by a diversified set of actors, including not only regional governments, but also universities and industry associations. The examples we use are projects, 'interface' organizations and human resources programmes since they provide relevant examples of mechanisms influencing the outcomes. We will concentrate only on the main drawbacks because they help to explain the rationale for emerging trends.

Project-focused policies

Projects have traditionally been the main form of CSRC. Dating back to 1968 when they were called *concerted projects*, similar initiatives have been in place albeit with different names and scope (Acosta and Modrego, 2001). They have offered a subsidy of around 50% towards a project led by a firm in collaboration with a university or PRO, usually for three years. Developments in the 1980s and 1990s led to diversification, ranging from more fundamental research to innovation.

A later programme launched in 2000 (the *PROFIT programme*) aimed more explicitly to strengthen the financial capacity of firms using repayable interest-free loans as the main tool.[4] Although CSRC was a specific goal, it was in fact combined with many other criteria in selection processes. The preference was for projects closer to the market (pre-development, demonstration, and viability studies), and also for those with higher investment and therefore in a better position to receive refundable credits. The participation of academic partners was one of the criteria (concerted projects were only a subset of the whole programme), but not a specific condition.

Research has shown that cooperation is not a determining aspect in project selection or funding (Santamaría *et al*., 2010), but plays a secondary role in supporting selection. In consequence, the concerted projects programme did not foster large consortia and often posed the problem of the free-riding behaviour of firms (Joost, 2003). Given the absorptive capabilities of the industrial fabric, most projects tended to have less scientific content and fewer partners. Therefore, project policies have impacted on the transfer of financial assets and the enhancement of innovation capacities, but not specifically on increasing cooperation through large-scale endeavours with high R&D content.

Interface organizations

The Offices of Technology Transfer (OTTs) are the main organizational form for promoting CSRC. Originally started as a state programme, OTTs developed into a network of offices owned by universities whose main function was the management of academics' consulting activities (Castro Martínez *et al*., 2008). Professors have traditionally provided a wide range of services including technical assistance, informal advice, and training as a way of raising salaries and complementing scarce university resources. For firms, this channel has been a way to obtain assistance in a country lacking an extensive sector for private R&D consultancy. Universities have tried to control and prevent conflicts of interest and to orient activities towards greater scientific content. But even today decentralization is still a resilient feature of CSRC practices since most activities are carried out individually (Ramos-Vielba and Fernández-Esquinas, 2009). Only the more formal arrangements, usually bigger projects and exploitation agreements, are managed conjointly with OTTs.

Technology centres were developed during the 1980s to support associations of firms and regional governments for renewing traditional industries. As a consequence, they were mostly concentrated in regions with firms in sectors such as metal, tool machinery, food, textiles and wood (mainly in the

Basque Country and Valencia). Although formally private, they have been heavily sponsored by the public sector. Their main feature was their direct support *to* firms. The public subsidies were defined according to the needs of each particular industrial sector. Other revenues came from direct contracts with firms or collaborative projects requiring their participation (Giral, 1999). This feature has influenced the specialization and the services offered, consisting of laboratories and testing, assessment and training adapted to firms' needs. The main concern has been solving immediate technical problems to maintaining competitiveness, through process innovation (Olazarán *et al*., 2009). The main drawback is the sparse contract R&D resources from firms and therefore the possibilities for acquiring scientific input. This is why state policy has provided funding, and adapted legislation, to permit participation in public calls for projects, either with firms or university researchers.

Science parks were expanded during the 1990s and run as private corporations led by regional governments and universities, together with city councils and private partners. While councils provided land to foster urban development, universities and regional governments used new campuses and European funds to create innovation facilities (COTEC, 2000). However, the main problem faced by most parks was that of attracting potentially innovative firms. The scarcity of innovative businesses has created impediments in establishing university start-ups.

Human resource initiatives

Human resources programmes have been specifically designed to bridge the mobility gap. The *research training scheme* includes doctoral theses carried out in collaboration with a firm, contracts for postdocs to work in industrial laboratories and public aid for firms hiring R&D personnel. Other categories support exchanges between firm-based researchers and university professors (González-González *et al*., 2007). The decisive characteristic of this tool was its real cross-sector nature, which paradoxically also meant a lack of embeddedness of people moving from one sector into another. Research training is attached to a doctoral programme. The mobility of stable workers did not affect appointments in the other sector, since both professors and company researchers were officially still working for their original organizations. The results in terms of real mobility have depended on the scientific capabilities of the firm. The orientation has been toward academic science when the firms lacked R&D content. Therefore, the expectations and professional trajectories of both PhD students and postdocs have been mostly within universities (Fernández-Esquinas, 2002). Again, the main difficulty is finding firms able to provide both an adequate environment for training and the prospect of professional development for researchers.

The main problem faced by most science parks was that of attracting potentially innovative firms. The scarcity of innovative businesses has created impediments in establishing university start-ups

The instruments mentioned above have spread across the country. In particular, the three formal associations of OTTs, technology parks and technology centres respectively are jointly responsible for a very important part of the process of knowledge transfer. They are institutionalized as actors organized around networks with a significant degree of autonomy.[5] Regional governments have been one of the main supporters of these structures. At the state level the National R&D Plan has concentrated on projects and financial aid as the main instruments to foster collaboration with public partners. Over the years there has been a tendency to increase direct aid to firms due to the higher capacity of the state, in comparison to most regional governments, to use repayable loans in concert with tax incentives.[6] Loans have constituted the main increase in the R&D budget over the last 10 years. Financial aid makes up 60% of total public expenditure in R&D and 85% of public support to private R&D (ICONO, 2008). On the other hand, the central government has been reluctant to support local projects, and other tools such as block grants have been lacking until very recently.

This implicit division of work has produced an historically based lock-in for several years. The construction of the modern research system has been around a set of antecedent conditions that framed a specific trajectory of institutional development and consolidation. This has been difficult to reverse during the critical period of the expansion of the public sector. During the 1990s and part of the 2000s the central government, through the National R&D Plan, has faced the need to support a growing number of universities and researchers, in addition to national and international research infrastructure. On the other hand, since most of the resources for firms have been directed to financial aid, this has left few opportunities to invest in strategic options and develop policy innovations.

The policy shift for cross-sector research collaboration

A new trend starting in the 2000s has consisted of broadening the pool of resources to foster innovation, and stimulate the formation of new organizational

forms to span the boundaries between separate domains. There were two imperatives driving this shift. First, structural barriers and lack of incentives for larger public–private partnerships, targeting radical innovations, have been interpreted more explicitly as reasons for system failure (Molero and Buesa, 1998). Second, the emergence of new structural conditions has drawn some agencies into the policy process with new ideas and different expectations.

A new policy environment

Economic growth through the early 2000s and the availability of additional public funds to overcome the previous lock-in produced by the growth of the academic sector and the decentralized structures for knowledge transfer have transformed the opportunity context. Moreover, development of the multi-level state has led to a more complex arrangement of policy interests and intentions. Regional governments have gained political legitimacy, with increasing competencies and more economic resources. A process of policy learning has also allowed regional departments to develop plans with distinctive features. New agencies with an interest in national science policy have generated responses from agencies such as health and energy, to launch their own programmes and specialized centres. Moreover, universities and PROs are now more able to act as independent partners because legal reforms have granted them more autonomy to hire research personnel. Some universities and PROs are now strategic actors competing for both resources and establishing alliances.

Meanwhile, industrial policy trends at several government levels have placed an emphasis on the mobilization of R&D capabilities to promote a more knowledge-intensive industrial sector. Through the 2000s there has been a much more explicit alignment with the 'collaboration paradigm'. The public sector is being used more directly to increase the scale of arrangements by aggregating large firms, SMEs and universities around enabling technologies, and to create competitive environments through agglomeration of new firms in innovative spaces (Trullén, 2006). This trend is also facilitated by the development of firms. The economic growth of the country has resulted in bigger industrial firms with absorptive capacities that are able to interact with the public sector.

Science policy trends have resulted in structural changes stemming from legal reforms through two subsets of measures aimed at reducing boundaries. The first set is contained in the new *Universities Law* introduced in 2000. It encourages researcher mobility by engaging professors to undertake R&D in firms, permitting full-time appointments, and facilitates the hiring of technicians to support research teams that have contracts with companies. This in turn has facilitated a shift from mainly individual consultancy to more collective projects. The laws also allow the establishment of public–private centres in universities and the creation of start-ups. The second set relates to the amendment to the *Science Law* in 2002, which basically broadens the scope of PROs to participate in or set up firms and eliminates previous restrictions related to the exploitation of patents.

A new rationale for cross-sector research collaboration

CSRC is now being promoted in two major ways. First, through the creation of large projects that concentrate capacities around strategic research. Second, through the creation of environments that encourage the co-location of firms, universities, interface organizations and advanced service suppliers.

Recent policy initiatives assume that the diversification of partnerships is a more efficient approach to stimulate R&D and radical innovations. The rationale appears to be the need to steer high-quality fundamental research toward economic relevance, and to encourage concentration of resources in research fields of strategic importance for the economy and society. The new mechanisms explicitly seek to attract major players in well-defined sectors through the creation of consortia and networks. The chief example is the *Ingenio 2010 Scheme*. This was launched in 2005 as a major initiative in economic reforms (OEP, 2005).[7] The policy mechanisms seek to match science and innovation through consortia of multiple academic and industrial partners around enabling technologies, such as the consortia in the field of information and communication technology (ICT) and the *CENIT programme*. Similarly, excellence networks for bio-medicine research (*CIBER networks*) endeavour to generate large multi-institutional research where basic, clinical and epidemiological research can be more effectively integrated.

Measures to shape the innovation environment aim to create critical mass by locating new firms and high-tech SMEs close to universities and research centres. Various governments have adopted measures of this kind, which vary in terms of programme size and scope. A good Spanish example is the *Campus Programme of Excellence*, the first to support the Spanish university system by providing block grants (Rubiralta and Delgado, 2010). The main objective of this programme is to create environments conducive to the integration of social university life, attracting students and researchers in order to set up scientific facilities and firms with high added value. Initiating this programme required the coordinated action of regional governments, universities and economic agents.

Once these organizations and interface spaces are created, a common problem has been the absence of personnel with the capacity or incentives to interact. To overcome this problem some organizations have been subject to specific policies aimed at creating capacities (CICYT, 2000, 2004). In this respect the state has helped to institutionalize some of the structures.

For example, after 2002, science parks received specific help from the state through a programme that provides financial assistance to firms to locate in these spaces. Other organizations aimed at bridging sectors, such as incubators and infrastructure for clusters, were also located in science parks with the aim of creating innovative environments (COTEC, 2000).

In the case of the technology centres, although their funding comes mainly from the private sector (55%) (Callejón *et al*., 2007), the state government and especially the regional governments have contributed to their consolidation, frequently using universities (also dependent on regional governments) as intermediaries. For example, the *Support Programme for Technology Centres*, which was re-launched after 2000 as part of the National R&D Plan, offers grants for collaborative projects and contracts for postdoctoral fellows. This situation has led to a diversity of new and more stable centres for public–private research collaboration that can lend service to innovation through their combined capacities.

From project-based to organizational arrangements

In Spain, new organizational forms for collaboration emerged as the result of stakeholders' reactions to the system failure. The failures were generated by the limitations of both traditional science policies and the structures of universities and PROs. As a consequence, there is neither a single national scheme nor a unique CSRC model or federal network of collaborative research centres, such as in Australia or the USA. The variety of new structures basically depends on the agreements, expectations and capabilities of the partners, as well as the availability of funding.

The absence of a unified R&D policy and the lack of any registry of cooperative research centres make this issue difficult to study empirically. Nevertheless, it is possible to use a simple typology to observe and describe the emergence of hybrid organizational arrangements. For that purpose we have used the preliminary classification outlined by CREST (2004). Their classification specifies whether the initiative originates in the private or the public sector, depending on where the largest amount of funding in each case generally comes from. In addition, we have included a third intermediate option for organizations specifically created to attract private financing. The examples provided for each type in the classification are aimed to illustrate the rationale of stakeholders and the bottom-up processes driving a diversified set of CSRC structures.

Privately driven initiatives

The so-called 'enterprise chairs' in universities are mainly financed by private-sector contributions. Besides academic activities, they pursue research projects in subjects of interest to both the companies involved and the university. The firm proposes and orientates these projects and the university provides the infrastructure and human resources. A good example is located at the Polytechnic University of Catalonia, where 17 company professorships have been established covering various industrial sectors from transport, energy innovation, engineering and ICT. They represent a measure halfway between philanthropy and the beginning of a strategic association. This is a shift away from the more decentralized relations among individual teachers and firms providing consultancy towards a more long-term and socially visible form of collaboration. The underlying effect is to institutionalize what were previously loose-knit relationships.

The so-called 'enterprise chairs' in universities are mainly financed by private-sector contributions. Besides academic activities, they pursue research projects in subjects of interest to both the companies involved and the university

A privately initiated research centre within a university or PRO is a more complex process due to the financing and coordination required. The most relevant case is the agreement between the former Pharmatia-Pfizer and the Spanish National Research Council (CSIC) in 1996 to create a corporate laboratory inside the National Centre of Biotechnology (one of the institutes of CSIC). This later developed as a Pfizer and CSIC partnership through the Department of Immunology and Oncology. The centre initiated projects and built basic research programmes on epidemiology, clinical research, health and pharmacology. This agreement is considered an example of successful collaboration, although at the beginning it faced criticism for improper practice for selling public resources to a private company. One of the main reasons for implementing this model was the difficulty in establishing a partnership using the administrative rules operating in regular CSIC centres. The rationale in this case was thus to overcome institutional failure (Martín-Lomas, 2002).

Although technology centres receive considerable public support, their distinctive feature is their strong orientation to providing technological services to firms (around 60% of total funding comes through such service provision). Technology centres in many cases grew out of business associations that required innovation services, and were not intended as a tool for cross-sector research with the academic sector. There are several generations of centres with

very different profiles: some of them are active R&D performers, while others concentrate on providing services with less scientific content, depending on the industry sector and the role played by regional governments.

The growth in the number of technology centres has been due to three converging processes. First, an explicit policy to increase capabilities for critical stages of technological development and to undertake long-term endeavours to increase the value-added of the services provided. As a result, some regional governments are reorienting their funding to target radical innovations (Callejón *et al*., 2007). Second, evaluations of the *support programme* launched by the National R&D Plan (Modrego *et al*., 2003) has resulted in an orientation toward bigger and more ambitious collaborative projects, in order to increase their critical mass. Third, centres themselves are reorienting their activities to obtain alternative funding, especially from the *European Framework Programme*, which implies more emphasis on acquiring capabilities to establish strategic alliances with international partners. In sum, the technology centres have intensified their cross-sector collaboration to increase their own research capacities as a strategic element for maintaining their level of technological competitiveness.

Public–private corporations and consortia

There are also cases where partnerships have been driven by the public sector in order to increase funding from firms, either using grants to create large projects or new organizations for matching the funding provided by private partners. The following two examples represent options emerging from the State and one of the regional governments.

The *CENIT programme* (National Strategic Consortia for Technical Research) has created consortia comprising large firms, SMEs and universities. Started in 2006, it was specifically aimed at strengthening collaboration between the public and private sectors involving researchers working at different parts of the value chain. The outstanding feature of the CENIT programme is its financing of large-scale projects. The main objective is the generation of new knowledge that is useful in the creation of new products, processes and services and for the integration of technologies of strategic interest (OEP, 2005).

Some initiatives seek to generate collaboration through shared financial contributions among partners. The objective is to attract private financing through the commitment to matching amounts provided by each company. An example is the Technological Corporation of Andalusia (CTA), a private foundation promoted by the Andalusian regional government. CTA participants include firms, universities, research centres, financial entities and regional governments. Firms pay an annual subscription fee. Initially, this involved mainly large companies but later SMEs also joined the consortia. The regional governments match the private financing and commit support to universities. The CTA finances cooperative projects through competitive evaluation processes, with the presence of at least one research group from the public sector being a requirement (CTA, 2009).

Publicly driven initiatives

Funding for 'publicly driven' initiatives generally comes from the institution taking the initiative, usually because the goals are closer to state-of-the-art research. Examples include network of excellence centres and independent institutes derived from a combination of different efforts by public administrations and firm associations.

The Cooperative Research Centres (*CIC*) *programme* launched by the Basque regional government is the only public plan to create a homogeneous network of excellence centres. This model draws on pre-existing international programmes like the *Australian Cooperative Research Centres* (CRCs). Centres are conceived within the CIC programme as organizations devoted to specialized research in a specific scientific or technological field considered as strategic for the economic and social development of the region. At present the CIC programme covers seven sectors: energy; nanosciences; micro/nanotechnologies; biomaterials; biotechnology; biomedicine; and tourism. Most centres have been launched using public funds. They seek to achieve research excellence through the recruitment of highly respected researchers. In the second stage of development the programme is expected to take advantage of the synergies derived from the experience and to benefit the system as a whole (CICNetwork, 2007).

Several independent institutes have been created with inputs from universities, governments and industry. In some cases the private partner is an association of firms working in the same sector and cooperating with a public agency toward common goals. The following are some relevant examples oriented to translational research and manufacturing:

The Spanish National Cardiovascular Research Centre (CNIC) works mainly in association with a PRO and a group of large corporations linked to prestigious international scientific programmes. Postgraduate training is also a objective. Such models are created independently as a means of finding more flexibility in the rules and methods of financial control and, above all, the hiring and managing of personnel (CNIC, 2009).

The Centre for Scientific and Technological Competence in Transformed Meat Products (CECOC-PTC) is a consortium of PROs, at both national and regional level, and a business association. Created in 2001 using funding from the National R&D Plan to support competence institutes (CICYT, 2000), this centre was formed by an

agreement between the National Organization of Agricultural Research (INIA), the Research and Agricultural Technology Institute (IRTA) and the Spanish Federation of Food and Drinks Industries (FIAB). The CECOC-PTC is a network centre with a stable organizational structure and with considerable research autonomy. Coordination of the network, as well as its administrative and financial management, is handled by the IRTA, a public corporation owned by the regional government of Catalonia in the field of food and agriculture research. This centre is an example of multiple partners with overlapping interests working at several government levels (IRTA, 2009).

Mapping the trend towards organizational stability

The above examples show that CSRC structures in Spain are the result of the coalescing of interests across different sectors, organizations and researchers. The heterogeneity of CSRC models reveals different attempts to overcome many traditional system failures. This situation has created a wide range of mechanisms depicted in Figure 1. The vertical axis presents the core activities from advancing basic knowledge to commercialization, according to the explicit emphasis conveyed by each modality. The horizontal axis presents the degrees of organizational stability of each CSRC initiative. By organizational stability we mean interactions that are more long-term, independently led, administratively autonomous, and involve a larger number of researchers and organizational partners.

This classification reveals different types of tools along the horizontal axis. First, we identify monetary support regardless of any further organizational efforts by the firm (for instance free-interest credits or fiscal aid), followed by short-term projects. Second, more stable formats appear such as the consortia created for large longer-lasting projects and the networked virtual centres.

The schema also shows the emergence of collaboration tools with greater scope to link quality science with innovation, which is also reflected in ever more stable organizational forms. The prevalent trend appears to be from lower to higher organizational stability. Complementarily, evolution along the vertical axis reflects a propensity for higher scientific content and technological development. Another relevant aspect is the apparent consistency of the timeframe of the several waves of national and regional science and innovation policies with the emergence of more stable organizational forms.

When a time scale is overlaid on Figure 1 (top horizontal axis), we observe few exceptions from the general trend. In fact, few inconsistencies emerge with the stability axis (bottom) in terms of later policies coinciding with relatively more and more stable organizational forms. Projects date mostly from the 1980s, while interface organizations (TTOs, S&T parks) started in the late 1980s and developed with technology centres in the 1990s. Institutional collaboration and new organizational forms aimed at matching higher scientific content with productive goals emerged mainly after 2000. Thus the progressive convergence of organizational stability with

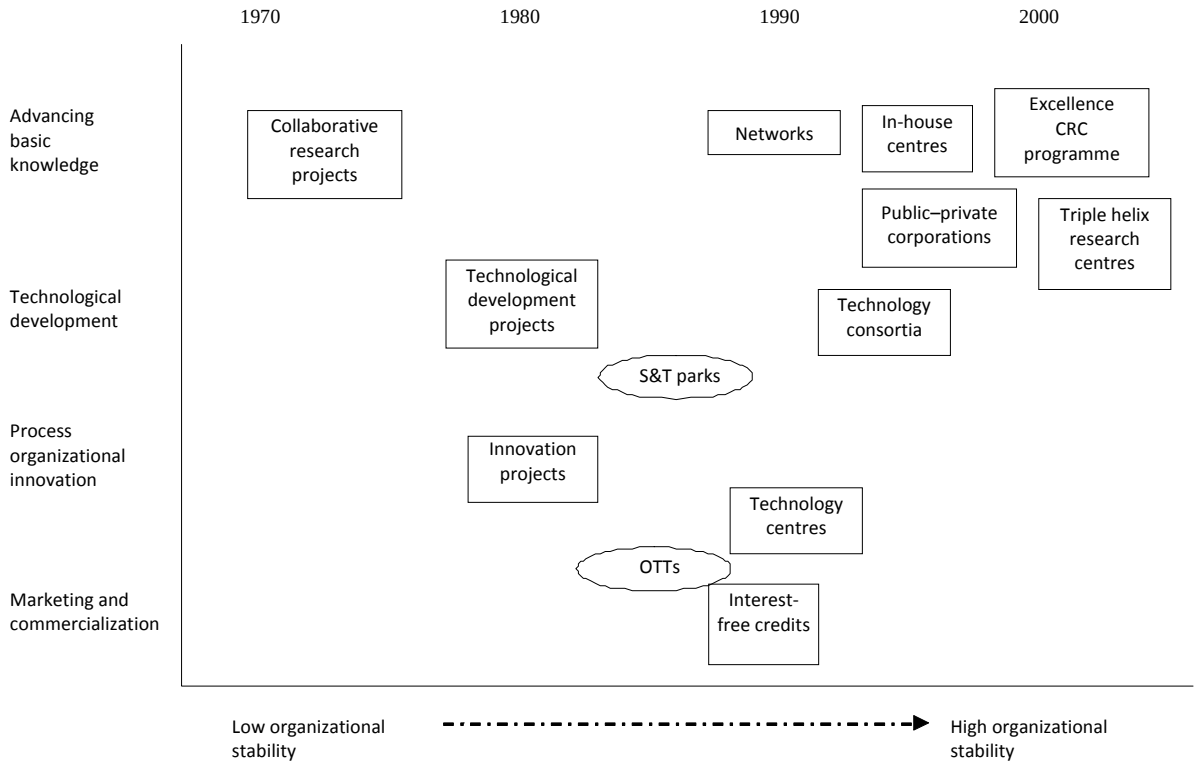

Figure 1. Trends in cross-sector research collaboration mechanisms in the Spanish innovation system

scientific and technological based CSRC initiatives is consistent with the time frame.

Conclusions

Using the concept of system failure as an analytical device has enabled us to identify blockages that hinder the effective networking between the components that make up the Spanish research system. It has also enabled us to identify some useful lessons for understanding CSRC policies and their impact.

First, the nature of the industrial capability can inhibit effective linkages. The predominance of SMEs with low technological base, a lack of both organizational ability and skilled human resources, and the orientation of some large companies to activities of low technological content, present major barriers to research collaboration. Financial support for short-term grants and repayable loans may orient firms toward technical services and low-risk applied research, rather than long-term capacity-building.

Second, research collaboration can be inhibited by regulations and practices that fail to generate incentives to collaborate within the research system. Evaluation procedures for individuals and teams within the academic sector offer examples. Similarly, peer-review processes oriented only to academic outputs can create situations where individuals are trapped by 'excellence' criteria that place little value on technology transfer. Moreover, the existence of only one career system, where promotion relies almost entirely on publications, offers little encouragement for the involvement of professors and researchers in different types of cooperative interactions. A more balanced strategy is needed to encourage or even enable scientists to work across industry and academic sectors.

Third, horizontal integration between departments, and vertical integration between levels of government, makes coordination difficult. Science and innovation policies have followed independent paths for the past three decades leading to a complex, dual-policy system. This fragmentation is particularly acute for catch-up countries with low private investment in R&D such as Spain. The consolidation of multi-level governance in the absence of coordination mechanisms has resulted in a very complex model, with few synergies between regional and central programmes. Policies for promoting collaboration have been conditioned by path dependence for some years, maintaining the separation of organizational domains. The process observed in the Spanish innovation system highlights the importance of the institutional set-up in constraining the options for agencies to coordinate innovative policies.

In spite of these systemic failures, we have observed a trend away from project-based cooperation to more structured and stable forms of research collaboration. This trend raises important issues for the governance of innovation. On the one hand, it is expected that these new arrangements contribute to improvements in cross-sector linkages. They imply the formation of more stable arrangements to carry out complex activities, and sometimes the emergence of hybrid organizations. In accordance with assumptions that economic returns of both public and private R&D depend on the quality of the science–innovation interface, increasing complexity in public–private partnerships appears likely. Bigger and more stable organizational forms suggest more opportunities at the interface between science and industry, creating critical mass around key technologies.

On the other hand, some research suggests that the division of work in CSRC should be in accordance with territorial proximity. That means that regional level programmes may be more effective in facilitating process innovation, whereas national and international programmes should focus more generally on scientific endeavour (Fernández-Ribas, 2009). However, the policy trend described above points toward a situation that is rather the reverse. The policy division for the upper level of government appears to concentrate more on improving absorptive capacities in firms, while the lower level tries to fill the excellence gap with new hybrid organizations targeting radical innovations. Whether this is a promising trend or just another consequence of systemic failures is a matter for further research.

Notes

1. GERD is 1.37% of gross domestic product, of which 63% is spent by the public sector; and 65% of researchers are employed in the university and government sectors. Spain is now the tenth-ranking country for scientific articles registered on ISI-Web of Science (ICONO, 2008).
2. The main legal reforms in the 1980s aimed at constructing a modern research system are the *University Reform Act* of 1983 and the *Science and Technology Act* of 1986. Policy tools were included mainly under the National R&D Plan starting in 1987 (Sebastián and Muñoz, 2006).
3. When we refer to the state we mean the *general administration of the state*. Since 1978 Spain has been transformed from a very centralized country into a quasi-federal, political system. The regional level of government consists of 17 *autonomous communities* (regional governments).
4. Subsidies are combined with interest-free loans to support specific projects, especially those in cooperation with universities (firms may receive a subsidy to pay a maximum of 70% of the collaboration contract with a university, although this contract should be less than 20% of the total cost of the project). On the other hand, firms receiving repayable loans have to provide a pay-back guarantee from a bank. For SMEs this can be considered as a push for investing in projects that can generate cash in the short term.
5. Currently OTTs are present in all universities and PROs, and also in many public hospitals. The network is managed conjointly with the association of university rectors <www.redotriuniversidades.net>. The association of science parks — APTE — comprises 45 members and 36 associates from all over the country <www.apte.org>. Technology centres constitute a federation — FEDIT — including 65 centres from most of the regions <www.fedit.com>.
6. Tax breaks are also a widely used tool to promote collaboration. Firms are able to deduce contract with universities as part of the R&D-related expenditure. Currently Spain has one of

the most favourable tax exemption schemes for R&D and innovation of all OECD countries.

7. Interestingly, *Ingenio 2010* was launched as an independent programme, and only afterwards incorporated in the National R&D Plan. One of the main criticisms of Ingenio 2010 was the lack of coordination with other state and regional agencies <www.ingenio2010.es>.

References

Acosta Ballesteros, J and A Modrego Rico 2000. Promotion of cooperative research: a Spanish experience. *Science and Public Policy*, **27**(5), October, 337–346.

Anchordoguy, M 2000. Japan's software industry: a failure of institutions? *Research Policy*, **29**, 391–408.

Bozeman, B 2000. Technology transfer and public policy: a review of research and theory. *Research Policy*, **29**, 627–655.

Bonaccorsi, A 2007. Explaining poor performance of European science: institutions versus policies. *Science and Public Policy*, **34**(5), June, 303–316.

Buesa, M, J Heijs, T Baumert and M Martínez-Pellitero 2006. Regional systems of innovation and knowledge production function: the Spanish case. *Technovation*, 463–472.

Callejón, M, A Barge-Gil and A López 2007. La cooperación público privada en la innovación a través de los centros tecnológicos. *Economía Industrial*, **366**, 123–132.

Castro Martínez, E, I Fernández de Lucio and J Molas Gallart 2008. Theory and practice in knowledge transfer: the emergence of 'interface structures'. In *The Genesis of Innovation: Systemic Linkages between Knowledge and the Market*, eds B Laperche and G N von Tunzelmann, pp. 146–161. Cheltenham: Edward Elgar.

CICNetwork 2007. Entorno CIC en Euskadi (dossier). *Revista CIC Network Ciencia y tecnología*, **1**, 32–55.

CICYT 2000, 2004. *Plan Nacional de I+D+I*. Madrid: Comisión Interministerial de Ciencia y Tecnología.

CNIC 2009. Scientific Report, National Centre for Cardiovascular Research, <http://www.cnic.es/doc/docs_sc2009/baja_calidad/memoria_2009.pdf>, last accessed 10 October 2010.

COTEC 2000. *Los parques científicos y tecnológicos en España*. Madrid: Fundación COTEC.

CREST 2004. The public research base and its links with industry, Report of the CREST expert group (J Howells, rapporteur), OMC-UC.

CTA 2009. Memoria Anual. Corporación Tecnológica de Andalucía, E-book: <http://www.corporaciontecnologica.com/cta/html/portal/com/bin/contenidos/laCorporacion/salaPrensa/kit_prensa/1279198273221_memoria_cta_2009_ebook.pdf>, last accessed 10 July 2010.

Dorado, R and L Oro eds 1991. *Ciencia, tecnología e industria en España*. Madrid: FUNDESCO.

Edquist, C and L Hommen 1999. Systems of innovation: theory and policy for the demand side. *Technology in Society*, **21**, 63–79.

FECYT 2006. *Shortcomings and Needs of the Spanish System of Science and Technology: Recommendations to Improve the Transfer Processes for Knowledge and Technology to Companies*. Madrid: FECYT.

Fernández-Esquinas, M 2002. *La formación de investigadores científicos en España*. Madrid: CIS-Siglo XXI, Colección Monografías, 189.

Fernández-Esquinas, M, C Díaz-Catalán and I Ramos-Vielba 2011. El proceso de institucionalización de la evaluación científica en España. In *Innovación tecnológica, conocimiento científico y cambio social*, eds M T González-de-la-Fe and A López-Peláez. Madrid: CIS.

Fernández-Ribas, A 2009. Public support to private innovation in multi-level governance systems: an empirical investigation, *Science and Public Policy*, **36**(6), July, 457–467.

Gibbons, M, C Limoges, H Nowotny, S Schwartzman, P Scott, and M Trow 1994. *The New Production of Knowledge*. London: Sage.

Giral, J M 1999. Los centros tecnológicos: modelo y financiación. *Economía Industrial*, **327**, 87–94.

González-González, A M, T González-de-la-Fe, M Fernández-Esquinas, R Peña-Vázquez, M Bonnet-Escuela and M Van Oostrom 2007. *Políticas de recursos humanos y carrera investigadora en el sistema español de I+D+I.* Madrid: Ministerio de Educación y Ciencia.

ICONO 2008. *Indicadores del sistema español de ciencia y tecnología*. Madrid: FECYT.

IRTA 2009. Memoria de Actividades, <www.irta.cat>, last accessed 15 October 2010.

Joost, H 2003. Freerider behaviour and the public finance of R&D activities in enterprises: the case of Spanish low interest credits for R&D. *Research Policy*, **32,** 445–461.

Komninos, N and A Tsamis 2008. The system of innovation in Greece: structural asymmetries and policy failure. *International Journal of Innovation and Regional Development*, **1**(1), 1–23.

Laranja, M, E Uyarra and K Flanagan 2008. Policies for science, technology and innovation: translating rationales into regional policies in a multi-level setting. *Research Policy*, **37**, 823–835.

Lhuillery, S and E Pfister 2009. R&D cooperation and failure in innovation projects: empirical evidence from French CIS data. *Research Policy*, **38**, 45–57.

Lundvall, B, B Johnson, E S Andersen and B Dalum 2002. National systems of production, innovation and competence building. *Research Policy*, **31**, 213–231.

March, J and J Olsen 1996. Institutional perspectives on political institutions. *Governance*, **9**(3), 247–264.

Martín-Lomas, M 2002. A new era begins at the CSIC. *Quark: Ciencia, medicina, comunicación y cultura*, **22**, 29–32.

Modrego, A, A Barge and R Nuñez 2003. *Evaluación de los centros tecnológicos en España.* Madrid: FEDIT.

Molero, J and M Buesa 1998. Industrial technology partnerships in Spain. *STI Review*, **25**, 161–177.

Muñoz, E 2001. The Spanish system of research. In *Research and Innovation Policies in the New Global Economy: an International Comparative Analysis*, eds P Laredo and P Mustar, pp. 359–397. Cheltenham: Edward Elgar.

OECD 2005a. *Governance of Innovation Systems*. Paris: OECD.

OECD 2005b. *Public-Private Partnerships for Research and Innovation: an Evaluation of the Spanish Experience.* París: OECD.

OEP, Oficina Económica del Presidente 2005. Programa Nacional de Reformas. Available at <http://www.la-moncloa.es/PROGRAMAS/OEP/PublicacionesEinformes/PNR/>, last accessed 10 July 2010.

Olazarán, M, E Albizu and B Otero 2009. Technology transfer, technology centres and SMEs: evidence from the Basque Country. *European Planning Studies*, **17**, 3–23.

Ramos-Vielba, I and M Fernández-Esquinas 2009. Beneath the tip of the iceberg: the multiple forms of university-industry collaborative linkages. Atlanta Conference on Science and Innovation Policy, Georgia Institute of Technology, Atlanta, GA, USA, 2–3 October 2009.

Rubiralta, M and L Delgado 2010. *Developing International Campuses of Excellence in Spain, CELE Exchange, Centre for Effective Learning Environments*. Paris: OECD.

Santamaría, L, A Barge-Gil and A Modrego 2010. Public selection and financing of R&D cooperative projects: credit versus subsidy funding. *Research Policy*, DOI: 10.1016/j.respol.2010.01.011.

Sebastián, J and E Muñoz eds 2006. *Radiografía de la investigación pública en España*. Madrid: Biblioteca Nueva.

Svarc, J 2006. Socio-political factors and the failure of innovation policy in Croatia as a country in transition. *Research Policy*, **35**, 144–159.

Tortosa, E 2006. La I+D en el marco autonómico. In *Radiografía de la investigación pública en España*, eds J Sebastián and E Muñoz. Madrid: Biblioteca Nueva.

Trullén, J 2006. La nueva política industrial española: innovación, economías externas y productividad. *Economía Industrial*, **363**, 17–31.

Woolthuis, R K, M Lankuizen and V Gilsing 2005. A system failure framework for innovation policy design. *Technovation*, **25,** 609–619.