

María Luisa Flor
José Luis Blasco Díaz
María Lidón Lara Ortiz
Universitat Jaume I (Spain)

Innovation policy instruments through the lens of open innovation. An analysis in the Spanish context

Abstract

Open innovation (OI) involves the deliberate use of external and internal knowledge flows by organisations in order to accelerate their innovations and expand the markets for the external use of innovations. Despite the relevance of OI for firms' competitiveness, firms' abilities to leverage and combine internal and external knowledge flows cannot be taken for granted. In this context, innovation policies can play a crucial role in stimulating firms' OI strategies. The objective of this research is to examine the degree to which existing public innovation policies promote open innovation by companies. In doing so, we review the set of innovation policy instruments developed by governments within the Spanish national and regional innovation systems and examine the extent to which they support open innovation by companies, either by facilitating firms' open innovation practices or by acting on the external factors that influence them. Our results show that innovation policies in Spanish national and regional settings partially promote firms' open innovation, since governments base their actions on the interaction between science, industry and government, sometimes with intermediaries that promote it. We propose the development of instruments to encourage firms to implement open innovation practices in such a way that they complement the existing ones and can fully achieve the benefits associated with open innovation.

Keywords: Innovation policy; National and regional systems of innovation; Open innovation practices; Inbound open innovation; Outbound open innovation; Coupled open innovation; Erosion factors; Spanish context

Corresponding author: e-mail: mflor@uji.es

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1. Introduction

The importance of the interrelation between the actors of regional and national systems of innovation for economic development and the increase of competitiveness has been repeatedly acknowledged, and it has been translated into the public policies that promote innovation. These policies usually contain various actions and initiatives that seek to involve and foster interaction among universities, companies and governments, as well as other entities and organisations. The rationale underpinning all these efforts is to establish a context that allows organisations to leverage their internal innovation capabilities by taking advantage of external conditions and contributing to regional economic growth and improvement of socioeconomic conditions.

The concept of open innovation is intimately linked to the foundations of innovation systems, insofar as it describes an innovation process characteristic of organisations that interact with their external environment through exploration, exploitation and expansion of knowledge (de Jong et al. 2010). Open innovation (OI) has been defined as “the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively.” (Chesbrough 2006, 1).

Firms’ increasing adoption of open innovation is a consequence of a series of changes in the environment, such as increased mobility of skilled workers, growing access to venture capital, greater dissemination of knowledge throughout the world or the higher capability of firms’ external suppliers, which have stimulated companies to adopt a significantly different model of innovation (Chesbrough 2006). Indeed, it has had a major impact on business practice, where many companies have become aware of the advantages of opening their innovation process, since OI can lower costs in their innovation process, reduce the time needed to

generate new products, or achieve creativity by incorporating external talent in the organisation (Chesbrough and Bogers 2014).

Despite the relevance of the open innovation model for firms' competitiveness, neither the availability of external knowledge and other innovation resources –such as human capital or financial resources– nor companies' ability to leverage and combine internal and external knowledge flows can be taken for granted (de Jong et al. 2010). In this context, the way governments configure the institutional and legal framework is critical to foster and help firms achieve the benefits of open innovation. That is, although it is companies that face opportunities and challenges and implement open innovation, instruments for innovation policy at a national and regional level represent the most direct form of intervention in a firm's innovative behaviour and in national and regional systems of innovation (Herstad et al. 2010). Hence, innovation policies can play a crucial role in stimulating firms' open innovation strategies, by shaping the systems of innovation in which the agents that form them interact, create and jointly exploit new technological and market opportunities.

Based on these premises, in this paper we examine the degree to which existing public policies designed to encourage innovation support the development of open innovation by companies. In doing so, we review the set of innovation instruments developed by Spanish governments at both national and regional level.

This work contributes to building a bridge between the innovation policies and open innovation literatures, insofar as it allows us to enrich the bases of innovation policy with the contributions of open innovation. As Cano-Kollmann et al. (2017) have stated, despite the substantial body of literature on the relationships between public policies and private innovation, the relationship between open innovation and public support for innovation has

attracted scant research attention. From the point of view of policymakers, we propose recommendations aimed at developing actions to promote firms' open innovation practices in such a way that they fully achieve the benefits associated with open innovation.

The work is structured as follows. First, we present the foundations of public policies for innovation. We then describe the basic aspects related to the open innovation model and the rationale for considering public intervention. Next, we introduce the Spanish institutional context, describe the procedure followed to gather the data and analyse the instruments launched by Spanish national and regional governments through the prism of the open innovation paradigm. The final sections include the discussion, and the main conclusions and implications for policymakers.

2. Innovation policy

An innovation policy has been defined as a public intervention to support the generation, market introduction and diffusion of innovation, whereby an innovation is a new product, service, process or business model that is to be put to use, commercially or non-commercially (Edler et al. 2016). Hence, although innovation policy overlaps with and is linked to science, research and technology policy (as it involves knowledge generation), rather than being restricted to the production of underlying knowledge or technology, it is much broader and includes commercialisation instruments and measures aimed to develop artefacts and models for the marketplace (Doern and Stoney 2009; Martin 2016).

Edler and Fargerberg (2017) identify three main types of innovation policy, depending on the perspectives of innovation adopted: mission-oriented, invention-oriented or system-oriented. Mission-oriented innovation policies are aimed at providing new solutions to specific challenges. Invention-oriented policies concentrate on the R&D/invention phase. System-

oriented innovation policies take all the phases of the innovation process into account and, in addition to the capabilities of the actors involved, also consider the interaction between them. With the latter type, based on the system of innovation approach, an innovation policy pursues the establishment of an institutional environment in which companies, organisations and governments are able to learn, develop and share new knowledge, products and services. Accordingly, the instruments for innovation policy are diverse and can be related to different areas, embracing aspects such as (Edler and Fagerberg 2017; Edler et al. 2016): (1) creating new knowledge and innovation; (2) supporting non-financial capabilities and skills to generate and commercialise innovation; (3) increasing interaction and learning at the national and/or regional level; (4) influencing demand for innovation; (5) regulation and standardisation; and (6) understanding and benefitting from future technological trends. These instruments can also be classified according to whether they focus on the supply or the demand side of innovation; and whether they are monetary or non-monetary (Aschhoff and Sofka 2009; Cano-Kollmann et al. 2017; Edler and Fagerberg 2017). Whereas innovation policy instruments that target producers of innovation (i.e., focus on the supply side) aim to support firms to innovate more quickly, be more interactive, or do so with different kinds of partners, instruments that target users of innovation (i.e., intervene on the demand side) support firms' and public actors' demands for innovation, for example, with public procurement programmes (Edler and Fagerberg 2017). Monetary instruments for innovation, through grants or subsidies, reduce the cost and risks of taking on complex projects. In addition to funding, there must be both a proper institutional environment and a set of conditions that facilitate collaboration between different parties, which can be promoted by

non-monetary instruments (e.g., providing information, facilitating networking, etc.) (Cano-Kollmann et al. 2017).

3. The open innovation model

The traditional view of firms' innovation process, as represented by the closed model of innovation, is that a company's knowledge is internally generated and exploited and does not transcend the boundaries of the organisation. Under this view, the company conceives, develops, commercialises and finances its own innovation through internal processes (Chesbrough 2003). In contrast to this closed model of innovation, the concept of open innovation was introduced by Henry Chesbrough to reflect how companies open up their innovation processes, incorporate external knowledge inputs and exploit their knowledge outputs externally. This opening up, according to Chesbrough (2003), was a consequence of a series of environmental elements, which he called "erosion factors", such as the intensification of global competition and technological progress, the global dissemination of knowledge and integration of technologies, the need for interdisciplinary research, a growing mobility of researchers and engineers, or the growing importance of venture capital. These erosion factors brought additional challenges (and opportunities) for firms, and induced companies to adopt a significantly different model of innovation, the open innovation model, characterised by purposively managing knowledge flows, focusing on collaboration with external agents and the combination of internal and external knowledge to carry out innovation activities (Chesbrough and Bogers 2014).

Under the open innovation model, some companies seek value creation by identifying and incorporating external knowledge, while others seek external markets for their innovations. Accordingly, companies can carry out three core innovation processes or types of open

innovation (Chesbrough and Bogers 2014; Gassmann and Enkel 2004): (1) Outside-in or inbound open innovation, (2) Inside-out or outbound open innovation, and (3) Coupled open innovation. With inbound open innovation, a company incorporates external knowledge into its own innovation process, either through sourcing or by acquiring the external knowledge (Chesbrough and Bogers 2014; Dahlander and Gann 2010). Outbound open innovation makes it easier for other businesses to take advantage of internal innovations, which may or may not involve some form of monetary compensation (Dahlander and Gann 2010). Coupled OI links inbound and outbound processes and involves two (or more) partners through joint invention and/or commercialisation activities (Chesbrough and Bogers 2014). Thus, implementation of open innovation by firms is not a clear-cut practice; rather, it entails a set of mechanisms through which firms may search, source and collaborate to different degrees, depending on the sectoral contexts in which they operate and the institutional contexts in which they are located (Herstad et al. 2010). The literature has identified a wide range of practices that firms can carry out when implementing inbound, outbound and coupled open innovation (Flor et al. 2019). Table 1 shows examples of practices and mechanisms related to each type of open innovation.

Although the decisions to implement the OI innovation practices are mainly taken in companies, both the rapid diffusion of the phenomenon in the business world and the relevance of open innovation practices to favour firms' results, suggest that governments still need to support firms' efforts through public policies that stimulate their open innovation activities.

Table 1. Firms' open innovation practices

OI Type	Examples of practices
Inbound	<p>Sourcing</p> <ul style="list-style-type: none"> ▪ Linkages with customers ▪ Linkages with suppliers ▪ Technological scouting ▪ Crowdsourcing <p>Technology and knowledge purchase</p> <ul style="list-style-type: none"> ▪ Innovation intermediaries ▪ Intellectual property in-licensing ▪ R&D outsourcing ▪ Funding start-up companies in one's industry ▪ Competitions and tournaments <p>Research partnerships</p> <ul style="list-style-type: none"> ▪ Collaborative arrangements with universities and research centres ▪ R&D cooperation
Outbound	<ul style="list-style-type: none"> ▪ Donating IP and technology ▪ Intellectual property out-licensing ▪ External corporate venturing ▪ Participation in public standardisation ▪ Spin-offs ▪ Corporate venture capital ▪ Corporate incubators ▪ Alliances
Coupled	<ul style="list-style-type: none"> ▪ Participation in networks ▪ Innovation communities ▪ Ecosystems and platforms ▪ Consortia ▪ Joint ventures ▪ Regional clusters ▪ Sharing facilities

Source: Adapted from Flor et al. (2019)

4. Innovation policy and open innovation

Many current innovation policy actions have their roots in the closed innovation era and stem from the rationale of developing large national or regional markets, protecting local companies, restricting foreign workers and students, and subsidising large local firms to keep them innovating (Chesbrough and Vanhaverbeke 2018). In order to promote open innovation,

public policies should enable external conditions to motivate firms to adopt OI processes, and develop instruments that facilitate their open innovation processes.

With regard to external conditions, as stated by Chesbrough and Vanhaverbeke (2018, 457), the same erosion factors that have caused private firms to move away from the closed innovation mindset are also forcing innovation policies to change. In this line, innovation policy to improve external conditions that favour firms' open innovation should aim to (1) create a strong base of public knowledge that facilitates firms' access to external knowledge, (2) increase mobility of knowledge workers, and (3) improve access to financial sources (De Jong et al. 2010; Wang et al. 2012).

The availability of and access to a solid public knowledge base is important for companies to participate in innovation, since it makes their search for innovations more effective and efficient (Cockburn and Henderson 2000; de Jong et al. 2010). Despite being a traditional action within innovation policy programmes, government funding of basic research constitutes an important element for the development of the open innovation approach. Research carried out by universities is critical as a seed for future innovations and greatly enriches the knowledge landscape. In addition, the fact that companies increasingly devote their efforts to research for immediate application, which results in less basic research being conducted inside corporate research laboratories, translates into a growing need for public funding of scientific discovery (Chesbrough and Vanhaverbeke 2018; de Jong et al. 2010; Wang et al. 2012).

Policymakers can also directly target the diffusion of knowledge and, by doing so, ensure that the current stock of basic knowledge becomes more widely accessible. Specifically, public intervention can encourage university researchers to put their basic knowledge into practice

and create mechanisms that facilitate diffusion such as knowledge valorisation grants, public–private partnerships or technology transfer offices at universities (de Jong et al. 2010). Additionally, as highlighted by Bogers et al. (2018), effective policy making around OI must consider the benefits of openness in science, as exemplified by the requirement for researchers to publish open access articles, and refund the costs incurred in paying the publishers for the service.

Education and mobility of workers also favours open innovation, since a high-quality workforce allows knowledge to be extended to other organisations and increases the capacity of companies to absorb external knowledge (Chesbrough 2003). Although developing a mobile, well-educated labour force is primarily a matter for education and labour market policies (de Jong et al. 2010), specific actions to facilitate mobility of researchers between public and private institutions can be deployed in the context of an innovation policy. Support for industrial doctorates and for firms to hire technologists and scientists are examples of such interventions, which are already being implemented in several countries (Herstad et al. 2010). Also, knowledge diffusion and exchange between universities and business would be improved if academics could be temporarily employed in private companies and vice versa (Chesbrough and Vanhaverbeke 2018).

As for access to funding, innovation is a risky undertaking that requires the allocation of financial and intellectual resources under specific conditions (Wang et al. 2012). As a consequence, innovating firms face considerable problems in acquiring external funding. Innovation policy programmes have traditionally acknowledged this market failure and funded R&D research carried out by firms (Herstad et al. 2010). Nevertheless, it is not only a matter of providing funding to generate innovations, but also of being aware of difficulties in

later stages and supporting the commercialisation of innovations. The funding chain conceptualises the need for appropriate types of financing, from the initial research to the establishment and growth of a new venture, and the type of funding and partners involved will vary in each stage (Chesbrough and Vanhaverbeke 2018). In addition to direct subsidies, policymakers can also facilitate innovating companies' access to finance through options such as seed capital, guarantees or matching funds; and well-functioning capital markets that allow for corporate venturing (de Jong et al. 2010). Hence, together with traditional direct incentives for R&D, policymakers might stimulate private investors including banks, venture capitalists and business angels, as they are specialised in judging and financing business opportunities (Chesbrough and Vanhaverbeke 2018).

Innovation policies can also design actions specifically aimed to develop a firm's OI processes. Instruments can assist and facilitate implementation of inbound, outbound and coupled OI practices, either by facilitating these practices or by eliminating barriers to their implementation.

With inbound processes, companies access knowledge from outside their boundaries to complement their internal innovation base, in such a way that they can increase their understanding of the market or identify new directions to explore. In order to apply inbound OI, firms can source and acquire external knowledge (Dahlander and Gann 2010). Hence, firms can collaborate informally with customers and suppliers and acquire external knowledge by purchasing technology through the market place (e.g. through innovation intermediaries, outsourcing R&D activities, in-licensing, etc.) and through active and deliberate cooperation on R&D with other firms and institutions (e.g., competitors, universities, research institutes, public research laboratories). With regard to technology

purchase, in addition to supporting firms' R&D outsourcing or in-licensing, public initiatives can foster less traditional modes of inbound OI, related to creating better conditions for technological scouting –which would also help to identify potential partners– and using services from innovation intermediaries. Innovation intermediaries (or innomediaries) provide innovation platforms that link companies with potential problem-solvers. Policymakers could design actions aimed to lower participation costs for firms, since they facilitate the diffusion of knowledge and, in addition, can help make the market for knowledge and intellectual property (IP) more transparent (Chesbrough and Vanhaverbeke 2018).

Collaboration requires partners to possess similar or complementary competences and may entail the development of innovation projects that require a minimum scale to be carried out. Support for collaboration is important in innovation policies adopting a systems approach, since interaction between firms and other organisations is one of its key elements. In this context, in addition to providing financial support for collaborative innovation projects, public action can also target non-financial aspects, aimed to remedy system failures that may result in aspects such as lack of abilities to initiate collaboration agreements, especially for small firms, lock-in to specific collaboration partners or sources of ideas, or excessive overall closure of learning processes (de Jong et al. 2010; Herstad et al. 2010). Specifically, in order to stimulate formal collaboration, actions might not only be directed towards identifying potential partners, but also creating a stable environment that fosters trust among partners and the development of skills with which to manage the formal aspects of collaborative innovation (e.g., design of contracts, governing the alliance, etc.).

Outbound practices allow firms to exploit their existing technological knowledge outside the markets they serve directly and to commercialise unused IP assets (Chesbrough and Garman

2009). They can do this by revealing their internal knowledge with no immediate financial gain (e.g., donation to commons, participation in standard setting processes) or by commercialising their inventions and technologies (e.g., out-licensing). Public intervention to facilitate firms' outbound OI practices can focus on different areas. Governments could support standard setting processes, as the more technologies are standardised, the better they can be traded, which may be done by backing standard setting organisations such as the ISO (de Jong et al. 2010). Out-licensing is a challenging activity for most firms due to its high complexity, as significant transaction costs are involved in transferring technologies between organisations (Dahlander and Gann 2010). Policymakers should help firms develop the skills that are needed to commercialise technologies and explicitly support trade by establishing instruments or rules to value IP adequately, enhancing technology markets and fostering the role of intermediaries to connect potential buyers and sellers of technology (de Jong et al. 2010). As for corporate venturing, it is a common concern for companies to outsource their knowledge if they feel that they cannot find suitable partners and transfer their knowledge effectively (Chesbrough 2006). Public actions can promote this option in different ways, some of which go beyond innovation policy areas, such as providing direct support, better access to finance, entrepreneurship education, support for technology markets, and entrepreneurial skills development (de Jong et al. 2010).

Coupled OI includes practices such as participation in strategic networks, innovation communities, regional innovation clusters and shared facilities (Chesbrough and Bogers 2014; Flor et al. 2019). In general terms, these practices allow companies to quickly fill specific knowledge needs through interaction between parties, usually resulting in an intensive exchange of knowledge and mutual learning. Governments may implement policies to

develop networking skills, directly stimulate interaction, facilitate intermediaries and back up emerging clusters (de Jong et al. 2010). Another important way to reinforce this type of practice is by promoting environments –platforms, networks, forums, etc.– in which to identify shared problems and search for scientific-technical and innovation solutions, including coordination with supra-national and regional policies.

5. Methods and findings

In this section we assess the extent to which current innovation policies in Spain contribute to firms' open innovation. We start by describing the situation of innovation policies in the Spanish context. Next, we explain how we gathered the data for our study and their analysis. The last subsection reports the findings of the analysis.

5.1. The Spanish innovation context

According to the European Innovation Scoreboard (EIS) 2017, Spain is a 'moderate innovator', with innovation performance relative to that of the EU declining by 1.8% between 2010 and 2016 (European Commission 2017). In an attempt to address this weakness, the government developed strategies and plans to improve innovation activities and outputs (Fernández-Zubieta et al. 2018). In this context, the creation of the Spanish System of Science, Technology and Innovation (SECTI, from its initials in Spanish) explicitly considered the set of agents, both public and private, involved in the functions and structures related to the research, development and innovation policy. The SECTI was implemented through the Spanish Strategy for Science, Technology and Innovation (EECTI), the framework for the government's policy on innovation. The EECTI, which is aligned with the European Framework Programme for the funding of Horizon 2020 R&D and innovation activities, was

implemented through the National Plan for Scientific and Technical Research and Innovation and through regional innovation plans. In particular, the National Plan for Scientific and Technical Research and Innovation (PNI+D+I 2017-2020), initially PECTI 2013-2016 and extended in 2017, constitutes the multi-year frame of reference for coordinating innovation policy actions at a national level. At a regional level, the autonomous regions formulated their own strategies and plans. In 2014, each region adopted its Research and Innovation Strategy for Smart Specialisation (RIS3), strategies aimed to identify comparative advantages for each region and consider the diversity of regional potential (ERAC 2014). At both the national and regional levels, it is assumed that universities and the economic and social agents must work together, each with their own characteristics, but with complementary functions, to configure a system of research and innovation (Blasco Díaz 2017). Consequently, in the Spanish context, both a structural and a functional approach are integrated in a complex system in which one national system and different regional innovation systems coexist, developed by the state administration and by the autonomous regions in their respective regional contexts.

5.2. Data gathering and analysis

To examine the extent to which existing innovation policy initiatives promote open innovation in Spain, we reviewed the actions carried out by the government at a national level and the regional actions deployed in a number of autonomous regions. We focused on the four autonomous regions with the highest expenditures on innovation activities in 2016 (Instituto Nacional de Estadística 2019), where internal expenditure on R&D activities was highly concentrated within the Spanish context (data for 2017): Madrid (26.3%), Catalonia (23.3%), the Basque Country (9.6%) and the Valencian Community (7.7%). We examined the areas that have traditionally been included in an innovation policy and that apply in most countries

and regions. In line with previous research (e.g., Herstad et al. 2010), we only addressed policies and instruments explicitly formulated to nurture innovation and did not consider other policy areas such as labour market regulations with more indirect impacts.

Specifically, to make an inventory of the instruments, we reviewed the public announcements of actions implemented within the Spanish National Plan (PNI+D+I 2017-2020) and, also, for the regions, studied the announcements in the existing regional innovation plans for that period. We then classified them into the six categories identified in the previous section, related to the improvement of external conditions (erosion factors) that favour firms' OI and the development of OI processes by the companies. Accordingly, the policy innovation actions were classified in the following areas: (1) creation of a strong base of public knowledge; (2) promotion of workforce mobility; (3) improvement in access to financial sources; (4) promotion of inbound open innovation practices; (5) promotion of outbound open innovation practices; and (6) promotion of coupled open innovation practices. Then, within each OI policy area, the actions were linked to specific instruments. In the process, we focused on the objectives described in each action. Although some actions can be related to more than one OI instrument, we decided to match each action only with the instrument that it was most directly related with. Although this approach is debatable, it is more simple and provides a clearer picture of the situation.

5.3. Findings

Table 2 summarises the findings of our analysis. It shows the policy areas for OI, the set of innovation policy instruments related to each OI policy area identified in our review of the actions related to the innovation plans, and the total number of actions related to the specific

instruments deployed in each national/regional innovation plan. The score in each cell is the result of considering all the actions matching a particular instrument.

Table 2. Innovation policy areas and instruments for OI in Spanish national and regional innovation plans (selected regions)

Area for OI innovation policy	Actions	National Plan	Valencian Community	Basque Country	Madrid Community	Catalonia
1. Public knowledge creation and diffusion	R&D funding	II	I	III	II	I
	Open access of research findings	I				
2. Employee mobility	Industrial doctorate	I	I	I	I	I
	Hiring of technologists and researchers		I	I		
	Short staying of researchers in firms		I			
3. Access to financial resources	Funding for new high-tech start-ups	I	I	III	II	
	Support/funding of R&D and innovation projects	IIII	IIIIII	III		
	Support for private funding	I		II	II	I
4. Promotion of inbound OI	Innovation intermediaries			I		
	Support for inter-firm cooperation		I			
	Support for international cooperation	III	II	II		I
	Project cooperation between firms and other organisations	III	III	II		I
	Technical support from technological centres and specialised firms				I	
	Knowledge valorisation and transfer		III	II		III
	Public procurement of innovation	II	I			I
5. Promotion of coupled OI	Technological and digital platforms	I	I			
	Support for clusters	I				
	Consortia	III	I		II	
	Support for shared infrastructures				I	I

Note: Each symbol, I, indicates one specific action related to the identified OI instrument

Source: the authors

The results of our analysis show that the Spanish National Plan includes a diverse group of actions, which are related to all the areas that foster OI in firms, with the exception of promotion of outbound OI practices. As regards regional interventions, in general terms, although they contain a smaller set of actions than the national plan, they follow a similar pattern, as they cover all the identified innovation policy areas for OI except for outbound OI. The innovation plans of the Basque Country and Valencian Community include the most diversified set of actions, followed by the Catalonia plan; the innovation plan for the Madrid Community has the narrowest focus.

As for the innovation policy areas related to external conditions (erosion factors) that facilitate implementation of firms' open innovation, the set of instruments aimed to strengthen the creation of a public knowledge base is mostly focused on traditional mechanisms, namely funding of research carried out by universities and research institutions. The diffusion of public knowledge base is adopted in the national plan, which includes actions devoted to funding the promotion of open access to research data by scientific communities, and the recognition of works published in open access in repositories.

With regard to mobility of workers, although researchers' mobility can also be associated with geographical mobility, inter-institutional and inter-sectoral mobility are essential elements for stimulating the Spanish innovation system. In this vein, stimulus of industrial doctorates is an action implemented in the national plan that is also considered in all the regional plans. Also, hiring of technologists and researchers and the mobility of researchers between the public research sector and firms are actions that are part of this OI policy area in the Valencian Community.

Access to funding for innovation is an important part of the Spanish National Plan, which seeks to activate both public and private investment in the different phases of the innovation process. The plan contributes to the achievement of this objective through funding of firms' R&D and innovation projects. The Valencian Community and the Basque Country are the other two settings where this type of projects is supported. This instrument is complemented with actions designed to consolidate start-ups with a technological and scientific base. The increasing relevance of these actions is confirmed by their inclusion in most of the regional settings. In addition, private funding from specialised investors is explicitly stimulated in the national plan and the Basque Country, Catalonia and Madrid regional plans through actions to foster interaction between firms seeking private funding and entities meeting these needs.

Regarding actions aimed to promote open innovation by firms, in general terms, all the plans give the highest weight to improving inbound open innovation, with a wide variety of actions aimed at fostering cooperation. The role of traditional instruments in innovation policies is widely acknowledged, such as establishing mechanisms for collaboration in R&D projects, both inter-firm and public-private cooperation (especially small and medium-sized ones). External knowledge acquisition through technical support from technical centres and specialised providers is also stimulated in Madrid regional plan. Specific instruments for knowledge valorisation and transfer are included in most regional plans, with actions oriented to strengthening transfer activity through official technology transfer offices, and from science and technology parks, technology centres and other innovation-stimulating structures. While these instruments can be considered to focus on the supply of innovations from an innovation policy systems approach, both at the national and the regional levels there is also presence of instruments focusing on the demand side of innovation, such as public

procurement of innovation. Although described as inbound OI actions in Table 2, most of these instruments can also be understood to enhance the public knowledge base.

As regards facilitating of coupled OI, innovation plans combine traditional actions, such as support for consortia and clusters, with new instruments, as represented by support for technological and digital platforms and shared infrastructures. Specifically, the national plan, offers the broader set of actions, and the Basque Country plan does not implement any.

6. Discussion

In this study, we examined the innovation actions implemented at a national level and in four innovative Spanish regions through the lens of potential areas of application of an open innovation policy. We derived the areas by considering three external elements or erosion factors –creation of a public scientific knowledge base, mobility of workers and access to finance– that can facilitate firms’ adoption of the open innovation model, and the three types of open innovation –inbound, outbound and coupled– that firms can implement. From our analysis, we identified that existing policies support open innovation to different degrees, the most popular being actions to facilitate firms’ access to financial resources and to promote their inbound OI practices. Surprisingly, we were not able to identify any action designed to promote firms’ outbound open innovation. The Spanish national innovation plan is the most ambitious and complete, as it covered all the OI policy areas and deployed the highest overall number of actions. In general terms, it is an innovation policy based on the interaction between science, industry and government, sometimes with intermediaries that promote it, and, with regard to open innovation, that partially adopts the open innovation approach. As de Jong et al. (2010) note, the fact that many policy measures are in place indicates that

designing an innovation policy to facilitate open innovation does not imply a great change to the existing policy measures.

As for encouraging open innovation in firms through actions related to external factors, the initiatives in the national plan, the Valencian Community and the Basque Country go further than the slightly narrower approach adopted in the Madrid and Catalonia regions. Concerning the creation of a strong public knowledge base, all regional systems include traditional actions related to R&D founding. At this point, we must highlight that a number of actions to foster inbound and coupled OI are also relevant instruments in the diffusion of a public knowledge base as they promote the valorisation of knowledge in universities and public research organisations, and stimulate the interaction with companies in order to adopt new basic and applied knowledge. Employees' mobility is supported in all plans through the promotion of industrial doctorates, and particularly complemented with short mobility of researchers and hiring of researchers and technologists by firms in the Valencian Community. Access to financial resources is important in most of the plans, being Catalonia's support very limited in this OI area. The acknowledgement of the need for access to financial resources for new high-tech start-ups is present in the rest of innovation plans, which in the cases of the national plan and the Valencian Community and Basque Country also strongly provide support and funding to R&D and innovation projects. In the case of all the plans the res. Assistance to private funding is an emerging aim, in line with the need identified by Chesbrough and Vanhaverbeke (2018) to provide support for funding in further stages of the innovation process. Thus, as stated in the national plan, business investment should be favoured through the development and consolidation of risk capital funds in all its phases, including seed capital and equity funds with co-participation from public entities that support innovative

companies with a high growth potential in strategic sectors for the Spanish economy. At a regional level, the incorporation of actions encouraging funding from private investors for firms is noteworthy in most of the plans.

As regards the promotion of firms' open innovation practices, our results show that the current instruments in innovation plans offer more support to promote inbound OI processes, and that they mostly concentrate on research partnerships. Specifically, the focus of both national and regional innovation policy measures has been on providing support for inter-firm cooperation and collaborative arrangements with research institutions. In particular, international cooperation is explicitly encouraged in all the innovation plans, with exception of Madrid's. In contrast, R&D outsourcing through technical support from technological centres and specialised firms is only present in Madrid. In addition to more traditional actions related to R&D funding, the fact that there are actions explicitly designed to promote knowledge valorisation and transfer in three autonomous regions is a sign that more stages of the innovation process are carried out with external partners. Although cooperation with individual users is still missing, the inclusion at a national and a regional level of public procurement of innovation as an innovation action shows the increasing recognition that it is important to foster innovation from the demand side (Oltra et al. 2017).

In turn, specific actions aimed at facilitating outbound open innovation are missing. The absence of actions aimed to facilitate IP management is a limitation to advancing open innovation. Many companies find it too difficult to value their technologies, or apply for patents. As other authors have pointed out, the absence of a well developed technology market represents a critical limitation to the advance of open innovation (Bogers et al. 2018; de Jong et al. 2010).

Coupled open innovation is mainly promoted in many plans by means of specific legal formula for cooperation, such as consortia, in which the partners share investment, project execution and/or exploitation of the research results. New instruments are encouraged in the national plan and the Valencian Community, which offer their support through actions to promote technology platforms. This government support in creating technology platforms can be seen as an indicator of the increasing relevance of new channels for collaboration through knowledge sharing, as represented by users or innovation communities. In a certain way, these actions are reflecting the change in the innovation policy approach, as suggested by Chesbrough and Vanhaverbeke (2018), in that policymakers should redirect their policies towards networks or ecosystems in which innovation partners jointly create new business opportunities. Also, the inclusion of actions to foster shared infrastructures, which is implemented in Catalonia and Madrid Community, confirms the role that new instruments can have in stimulating interaction between firms and organisations. Other interaction measures, such as support for clusters, although traditionally included in many innovation programmes, are not so common.

7. Conclusion

Public policies to favour the competitiveness of companies, industries, regions and countries through innovation have been part of national and regional government policies in recent decades. However, in many cases they were designed for a closed model of innovation, where access to external knowledge sources was not a priority and firms did not seek new uses for their knowledge so intensively (Chesbrough and Vanhaverbeke 2018). The fact that opening their innovation process can enhance firms' competitiveness firms suggests the

appropriateness of examining the alignment of innovation policies with the open innovation paradigm.

In this study, we examined the extent to which existing innovation policies offer support for firms' open innovation by reviewing the set of innovation policy instruments developed by national and regional governments in Spain. Spain is a moderate innovator (European Commission 2017) characterised by the coexistence of different innovation systems with their respective innovation policies developed by the national and regional governments. In this context, in response to innovation challenges, a number of public instruments were designed to foster R&D activities, to increase knowledge transfer between public and private sectors, to redress human resource weaknesses, and to increase the coordination of policies among national and regional administrative units (Fernandez-Zubieta et al. 2018). Most of these initiatives were conceived through the prism of a system-oriented innovation policy, deriving from the creation of the Spanish System of Science, Technology and Innovation and the formulation of the Spanish Strategy for Science, Technology and Innovation at a national level and the regional innovation strategies and plans. With this systems approach, the focus is on the creation of an environment where interaction and knowledge generation and sharing between firms, research organisations and governments contributes to socioeconomic prosperity.

The variety of actions related to the OI policy areas identified in our analysis illustrates the connection of the innovation systems approach with the open innovation framework, not only in terms of fostering collaboration among different agents but also in creating a strong base of public knowledge that can help solve societal problems and improve innovative performance in the regions. As has been stressed, although both approaches examine different levels of

analysis, they focus on similar phenomena, as the open innovation framework reveals what happens inside the ‘nodes’ of innovation systems (de Jong et al. 2010).

Nevertheless, despite the fact that the emphasis on national and regional systems of innovation has shifted the focus of innovation policies towards a more interactive and open approach, our results show that it is still necessary to incorporate actions to promote more widely the development of open innovation by firms, which suggests several implications for policymakers. With regard to improvement of external conditions that favour firms’ open innovation, in addition to traditional R&D funding and employees’ mobility, public intervention should pay more attention to actions designed to facilitate new instruments that support public knowledge diffusion.

With regard to instruments to assist and facilitate implementation of OI by firms, current instruments offer more support to promotion of inbound OI processes, and they mostly focus on research partnerships, with financial support for collaborative innovation projects, actions to promote knowledge valorisation and transfer, and measures of public procurement of innovation. In this context, help for companies with non-financial aspects is an important area that deserves to be covered through public intervention. In addition, policymakers should broaden the set of measures by backing less traditional modes of inbound OI, such as technological scouting or using services from innovation intermediaries, as they are barely stimulated through explicit actions in existing innovation plans. Promotion of outbound open innovation is absent in all the plans. Policymakers should create measures that encourage firms to exploit their innovation results beyond their current markets by facilitating commercialisation of their inventions and technologies. In this sense, given the difficulties that many firms face in valuing their new developed technologies, finding buyers and

negotiating contracts, actions that offer guidance and assist firms to value their intellectual property and facilitate their trade by making the supply and demand for technologies more visible can constitute fruitful avenues (de Jong et al. 2010). Finally, as regards coupled open innovation, it largely relies upon consortia creation and, at a lesser extent, on the provision of platforms and environments for interaction. Nevertheless, coupled open innovation practices are still difficult to implement for certain companies, as they require networking skills. Accordingly, a line of action for encouraging coupled OI practices is linked to reinforcing this type of skills, aimed to directly stimulate interaction and help firms build trust and encourage knowledge exchange. Despite being more traditional modes, since currently the locus of innovation is no longer in the firm but in the network (Chesbrough and Vanhaverbeke 2018), policymakers should still consider shifting their support from single firms to the innovation ecosystem through a variety of forms.

This study has some limitations. Firstly, although we focused our attention on the national and regional innovation plans, we focused on the public announcements of actions implemented within them, which are more limited than the set of potential initiatives described in the plans. This circumstance may have offered a more restrictive view of the open innovation policy. Gathering data on additional sources would have provided us with a more accurate view of the implementation of an OI innovation policy. Another limitation stems from the fact that we only considered the number of actions related to each OI instrument. Additional information of the actions implemented, such as the amount of resources assigned by the government, would allow us for a richer analysis. Finally, we only examined the most innovative regions in a moderate innovating country. Study of innovation policies in other regions and countries might illustrate different needs on the basis of the OI actions implemented.

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