ORGANIZATIONAL INNOVATIONS IN THE PUBLIC SCIENCE SECTOR

An International Comparison of Cooperative Research Programs

Sandro Giachi

Consejo Superior de Investigaciones Cientificas (CSIC), Spain

Abstract: This research is about the transformation of the organization of R&D activities in the public sector. We conceptualize such changes as intentional organizational innovations aimed to foster the collaboration between science and industry, improving the flexibility of the organizational model and strengthen the connection between research and society. We focus on the case of innovative public programs for cooperative research around the world. Through a brief review of the literature, we discuss a typology that has been proposed for classifying cooperative research programs and organizations based on two dimensions: institutional embeddedness and firm participation. We test the validity of such typology through an international comparison of policies and programs including countries from Asia, Europe, North America and Oceania. Our findings show that, despite many cross-countries differences, there are also some common trends that can be partially captured by the proposed typology. Other implications for studying organizational innovations in public research are discussed.

Keywords: Legitimation of Science, Open Innovation, Public Policy, Sociology of Innovation, Typology.

1. Introduction

The concept of innovation is not fraught exclusively with new technologies, products, or services. Recent studies pay more attention to social, institutional, or organizational features of innovation, showing the existence of "hidden" processes not so easy to see in the economic and social life (Castro Spila et al., 2016). Although such hidden processes usually are not captured by official statistics, they encompass a diverse and relevant social phenomenon. Good examples of such "hidden innovations" are teleworking, new collaboration-based services (crowdfunding, coworking, timebanking, flat sharing, etc.), or the emergence of hybrid political actors between traditional parties and social movements.

Our research focus on the diffusion on new organizational models in the public science and research sector. This is an interesting field for understanding institutional and organizational innovation processes. Such innovations emerge thanks to public programs aimed to foster an organizational change in researchers' workplace through cross-sector collaboration with other institutions such industries and firms. Usually such programs imply the creation of new collaborative arrangements, such as the new research centers or the transformation of existing ones. However, we still need a better understanding about these organizational innovations and related public policies. There is a lack of studies comparing different experiences across the world (Turpin and Fernández-Esquinas, 2011; Lal and Boardman, 2013).

Our aim is to compare the most relevant policies that have been undertaken to create and fund new organizational models for public research based on collaborative purposes and cross-sector institutional participation. The article is structured in the following way. After a brief discussion about the concept of organizational innovation (Section 2), Section 3 describe the organizational change experienced by public research sector, as well as the main forces underlying such change. Section 4

introduces the case of cooperative research programs as an example of organizational innovation in public research. Then, Section 5 shows the main findings of our comparative cross-country documentary review of cooperative research programs. Finally, Section 6 discusses the relevance of such findings for the debate about organizational innovation processes in the public research sector.

2. On Social, Institutional, and Organizational Innovations

From a sociological standpoint, the concept of innovation can have different meanings (Hill, 2010; Fernandez Esquinas, 2012; Menendez Viso, 2016). "Innovation" means the generation or adoption of "something new", implying an improvement. If there is no improvement, it is a change, but not an innovation. If we talk about the "innovation process" we can refer to different processes: the generation of something new, or its diffusion. In addition, there are several types of innovation, depending on the object. For instance, we can talk about a technological innovation to refer to the invention or adoption of a new technology (a machine, an algorithm, a tool, etc.); about an economic innovation to refer to improvements generating positive monetary or competitive benefits. Among these, we differentiate between product innovations (i.e. new tangible goods) or process innovation (i.e. improved services). Depending on the scope or the impact of the innovation, we talk about incremental or radical innovations, too.

Another important difference is about the collective or social nature of innovation (Menendez Viso, 2016). In this sense, we can differentiate between social, institutional, or organizational innovations. First refers to such innovative programs, actions or reforms with a positive effect on the political system or the community (i.e. participatory democracy, cooperative economy). By contrast, institutional innovations can have a double mean: a "new type of institution", or "a new form of organizing an already existing institution", closer to social innovation. Here we use the term "institution" consistently with the sociological standpoint: an ideal or symbolic referent for a real organization, or the symbolic category in which an organization is embedded (Portes, 2006).

Organizational innovations should not be confused with organizational change. The former implies an improvement, not just a change. There are at least two meanings for the term "organizational innovation" (Hage, 1999; Lam, 2005). The first one is about "adopting a new method of organizing work with an already existing organization", or the capability of an organization to adopt or produce innovations, implying greater creativity, adaptability, or resilience. By contrast, the second meaning of organizational innovation is about "a new type of organization or organizational model". Despite its similarity with the meaning of institutional innovation, they are not the same: when some organizational innovations encompass a new population of organizations and they institutionalize their presence, at such point we could talk of an institutional innovation, but not before. In this study, we use the second meaning of organizational innovation: the creation or diffusion of new organizational models that are socially perceived as improvements, and that can progressively become radical ruptures.

3. Organizational Change in R&D Systems

Globally, knowledge and technology are acquiring an increasing relevance within human societies. In the so-called "Knowledge Society", scientific and technological knowledge encompasses an essential resource for progressing. Science as an institution has a high reputation and a privileged position within the Knowledge Society (Böhme and Stehr, 1986; Nowotny et al., 2001). Such recognition is mainly due the practical implications of scientific discoveries and technological innovations. There are no doubts that, in recent history, science and technology radically transformed several aspects of social and political life, although recently we posed greater attention to economic impacts.

A good example of such role for Science is given by new information technologies as they caused a second industry revolution that deeply transformed production systems and corporate structures. In the contemporary economy, information technology-based innovations decentralized and multiplied production workplaces, increased global connections, and minimized transaction times. In sum, they fostered a corporate organization based on information and continuous change (Castells, 2010: Ch. 3). In addition, new information technologies encompass a good example for demonstrating that technological innovation deeply transformed our lifestyle, culture, and behavior.

Change in economic and social organization due to technological innovations fostered changes in knowledge production too. New forms of producing knowledge are needed to provide a better

adaptation to the use of such knowledge within the new economy and society. The diffusion of the scientific paradigm within firms and other social groups (traditionally external to academic institutions) facilitated that such actors undertook their strategies for producing scientific knowledge and, so, the overall level of such knowledge available at the societal level. Scholars usually refer to such transformation as the transition from a "Mode 1" to a "Mode 2" of scientific knowledge production (Gibbons et al., 1994; Nowotny et al., 2001). Nowadays, we can affirm that both modes coexist although they do with a different intensity: Mode 2 is currently prevailing, after decades of predominance of academic science (Mode 1).

This viewpoint has a cultural and a structural implication: both are related with the organizational dynamics of science. First implication is characterized by sociologist Bruno Latour's definition of transition from a "science culture" toward a "research culture": the former refers to a culture based on truth, trustworthiness and replicable demonstration, while the latter is related with an activity plagued by risk, uncertainty, and curiosity (Latour, 1998). Such transition would imply the need for new norms and values to evaluate the activities of scientific organizations. Such uncertainty comes from the characteristics of the "application context" and can be resumed in the following way (Gibbons et al., 1994:6):

- Constant reformulation of organizational structures
- Multiplication of the settings for knowledge production
- Increase of connections between scientific agents
- Increasing separation between specializations, despite their continuous reciprocal recombination through transdisciplinary activities.

In other words: within Mode 2, organizations become more flexible, while the structure of informal relationships between scientific actors becomes the most fixed part thanks to its continuous restructuration.

Besides the Mode 2 paradigm of knowledge production, other frameworks have been proposed to explain recent changes in scientific organizations (Hessels and van Lente, 2008). For instance, philosophy of science proposed several concepts for labelling the new forms of knowledge production, like "strategic research", "post-normal science", or "post-academic science". All these concepts indicate a transformation in scientific practices and the role of science in society, implying greater dependence from the context, collectivization of tasks and collaboration in science and technology production.

A proof of such transformation in scientific activity is the increase of technology-based industries that reduced the traditional boundary between academic institutions (i.e. the University) and other types of organizations (i.e. R&D intensive industries). Such process facilitated the emergence of new organizational forms for research that are more flexible and based on learning processes for increasing human capital, within universities too (Jacob and Hellström, 2003). Examples of such type of organizations can be industrial R&D partnerships, inter-firm networks, or think-tanks and similar research institutes (Nowotny et al., 2001: 15-16).

4. The Case of Cooperative Research Programs

The increasing relevance of science-industry collaborative relationships often implied building new arrangements for facilitating interactions between institutional domains that traditionally have been separated. These innovative initiatives are very different from traditional short-term forms of university-industry collaboration that do not imply creating new infrastructures, such as contract research, student mobility programs, or consulting services that faculties provide to firms. By contrast, public research sector launched new arrangements for science-industry collaboration such as science and technology parks, technology transfer offices, company incubators, university spin-offs, and mixed or collaborative research centers (Jacob et al., 2000; Etzkowitz, 2010).

The last model (mixed or collaborative research centers) is particularly interesting for several reasons. First, such centers are oriented toward activities that are potentially relevant for industry (at least at medium-long range); at the same time, they maintain close relationships with firms and other industrial partners (Ponomariov and Boardman, 2012). The interest toward such organizations showed by governments, innovation agencies, national scientific councils, or industry association have been increasing, consistently with the availability of funds and resources. The strategic role that such structures are acquiring in some innovation systems sometimes caused a reconsideration of their nature: not just science-industry knowledge transfer channels, but also R&D agents stimulating new research and innovation activities.

The diffusion of cooperative research programs and organizations within national science, technology and innovation systems is a quite recent phenomenon. In spite that we can find pioneering experiences in the U.S. during the 30s (Baba, 1988), the most relevant and long-standing initiatives started during the 80s and the 90s in some English-speaking countries. More recently, several European countries, such as Austria, Belgium, Germany, Ireland, Norway, or Sweden, as well as other countries from other parts of the world, like Asia or Southern America, adopted cooperative research models (PREST, 2002; Arnold et al., 2004; 2010; Turpin and Fernandez-Esquinas, 2011; Lal and Boardman, 2013).

Our research deals with such programs oriented toward building and consolidating organizations that (Gray et al., 2013)

- are quite stable and easy to identify within innovation systems
- are aimed by orienting their R&D toward industry as well as public interest
- try to facilitate interactions between science, industry, and other sectors

To do so, such organizations collaborate with several types of institutional actors and they have organizational structures different from traditional institutional domains, such as the public bureaucracy, the academic research organization, or the for-profit company model.

This general definition should be useful for identifying and describing empirical cases. To show its usefulness, we should look at the variation between types of centers. Classifying different programs and experiences for cooperative research and public research institutes recently attracted the interest of scholars because it is a kind of previous step for formulating hypotheses about the functioning of such organizations (Bozeman and Boardman, 2004; Perkmann and Walsh, 2007). Such problem became relevant because of the spreading of cooperative research models external to the context of pioneering English-speaking countries (Australia, Canada, the U.S.), as well as the use of such models of strategic settings for scholar research (Bozeman, 2013; Lal and Boardman, 2013).

The most known (and probably the only) effort to build a typology of cooperative research programs and organizations with the aims of international generalization was recently made by a team of U.S. scholars specialized in such matter (Gray et al., 2013). The typology is defined starting from the professional experience of the authors as evaluators of public programs and an extensive review of bibliography, employing the contributions provided by Bozeman and Boardman (2003) from the U.S., Carayol (2003) from Europe, and Teirlinck and Spithoven (2012) from Belgium. According to Gray et al. (2013), there are at least two relevant dimensions for classifying cooperative research organizations (Table 1):

1. The first dimension is the institutional base of the organization, distinguishing between centers embedded in universities, and centers embedded in governmental or other public structures.
2. The second dimension refers to firm participation, distinguishing between centers participated by only one firm (bilateral relationship, or partnership) and centers that collaborate with two or more firms (consortium, or network)

Crossing these two dimensions we obtain four ideal-types of research centers (Table 1). Such types would show differences according to their basic features as cooperative research organizations: formalization, R&D, and collaboration. For instance, "university-industry consortiums" should exhibit less formal but more decentralized and complex structures; they should specialize in basic research activities, produce generic knowledge, provide benefits in terms of human and social capital, collaborate with big companies, and adopt long-range planning strategies. By contrast, "public-private partnerships" should exhibit more formal and centralized structures (although less complex), collaborate with a small or medium enterprise (SMEs), and be oriented toward the short-term technology development and commercialization.

Table 1 – General Typology of Cooperative Research Arrangements

TYPE OF ARRANGEMENT	**Dimension 2: Industry Participation**		
	Network		**Bilateral**
Dimension 1: Institutional Base	**Public (Governmental, Third Sector, etc.)**	Public-Private Consortium	Public-Private Partnership
	University (both Public and Private)	University-Industry Consortium	University-Industry Partnership

Source: Gray et al. (2013:17)

5. An International Comparison of Cooperative Research Policies and Program

In this Section, we materialize the trends we specified in the previous section, showing relevant examples of organizational innovation found in several countries. We consider different geographical areas, like North America, Asia, and Europe, contrasting similarities and differences between their policies and programs. Among European countries, we give a special focus to the case of Spain. Our review is not exhaustive, but just an illustration of the existing types of experience. We reviewed documents proceeding from different sources, like public science, technology and innovation plans, evaluation reports, the content of institutional webpages, and scholar bibliography. Details about our methodology and the features of each national case we studied can be found in *anonymized* (2016: Ch. 1; Ch. 3).

5.1. Identification and Description of the Programs

Comparing policies from different countries we observed how the heterogeneity existing across the aims and the structures of cooperative research programs reflects a strong diversity in terms of geographical and institutional contexts (Lal and Boardman, 2013). Despite such heterogeneity, we also found converging aims and strategies, as comparative studies about science-industry collaboration policies already highlighted (Turpin and Fernandez-Esquinas, 2011). Table 2 resumes the findings of our review that we discuss in the next paragraphs.

First, we observe that only the U.S. exhibits a high diversity of programs; many of them are long-standing policies with a large scope that influenced the models adopted by other countries. Other long-standing experiences are found in Canada and Australia. Asia-Pacific Regions, such as South Korea and Japan, show some pioneering experiences, although if it is difficult to establish if their recent magnitude and level of development are like the case of English-speaking countries. Empirical evidence shows that such new organizational forms are something relatively new in their innovation system traditional institutions. It seems obvious that both the European Union and China (and Hong Kong) are going to emulate -in some way- the models of English-speaking countries. In this sense the Spanish case is paradigmatic: a several policies with a small scope but with very different aims and structures.

Second, we found similarities in policy strategies, like the relevance of the central (i.e. federal) government, the reciprocal search for collaboration from universities and big companies, creating new virtual infrastructures like networks or physical arrangements like institutes. In all these cases, we observe that the initiative is usually taken by central governments through big funding programs, with some exceptions regarding autonomous initiatives from more "entrepreneurial" universities (i.e. the U.S.) or regional governments (i.e. Spain). By contrast, initiatives from public research institutes and SMEs are less frequent.

Third, we are not sure about the existence of general trends facilitating a stronger participation of SMEs due to the high diversity of participation forms. Many research centers created through these programs is oriented toward excellent basic research, or toward applied research with potential implications for solving economic or social problems. However, there are few programs specifically oriented toward technological developments and innovation services, excepting the U.S. and some European country. Neither is easy determining the impact of the programs, although if in certain countries like Australia or the U.S. payed more attention to this issue.

Fourth, funding policies usually employed public calls where participating institutions and companies must compete. This is essentially different to traditional government technology policies, based on non-competitive public subsidies or tax-free incentives. In addition, the structures created by cooperative research programs usually have an established duration and they are accountable. Therefore, strategic planning of evaluation is a key component of their functioning, although if in many cases governmental investments have a strategic aim, like producing outcomes that firms can exploit as soon as possible.

Fifth (and last), we highlight that we are talking about organizational that are different from public bureaucracies or the consolidated structure of many private companies. Cooperative research organizations have a specific design that is contingent to the achievement of their aim and, therefore, they usually are more flexible and change-adapting. About their external dynamics, they are oriented toward generating an innovative workplace for R&D. Cooperative research organizations usually exhibit a high level of uncertainty and potential conflicts in human resource management.

In conclusion, despite the high level of heterogeneity showed by the programs undertaken between countries and level of government, the

ensemble of experiences reflects common trends. There are some new recent trends too, like the following:

- A stronger attention toward regional policies and local contexts (Garrett-Jones, 2004; 2007);
- The need of solving political and management problems related with a multilevel system of governance, as we observed for the case of Spain (Fernandez-Esquinas and Ramos-Vielba, 2011);
- The problem of durability and transformation of existing programs (Turpin et al., 2011)
- The existence of institutional mechanisms of imitation and diffusion of cooperative research models across countries (Bozeman, 2013)

Table 2. Main Cooperative Research Policies and Programs around the World

Country	Policy/Program	Observations
UNITED STATES	- *Science and Technology Centers* - *Engineering Research Centers* - *Industry-University Cooperative Research Centers* - *Proof of Concept Centers* - *Small Business Innovation Research* - *Small Business Technology Transfer Awards* - *Manufacturing Extension Partnerships* - *University Research Centers*	- Long-standing programs covering almost the whole spectrum of the activities from the innovation cycle - Overall satisfaction and positive impact by both sides (science and industry), with some exceptions - Prominence of Federal Government and more entrepreneurial universities, although if recent trends are oriented toward local SMEs and policies at the State level
AUSTRALIA	- *Cooperative Research Centres* - *Other (local programs)*	- Long-standing and inclusive program with a big scope, although if limited to basic and applied research - Success in terms of greater collaboration - Increasing initiative of local governments
CANADA	- *Network of Centres of Excellence*	- Long-standing and inclusive program with good territorial structuration - Based on human resources and social relevance of research - Limited to excellent research: the impact on industry is not clear
SOUTH KOREA	- *Science Research Centers* - *Engineering Research Centers*	- Long-standing experience - Scope and impact are not clear - Excellent (both basic and applied) research - Prominence of National Government - Oriented toward more entrepreneurial universities
CHINA	- *Centers of Excellence (several institutions)*	- National policies directed toward universities and big companies, with the aim to cover the whole spectrum of innovation cycle - Creation of new physical infrastructures - Competitive funding - Functioning and impact are not clear
JAPÓN	- *Tokyo Institute of Technology* - *Others (excellence programs)*	- Governmental and university initiatives - Basic research oriented - Aim to open universities to firms - Impact is not clear: limitations of the programs
EUROPEAN UNION	- *Competence Research Centres* - *Knowledge and Innovation Communities* - *Other (national and regional programs)*	- (Often virtual) centers oriented toward excellent research where public institutes, universities and big companies cooperate thanks to community funds - High diffusion, but socioeconomic impact is not clear - Interesting national (i.e. Austria, Germany, etc.) and regional (i.e. Belgium, Sweden) experiences, consistently with the multilevel paradigm of European policy
SPAIN	- *Basque Excellence Research Centres* - *Cooperative Research Centres* - *CIBER Networks* - *IMDEA Institutes*	- Quite recent programs - Small number of centers, but big size - Strong initiative of regional governments or specific actors - Different types of companies - Focus on applied research, although centers cover many types of activities - Limited evidence about impacts on industry and applications

Source: Own Elaboration

5.2. Resume of Comparison and International Typology

We can position the main international experience we identified within the typology proposed by Gray et al. (2013) as shown in Table 3. We decided to allocate a program within an ideal-type using the information provided by our bibliographical review. Some programs can be assigned to different types at the same time, depending on their features. This is the case for Australian CRCs or Canadian NCEs because they can be based on both governmental infrastructures and universities. In any case, you should consider that this is a tentative classification and it should not be read in a straightforward way.

Table 3 shows that some types of programs or collaborative research centers are more diffused than others. Consortiums between industry associations and other institutions seem to be more frequent to find than strategic partnerships and those based on a public structure. In addition, we observe the existence of marked national and geographical trends. For instance, we observe that in European countries are more frequent models based on public or governmental action, while English-speaking and Asian countries seem opener to university initiative. We should also highlight that the U.S. are the only country that exhibit the presence of any type of program, due to the high number of programs and to the effort of their government and universities. In this sense, Spain encompasses an interesting exception, due to the diversity of its policies despite their recentness and small amount.

Although if the classification scheme we use is enough general to be applied to different institutional contexts and it is probably a good first step toward the international comparison of organizational innovation in the public science sector across several countries, it is also limited for its application in international scenarios. In our opinion, the separation between university-based and public-based programs comes from a cultural viewpoint excessively close to North America or English-speaking countries context. For instance, such framework caused to us some problem to classify the programs existing in South European countries -such as France, Italy, or Spain- where universities and public research institutes share many features and functions (Mustar and Laredo, 2002; Sebastian and Munoz, 2006). In these countries both types of organizations are public bureaucracies depending on the financial support of the National State in any level; they also are regulated by administrative rules and norms that are very different to the usual we can find in English-speaking or North European countries.

Table 3. Applying the Typology to different Countries

Public-Private Consortium • *Science and Technology Centers* (U.S.) • *Engineering Research Centers* (U.S.) • *Cooperative Research Centres* (Australia) • *Network of Centres of Excellence* (Canada) • *Centers of Excellence (*China*)* • *Centers of Excellence (*Japan*)* • *Competence Research Centres* (Europe) • *Knowledge and Innovation Communities* (Europe) • *Cooperative Research Centres* (Spain) • *CIBER Networks* (Spain)	**Public-Private Partnership** • *Proof of Concept Center* (U.S.) • *Small Business Innovation Research* (U.S.) • *Small Business Technology Transfer Awards* (U.S.) • *IMDEA Institutes* (Spain)
University-Industry Consortium • *Industry-University Cooperative Research Centers* (U.S.) • *University Research Centers* (U.S.) • *Cooperative Research Centres* (Australia) • *Network of Centres of Excellence* (Canada) • *Science Research Centers* (South Korea) • *Engineering Research Centers* (South Korea) • *University of Tokyo Institute of Technology* (Japan) • *Basque Excellence Research Centres* (Spain)	**University-Industry Partnership** • *Manufacturing Extension Partnerships* (U.S.)

Source: Own Elaboration

6. Conclusions

Our research is an advance in the debate about the nature and the diversity of the organizational innovations existing across different institutional sector and countries in the science and R&D fields. We showed which actions have been undertaken from the public sector for increasing collaboration in the organization of R&D, as well as the openness toward industry and society. In the last decades, many governments undertook significant changes in this sense. If we compare across different countries and level of government (federal, State, regional) we observe that this is a common trend, at least, if we consider the case of the most socioeconomically developed countries, like the U.S., Australia, or Canada, as well as a reduced set of European and Asian countries.

However, we also found interesting differences between the types of programs we internationally reviewed. Following the typology proposed by Gray et al. (2013) we observed that these forms of organizational innovations significantly differ according to the number of firms participating in collaboration, as well as to their institutional base. We also observe that such types of organizational innovation (i.e. public-private consortiums) are more frequent than others (i.e. university-industry partnerships). Such diversity does not seem to be related with the national context, because some countries simultaneously host different types of programs, like the U.S., Japan, or Spain.

Therefore, our research outcomes help to shed light on the state of the art of the debate about organizational innovation in public R&D, analyzing the types of innovative programs for cooperative research around the world and the main forces underlying their diffusion, like the social processes of change of scientific work, and the prominence of governments at different levels to foster cooperative research. By contrast, our research analyzes deeply neither the characteristics of the innovative organizational model, nor the innovation processes that took place at micro-level of the public research system. Such analysis is necessary for understanding the dynamics of change, the existence of conflicts, and the transformation or the effects of the informal structure of relationships. So, we suggest that future research in this same topic should focus more on the individual and inter-individual processes of innovation and change in scientific practices. Such approach should be useful for obtaining relevant practical implications and helping politicians, managers, and stakeholders to make decisions based on empirical observation.[1] Our research pretended to be a first step in such direction.[2]

[1] Another limitation of our research is the absence of evidence about countries from other geographical areas of the world, for instance, South America or Africa. It would be appropriate to deepen the knowledge about such countries in future research for testing again the validity of the proposed typology.

[2] By a methodological standpoint, further research on this topic should also consider the opportunity of employing systematic methods for mapping organizational innovation programs, similarly to those techniques developed for identifying social innovation projects (Pelka and Terstriep, 2016). We refer to methods of data collection based on documentary review, qualitative case studies and logic techniques for meta-analysis of content like Qualitative Comparative Analysis (QCA). Such techniques proved their capacity for comparative analysis of national case studies and could be successfully applied to international studies on organizational innovation in public science sector too. This could be an interesting path for developing the second step of our research.

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