A taxonomy of competition-based approaches as innovation policy measures to foster external knowledge search

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Abstract

Purpose – *This paper aims to provide a comprehensive view of the different competition-based approaches that policymakers can exploit to foster external knowledge search and their positioning among innovation policy measures. A growing number of companies have implemented initiatives to access external knowledge to increase their innovativeness, consistently with the open innovation paradigm. Competition-based approaches have received increasing attention by the private sector as a way to access external knowledge. However, despite their potential role as innovation policy measures, a limited attention has been devoted so far to investigate them from the policymakers' perspective.*

Design/methodology/approach – *To this aim, a two-stage empirical analysis has been carried out to develop a taxonomy of competition-based approaches. The first stage leveraged a multiple case study methodology including a sample of 20 competition-based approaches, while the second one leveraged interviews with Italian and European key informants.*

Findings – *This paper proposes a novel taxonomy including eight competition-based approaches, which differ among each other in terms of policy strategy, scope breadth and output required. Moreover, this paper enriches a well-established taxonomy of innovation policy instruments with the identified competition-based approaches.*

Originality/value – *This study contributes to the current debate on innovation policy by providing a taxonomy that includes eight competition-based approaches that can be exploited by policymakers to foster external knowledge search as well as their positioning among the innovation policy instruments. The taxonomy will hopefully support policymakers in identifying of the most suitable instruments in the light of their policy strategy and objectives.*

Keywords *Competition-based approach, External knowledge search, Open innovation, Innovation policy, Policymakers*

Paper type *Research paper*

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1. Introduction

Innovation reflects a firm's ability to access, understand and exploit knowledge (Zahra and George, 2002; Tseng *et al.*, 2011). Accordingly, the capability to search and recombine existing knowledge components in novel ways to generate innovations is becoming highly important for companies (Lanzolla *et al.*, 2021), as it enables them to expand the knowledge basis upon which they innovate, thus affecting their innovativeness (Stuart and Podolny, 1996; Mele *et al.*, 2022).

To enhance their innovativeness, companies can leverage externally generated knowledge as well as the internally generated one (Ritala and Stefan, 2021). Indeed, a growing number of companies have already implemented initiatives to access external knowledge (Pollok *et al.*, 2019), consistently with the open innovation paradigm (Chesbrough, 2006; Laursen and Salter, 2006). Open innovation refers to "a distributed innovation process that involves purposively managed knowledge flows across the

organisational boundary" (Chesbrough and Bogers, 2014, p. 4). In this domain, knowledge assumes a pivotal role as a key resource to establish and sustain the competitive advantage of firms by nurturing their innovation processes (Grant, 1996; Matricano *et al.*, 2019). Nevertheless, there are only few attempts within the extant literature pointing out how to properly manage knowledge in an open innovation context (Natalicchio *et al.*, 2017).

Competition-based approaches have received increasing attention by innovation management scholars and practitioners as a way for companies to advance research and technology as well as acquire externally generated knowledge to address unsolved innovation issues (Adamczyk *et al.*, 2012; Murray *et al.*, 2012; Letina and Schmutzler, 2019). These approaches are intended as open calls in which different actors such as firms or individuals compete to develop a solution to solve an innovation problem (West and Lakhani, 2008). Among them, a specific attention has been devoted to innovation contests (Terwiesch and Xu, 2008; Jeppesen and Lakhani, 2010; Boudreau *et al.*, 2011; Adamczyk *et al.*, 2012; Ferradas *et al.*, 2017), that is, "competition of innovators who use their skills, experience and creativity to provide a solution for a particular contest challenge defined by an organizer" (Bullinger *et al.*, 2010, p. 291).

At public level, competition-based approaches have been recognised as valuable policy instruments to support innovation (Kay, 2012; Williams, 2012; Burstein and Murray, 2016; Liotard and Revest, 2018). Indeed, extant literature on innovation policies – that is, those having a relevant impact on innovation (Edler and Fagerberg, 2017) – has pointed out the role of competition-based approaches in fostering innovation as well as increasing public and sectoral awareness on specific issues affecting the society (Kay, 2011), the latter being particularly relevant in the light of COVID-19 crisis (Patrucco *et al.*, 2022). For instance, a few contributions have investigated the role of inducement prizes as a competition-based approach through which policymakers can accelerate the identification of new solutions to tackle technological or societal issues (e.g. health crises and natural disasters) (Schroeder, 2004; Kay, 2011; Liotard and Revest, 2018), thus impacting on the society as a whole (Adamczyk *et al.*, 2012; Murray *et al.*, 2012). Nevertheless, a limited attention has been devoted so far to the competition-based approaches that policymakers can exploit to stimulate innovation by fostering external knowledge search. In particular, to the best knowledge of the authors, there is a lack of contributions providing a comprehensive view of the different competition-based approaches that can be exploited by policymakers as well as their peculiarities with respect to those exploited by the private sector. Moreover, a proper contextualisation of such approaches within the broader domain of innovation policy instruments is lacking too (Kay, 2011). Therefore, the paper aims to answer the following research question:

RQ1. Which competition-based approaches can be exploited by policymakers as innovation policy instruments to stimulate innovation by fostering external knowledge search?

To address this research question, the present study leverages a multi-stage empirical analysis that involved a set of 23 cases of competition-based approaches as well as a set of relevant Italian and European key informants.

The present study contributes to the existing literature by proposing a taxonomy that includes eight competition-based approaches that are suitable for policymakers to stimulate innovation by fostering external knowledge search. In particular, only four competition-based approaches included in the proposed taxonomy have been already addressed within the extant literature. Moreover, the study contextualises such approaches among the innovation policy instruments by enriching a well-established taxonomy of such instruments. Therefore, policymakers could benefit from the study to identify the most suitable instruments to foster innovation via external knowledge search, consistently with their innovation policy strategies and objectives.

The remainder of the paper is organised as follows. Section 2 illustrates the relevant literature on the topic as well as the existing gaps, also presenting the research question of the study. Then, the research methodology is presented in Section 3. Finally, results are presented and discussed in Section 4, while Section 5 discusses the implications of the study as well as its limitations and avenues for future research.

2. Literature review

2.1 Competition-based approaches exploited by policymakers

Competition-based approaches refer to open calls in which different actors such as firms or individuals compete to develop a solution to a specific innovation problem (Terwiesch and Xu, 2008; Jeppesen and Lakhani, 2010; Boudreau *et al.*, 2011). Such approaches have received an increasing attention by scholars and practitioners as instruments to support companies in the private sector in leveraging external knowledge search (West and Lakhani, 2008; Adamczyk *et al.*, 2012; Letina and Schmutzler, 2019). Accordingly, they have spread in this sector, primarily in the form of innovation contests (Jeppesen and Lakhani, 2010). Within these contests, actors involved (known as solvers) submit ideas, proposals or prototypes to address a specific innovation challenge shared by a firm that promotes the contest itself (known as seeker). At the end of the process, the seeker selects and awards the best submission (Terwiesch and Xu, 2008; Jeppesen and Lakhani, 2010).

Innovation contests have proven to be very effective in stimulating innovation (Ferradas *et al.*, 2017; Liotard and Revest, 2018), because of their ability to attract unknown solutions from different sectors and knowledge domains (Boudreau *et al.*, 2011). As a matter of fact, Jeppesen and Lakhani (2010) show that approximately one third of the unsolved technical problems within the R&D departments of large firms have been solved through innovation contests. Accordingly, innovation intermediaries have spread over the past decade to support their customers in searching for external knowledge by exploiting competition-based approaches (Howells, 2006; Terwiesch and Xu, 2008; Jeppesen and Lakhani, 2010; Randhawa *et al.*, 2017). Among them, online innovation intermediaries, such as Wazoku or NineSigma, make competition-based approaches such as innovation contests available as-a-service (Huston and Sakkab, 2006; Lichtenthaler and Ernst, 2008b; Chesbrough, 2009; Lichtenthaler, 2013; Lauritzen, 2017; Randhawa *et al.*, 2018; Schenk *et al.*, 2019; Vignieri, 2020). Furthermore, recent contributions show how innovation contests may be effective in supporting external knowledge search by small and medium enterprises (SMEs) (Leckel *et al.*, 2020), through an *ad hoc* design that address the idiosyncratic characteristics of such companies (Franzò *et al.*, 2023). In this vein, extant literature points out a set of design elements to be addressed when designing an innovation contest, such as the above-mentioned solvers, seekers and expected output (Bullinger *et al.*, 2010; Adamczyk *et al.*, 2012; Rodriguez Ferradas *et al.*, 2017). For instance, Doppio *et al.* (2020) identify a set of 14 design elements for innovation contests, which are summarised in Table 1.

More recently, competition-based approaches have gained an increasing attention by policymakers, which can exploit them to achieve technological leaps, address major societal challenges, develop generic technologies and increase public and sectoral awareness on specific issues affecting the society (Masters and Delbecq, 2008; Herstad *et al.*, 2010; Fernández-Esquinas and Ramos-Vielba, 2011; Kay, 2011; Adamczyk *et al.*, 2012; Kokshagina *et al.*, 2017). Liotard and Revest (2018) argue that competition-based approaches launched by public institutions (known as inducement prizes) may display a strong incentive effect ex ante and during the contest, produce favourable spillovers after the contest at innovation and economic levels in specific sectors and play a beneficial societal role. In addition, these approaches are considered very useful when problems to be solved are complex or novel, as well as when creativity is fundamental (Boudreau and Lakhani, 2013). For these reasons, policymakers can tackle complex issues that need to be

Table 1 Design elements of an innovation contest

Design elements	*Definition*
Goal	The overall strategic reason why the contest is organised
Seekers	Organisation seeking innovation
Challenge	The problem or opportunity that the Seeker wishes to tackle regarding a product, process, technology or business
Solvers	Individuals or organisations executing the Activities
Activities	Actions capable of delivering Solutions by means of problem-solving work, specific methodologies and know-how
Timeline	The duration, milestones, stages and events required to set up and carry out the entire contest
IPR	Intellectual Property Rights (IPR) policy for Solutions
Regulations	The formal and legal framework regulating all aspects of the contest
Incentives	The motivational elements for Solvers and/or Seekers, including prizes
Business model	Costs and revenues generated by the contest
Solutions	Overall outcomes that the contest achieves and its foreseen impacts
Governance	How the contest is managed and governed

Source: Adapted from Doppio *et al.* (2020)

solved through innovative solutions by exploiting competition-based approaches (Mergel and Desouza, 2013).

Among the competition-based approaches that can be exploited by policymakers, inducement prizes are "designed and organised as competitions with rules to achieve pre-specified technological challenges or targets before a deadline" (Kay, 2011, p. 361). These prizes have supported the development of advanced technical solutions for a long time. For instance, Letina and Schmutzler (2019) report the case of the EU Vaccine Prize, that is, the first inducement prize promoted by the European Commission to improve the knowledge about the cold-chain vaccine technology. The increasing attention devoted to these prizes relies on the fact that they drive innovations over and above the level that would have occurred without them. Furthermore, similarly to competition-based approaches in the private sector, they motivate unconventional players to tackle a specific technological issue because of the monetary reward offered as well as the non-monetary incentives such as publicity and networking (Brunt *et al.*, 2008; Kay, 2011).

However, despite the relevance of competition-based approaches to stimulate innovation by policymakers, there is a lack of studies characterising the peculiarities of competition-based approaches suitable for policymakers with respect to those exploited by the private sector, as well as positioning them among innovation policy instruments (Kay, 2011). Therefore, additional studies that may inform the development of innovation policies based on competition-based approaches to stimulate innovation are necessary (Jugend *et al.*, 2020).

2.2 Competition-based approaches and the other innovation policy instruments

Innovation policy refers to "public intervention to support the generation 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, p. 3). Thus, innovation policy – which have been recently addressed within the literature by using the term "public support for innovation" (Jugend *et al.*, 2020) – embraces the production of knowledge, artefacts and practices that are needed to generate innovations as well as to favour the subsequent adoption. The three main reasons that can justify the involvement of public actors within this process refer to:

1. overcoming market failure, that is, a suboptimal level of knowledge and innovation generation because related benefits can be appropriated not only by the knowledge generator but also by other actors, thus acting as a disincentive to generate knowledge (Nelson, 1959);

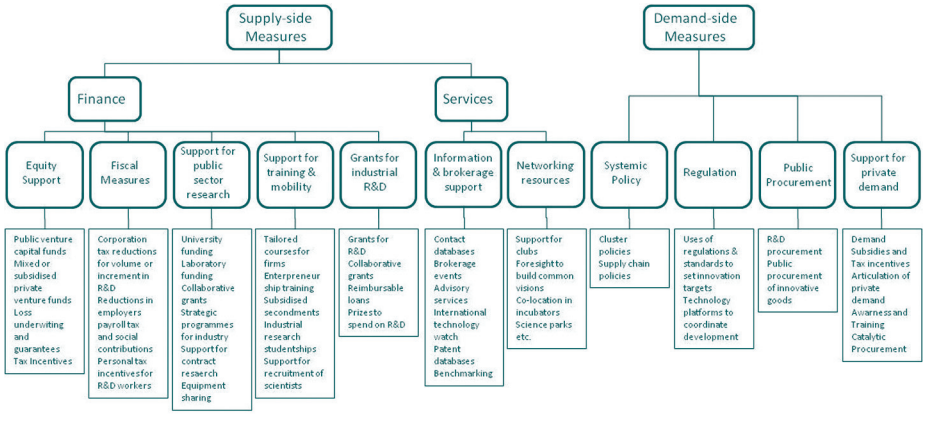
2. overcoming system failure, that is, a failure in the cooperation among the different actors involved in the generation of knowledge and innovation (Klein Woolthuis *et al.*, 2005); and

3. contributing to address societal challenges, that is, to steer innovation initiatives to satisfy citizenry needs (e.g. defence and health) and favour the creation of societally preferable markets (Mazzucato, 2011).

Extant literature has identified different policy instruments to foster innovation, such as tax incentives for R&D investments (Billings *et al.*, 2001), policies aimed at fostering collaborations and technology transfer from research centres (Van Looy *et al.*, 2011), incentives for the mobility of researchers (Baruffaldi and Landoni, 2012) and voucher schemes (Caragliu *et al.*, 2022). A common classification of such instruments is based on their orientation, that is, distinguishing between supply-side and demand-side instruments (Rothwell and Zegveld, 1981; Edler and Georghiou, 2007; Edler and Fagerberg, 2017). Supply-side instruments are "instruments providing additional inputs for private innovation process" (Aschhoff and Sofka, 2009; p. 1236), such as R&D funding or tax credit. Such instruments include financial ones and service ones. The former refers to financial resources given to firms to stimulate their innovation activities, which can take the form of R&D grants, fiscal measures, support for training and mobility, support for public sector research and equity support. The latter refers to measures that address the environment in which firms exert their innovation effort, which can take the form of networking measures or information and brokering support (Edler and Georghiou, 2007). Demand-side instruments include "all public measures to induce innovations and/or speed up diffusion of innovations through increasing the demand for innovations, defining new functional requirement for products and services or better articulating demand" (Edler and Georghiou, 2007, p. 952). Such instruments can take the form of systemic policies, regulations, public procurement and tools to support demand.

Furthermore, other contributions classify innovation policy measures based on their goals (Edler *et al.*, 2016). For example, supply-side instruments may support the creation of new knowledge and innovation through financial support to R&D and innovation activities, support the development of capabilities and skills required to innovate or support various forms of interaction and learning (Edler and Fagerberg, 2017). Figure 1 shows a well-known taxonomy of innovation policy instruments proposed by Edler and Georghiou (2007).

Figure 1 Taxonomy of innovation policy instruments



Source: Edler and Georghiou (2007)

Despite the presence of taxonomies of innovation policy instruments within the extant literature (Edler and Georghiou, 2007; Borrás and Edquist, 2013; Gök *et al.*, 2016; Edler *et al.*, 2016; Edler and Fagerberg, 2017), to the best knowledge of the authors, existing taxonomies do not include all the different competition-based approaches among the available innovation policy instruments. For instance, within the taxonomy proposed by Edler and Georghiou (2007), only three competition-based approaches are included, that is, Grants for industrial R&D, Information and brokerage support and public procurement (Rolfstam, 2009). This could hinder the policymakers' ability to select the most effective policy instruments (such as competition-based approaches) to foster innovation, according to the peculiarities characterising each of them (Jugend *et al.*, 2020). Hence, to fill the above-mentioned literature gaps and shed light on the role of competition-based approaches as innovation policy instruments, the paper aims to answer the following research question:

RQ2. Which competition-based approaches can be exploited by policymakers as innovation policy instruments to stimulate innovation by fostering external knowledge search?

3. Research methodology

The research process included two stages. The first stage aimed at identifying a preliminary set of variables to characterise the different policy-driven competition-based approaches. In this stage, the case study methodology was deemed appropriate, as case studies are a useful method for building a rich understanding of complex and contemporary phenomena and identifying the relevant variables that should be considered (Eisenhardt, 1989; Eisenhardt and Graebner, 2007). In particular, to develop a taxonomy of competition-based approaches that policymakers can exploit to foster innovation, we built a sample including both policy-driven cases and for-profit ones, given the rather limited diffusion of the policy-driven cases. Regarding for-profit ones, we focused our analysis on innovation intermediaries that leverage competition-based approaches to support innovation, as they represent an increasingly relevant enabler for companies to streamline innovation by exploiting competition-based approaches (Jeppesen and Lakhani, 2010; Colombo *et al.*, 2013). The overall sample was built according to theoretical replication logic, that is, "the logic of treating a series of cases as a series of experiments with each case serving to confirm or disconfirm the hypotheses" (Eisenhardt, 1989, p. 542). Following this logic, we selected examples of innovation policy instruments that fit with the taxonomy proposed by Edler and Georghiou (2007) and are consistent with the definition of competition-based approach proposed by West and Lakhani (2008). In this way, cases that overlap with already existing innovation policy instruments improved confidence in the validity of the extant taxonomy. On the contrary, other cases allowed us to extend this taxonomy by identifying new innovation policy instruments. A preliminary list of potentially relevant cases was built by leveraging two different sources of information: scientific literature search, which illustrates relevant examples of intermediaries that leverage competition-based approaches to support innovation (Chesbrough, 2006; Lichtenthaler and Ernst, 2008a, 2008b; Boudreau and Lakhani, 2009); and web search, by using keywords such as "competition-based intermediaries", "prizes", "prize intermediaries", "innovation marketplaces", "open innovation platforms" and "crowd-sourcing". The preliminary list included 46 potentially relevant cases. Then, the final sample was obtained by selecting the most relevant cases, that is, those for which the variables that characterise the competition-based approaches were easily observable (Eisenhardt, 1989), while excluding those referred to collaborative communities rather than to competition-based approaches, consistently with the aim of the research. The final list consisted of 23 cases, summarised in Table 2.

As far as data collection is concerned, we collected data related to each selected case from different sources, such as company websites, prize-participant blogs, scientific literature and publicly available documents. Both external validity (i.e. authenticity) and

Table 2 Cases examined

No.	Name	Nature	Website	Brief description
1	*#EuvsVirus*	Policy-driven	www.euvsvirus.org	European Commission's hackathon and innovation platform for solutions to fight coronavirus
2	*Crowdspring*	For-profit	www.crowdspring.com	Commercial platform for professionals' and organisations' design contests
3	*DesignCrowd*	For-profit	www.designcrowd.com	Commercial platform for professionals' and organisations' design contests
4	*Digital Learning Challenge (XPrize)*	Policy-driven	www.xprize.org/challenge/digitallearning	Not-for-profit Open Innovation competition to test the efficacy of educational interventions
5	*Eupartnersearch*	Policy-driven	www.eupartnersearch.com/Default.aspx	Platform to foster the exchange of ideas and partnership among European entities as well as the development of new practice for training and education
6	*Homegrown Innovation Challenge*	Policy-driven	homegrownchallenge.ca	Foundation-sponsored challenge to allow farmers to sustainably and competitively grow berries out of season in Canada
7	*Horizon prize for better use of antibiotics*	Policy-driven	research-and-innovation.ec.europa.eu/funding/funding-opportunities/prizes/horizon-prizes/better-use-antibiotics_en	European Commission's prize for developing a rapid test to identify respiratory tract infections
8	*Hydropower Operations Optimisation (H2Os) Prize*	Policy-driven	americanmadechallenges.org/challenges/h2os/	US Government-sponsored prize to help clean energy transition by improving the grid's reliability and resiliency
9	*Longitude Prize on Dementia*	Policy-driven	dementia.longitudeprize.org	Not-for-profit challenge for technological solutions to help people affected by dementia
10	*L-Prize*	Policy-driven	www.energy.gov/eere/ssl/l-prize-competition	US Government-sponsored technology competition to innovate common light bulb
11	*Ninesigma*	For-profit	www.ninesigma.com	Commercial service designing prize challenges for companies' Open Innovation strategies
12	*Open Innovation Call in Copenhagen targeting Air Quality and Urban Heat Island Effect*	Policy-driven	accesscities.org/open-innovation-call-in-copenhagen-targeting-air-quality-and-urban-heat-island-effect/	Call for ideas aims to reduce the negative impacts of urban air pollution and the heat island effect in Copenhagen
13	*Open Innovation platform*	Policy-driven	www.openinnovation.regione.lombardia.it/en/login	Platform created by Lombardy region (Italy) to strengthen governance capacity and to improve the competitiveness of the regional system of knowledge
14	*Perovskite Start-up Prize*	Policy-driven	www.herox.com/perovskiteprize	US Government's prize to accelerate the growth of the domestic perovskite industry

(*continued*)

Table 2

No.	Name	Nature	Website	Brief description
15	*Procura+ Awards*	Policy-driven	procuraplus.org/awards/	Award to highlight sustainable, circular and innovation procurements by innovative public authorities
16	*Prometheus*	Policy-driven	hei-prometheus.eu/entrepreneurship-acceleration-platform/the-competition/	European Union-founded start-up competition for digital transformation and sustainable development
17	*Qmarkets*	For-profit	www.qmarkets.net/	Private platform helping firms to improve intrapreneurship and open innovation initiatives
18	*The Big Hack*	Policy-driven	2022.thebighack.makerfairerome.eu/about/	Not-for-profit hackathon to develop prototypes for hardware and software projects
19	*The Sunny Awards*	Policy-driven	www.herox.com/sunnyawards	US Government's award for community solar projects that increase equitable access to solar energy
20	*Wazoku*	For-profit	www.wazoku.com	Commercial service designing prize challenges for companies' Open Innovation strategies
21	*XPrize Carbon Removal*	Policy-driven	www.xprize.org/prizes/elonmusk	Foundation-sponsored challenge to create and demonstrate solutions for carbon removal
22	*Yet2.com*	For-profit	www.yet2.com	Commercial service creating Open Innovation platforms for large organisations
23	*Zillion Designs*	For-profit	www.zilliondesigns.com	Commercial platform for professionals' and organisations' design contests

Source: Authors' elaboration

internal reliability (i.e. credibility and biases) were checked (Danto, 2008). To identify the set of variables characterising the different competition-based approaches, we leveraged the set of design elements for innovation contests proposed by Doppio *et al.* (2020) as a reference framework for data collection (Table 1).

Data was then analysed by adopting a structured coding process. First, all cases was separately analysed by two authors of the paper. The few different interpretations from two researchers were crosschecked by another researcher. Second, a cross-case analysis was performed to compare data from policy-driven cases with those from for-profit initiatives. The analysis of such data enabled us to identify a preliminary set of variables to characterise the different policy-driven competition-based approaches.

The second stage enabled to identify the most appropriate variables to characterise the policy-driven competition-based approaches (among those that emerged in the first stage), to develop a taxonomy of such approaches. To this aim, we engaged relevant Italian key informants in the Lombardy region. Lombardy has been chosen as empirical setting, being one of the most advanced and innovative regions in Europe, also accounting for more than 20% of the Italian gross domestic product [1]. In particular, interviews were conducted with public policy and legal experts working in the regional administration or government and in other regional agencies. Furthermore, to further strengthen the analysis, we also involved venture capitalists and entrepreneurs that are active in the Lombardy region, to gain an

understanding of the point of view of the potential users of such public policy instruments. Overall, we performed more than 20 semi-structured interviews, each one lasted at least one hour and was taped and transcribed. During the interviews, the variables identified in the first stage of the research were discussed and refined until a taxonomy emerged, which includes a set of competition-based approaches that policymakers may adopt to foster innovation. The results of the analysis were presented for validation to all the actors previously interviewed. Finally, we developed a small survey on the variables included within the taxonomy to be delivered to European public policy experts, to further strengthen the findings as well as to conduct a preliminary test of the applicability of the taxonomy in other contexts. We submitted the questionnaire via email to a sample of 105 European public policy experts and received 22 complete answers, thus obtaining a 21% response rate. Information on the public policy experts that answered to the survey is reported in Table 3.

4. Results and discussion

4.1 Cross-case analysis

The cross-case analysis of competition-based approaches has been carried out with the support of interviewed key informants. Such analysis brought into light some recurring differences among the analysed cases. It is worth mentioning that such differences are not affected by the nature of the case studies analysed (i.e. policy-driven and for-profit). In particular, the cross-case analysis did not bring into light specific patterns characterising policy-driven and for-profit competition-based approaches. On the contrary, it revealed some common patterns among all the cases analysed, which led the identification of the three variables to cluster the different competition-based approaches. The three identified variables are reported in Figure 2 and further described in the following sub-sections.

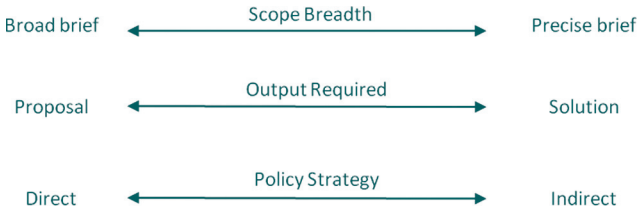
4.1.1 Scope breadth. The *scope breadth* variable refers to how broad or narrow the information in the brief is, ranging from "broad brief" to "precise brief". Indeed, some of the

Table 3 Information on the survey respondents

Survey respondent	*Nationality*	*Role*	*Type of institution*
1	Slovenian	Head of Department	Public foundation
2	Latvian	Head of Department	Government agency
3	Greek	Head of Department	Public research centre
4	Finnish	Head of Department	Public foundation
5	Finnish	Senior Advisor	Government agency
6	Latvian	Head of Department	Public research centre
7	Hungarian	Vice Director	Public research centre
8	Icelandic	Professor	Public university
9	Danish	Head of Department	Government agency
10	Cypriot	Head of Department	Public foundation
11	Belgian	Director	Government agency
12	German	Director	Public foundation
13	Latvian	Director	Government agency
14	Slovenian	Head of Department	Government agency
15	Latvian	Head of Department	Government agency
16	Hungarian	Vice President	Government agency
17	Slovakian	President	Government agency
18	Belgian	Head of Department	Public foundation
19	Polish	Vice Director	Government agency
20	Romanian	Professor	Public university
21	English	Head of Department	Government agency
22	Belgian	Director	Government agency

Source: Authors' elaboration

Figure 2 Framework drivers



Source: Author's elaboration

analysed competition-based approaches focus on tackling specific problems (i.e. a precise brief). For instance, Ninesigma supports its clients by offering "A structured service to find technology solutions, partners or experts to address a short-term, pressing technology gap". In contrast, other competition-based approaches focus on tackling broader innovation problems in which the solvers are free to work on the issues that they consider more interesting and valuable (i.e. a broad brief). For instance, Yet2.com has created a type of electronic showcase to enable every firm or person in the world to show and advertise new and interesting technologies: "yet2.com's TechPak listings enable companies to showcase their technology to the global community".

The cross-case analysis and the subsequent interviews with key informants showed that this variable is useful for helping policymakers customise their instruments for different targets and innovation purposes. Indeed, the choice of the scope breadth characterising the instrument does affect the degrees of freedom that participants can enjoy by joining the competition, as well as the possibility for the proponent to obtain valuable outputs. As stated by one regional government official: "When we think about a new set of regional grants, we always face some trade-offs. We need to decide how broad the call will be. A very broad brief will enable the participants to ideate and maybe propose very innovative solutions/approaches. On the contrary, a very precise brief will focus the effort of the participants toward the specific solutions we need".

4.1.2 Output required. The *output required* variable refers to the type of output required by the solver, which ranges from "proposal" to "solution". In some of the competition-based approaches analysed, participants (solvers) are asked to develop working solutions that address a specific need of a seeker. Once the seeker has selected the best solution, the process ends. For instance, Wazoku (former Innocentive) enables "Solvers to submit solutions to the challenge. The Seeker pays an award to the solver who best meets the solution requirements as outlined in the challenge". In other competition-based approaches, participants are asked to develop a proposal describing how they could address the innovation needs of the seeker. For instance, Ninesigma requires the participants in its competition-based approaches to deliver a Request for Proposal. As stated on the corporate website: "Request for Proposal (RFP) includes an outline of a proposed project in terms of timing, investment, and evaluation criteria. If NineSigma's client is interested in your proposal, you will negotiate the full scope of work, budget, duration, and other details directly with the client".

From the policymaker's perspective, the importance of the choice between proposal and solution lies in the effort required to solvers to deliver the requested output, which can hinder the participation of solvers that are endowed with limited resources. As a regional government official stated, "We could ask for working solutions. However, many potential participants, mainly SMEs, could lack the resources to enter this kind of project. On the contrary, we could ask for proposals and fund the execution of the project as described in

the proposal. But in this case, the approach would be riskier for the Region since we could finance projects that will not bring to the expected results".

4.1.3 Policy strategy. The *policy strategy* variable refers to the approaches that policymakers can adopt to exploit a competition-based approach as innovation policy instrument. Two different strategies emerge, whose main differences are summarised in Table 4.

Public institutions may directly play the seeker role (i.e. implementing a direct strategy) or enable other organisations to launch their own competitions to streamline innovation activities (i.e. implementing an indirect strategy).

On the one hand, through a direct strategy, a public institution can directly fund innovation activities through competition-based approaches that, for example, may impact the territory's economic and social development. The regional actors involved during the interviews have widely cited this strategy. For instance, a manager of a regional institution stated: "Lombardy is already playing an important role in the innovation landscape by directly funding innovation projects, for example, by exploiting public calls for proposals. It would be interesting to complement this approach with new policy instruments. The Region could choose the topics of the calls or of the prizes according to the social problems it has to tackle". On the other hand, through an indirect strategy, a public institution can play an enabling role by providing other organisations with *ad hoc* instruments that support them in exploiting the potential of competition-based approaches to foster their innovation activities. For example, a public institution can make a Web platform available to other organisations, which enables them to search for working solutions to their innovation problems, thus connecting the supply and demand for innovation.

Interestingly, the role played by the public institution affects the other characteristics of both strategies, that is, the actor in charge for the definition of the innovation topic to be addressed and the type of innovation topic addressed, as reported in Table 4.

In general, the policy strategy has been identified as the first variable to be defined by the policymakers while exploiting a competition-based innovation policy instrument. As stated by the Chief of Lombardy innovation office, "We have to decide first how the Region wants to foster innovation in terms of active (direct) or enabling (indirect) role, and then we can discuss the other aspects accordingly". In other words, policymakers must first choose the strategy to follow and then select the best approach (i.e. by properly addressing the other two variables), consistently with the chosen strategy).

4.2 A taxonomy of competition-based approaches

The ability of the three above-mentioned variables to discriminate among the different competition-based approaches was further confirmed by the answers obtained from the

Table 4 Main characteristics of direct and indirect strategies

Characteristics	*Direct strategy*	*Indirect strategy*
Role of the policymaker	It plays a "direct" role (i.e. as seeker) by defining how the firms are involved in the funding options	It plays an "indirect" role by developing an initiative to support innovation activities by firms (that work as seekers) and defining its rules
Actor in charge for the definition of the innovation topic	The policymaker (operating as seeker) defines the innovation topics on which the participants (operating as solvers) must work	The seeker (e.g. a firm) defines the innovation topic on which the participants (operating as solvers) must work
Type of innovation topic addressed	Participants are typically asked to solve societal problems	Participants are typically asked to solve problems that are useful for the seeker

Source: Authors' elaboration

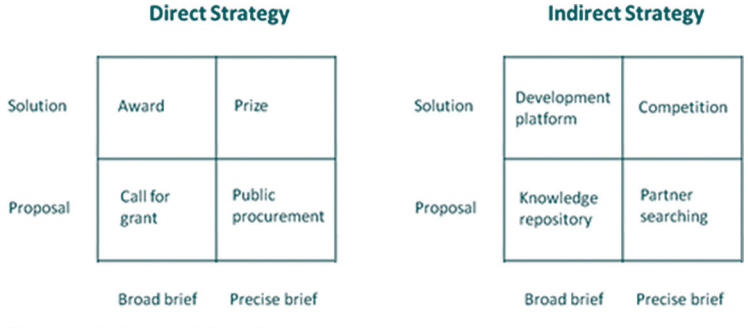
European policy experts involved through an *ad hoc* survey. Indeed, they fully agree that the three variables identified are relevant for clustering the different competition-based approaches. Moreover, the majority of respondents (62%) state that no other relevant variables should be considered to classify different competition-based policy instruments. Interestingly, some experts suggested a few additional variables that could be considered to further enrich the taxonomy of competition-based approaches. Such variables are primarily related to operative aspects, such as intellectual property rights considerations or how a firm can use the prize received. Regarding the latter, such evidence is consistent with the one collected by some of the interviewed key informants. As stated by a manager of a regional institution: "When talking about prizes, you should differentiate between prizes that are awarded without conditions (i.e., cash prizes that have no conditions on how the money can be spent or can be used for the general improvement of the winner – e.g., Queensland Tourism Innovation Awards – and "competitions"). In other words, is the competition a grant program whereby the funding must be used to support specific activities associated with the competition, or can the funding be used for purposes not associated with the competition itself?".

By leveraging the empirical analysis, a taxonomy including eight competition-based approaches to foster innovation by policymakers is proposed, as illustrated in Figure 3. The taxonomy was developed by first addressing the *Policy Strategy* (i.e. direct or indirect), which in turn affects the other characteristics of the related competition-based approaches. Therefore, two clusters of approaches are encompassed in the taxonomy, each one related to one of the two policy strategies identified. Each cluster includes four approaches, as a function of the features of the two other variables (i.e. *Scope breadth* and *Output Required*).

4.2.1 Direct strategy. Through a direct strategy, policymakers play an active role by operating as seeker as well as defining the topics on which the actors involved must work (usually addressing a societal problem) and rewarding them. In this domain, four different competition-based approaches are identified: Award, Prize, Call for grants and Public procurement.

4.2.1.1 Call for grants. A call for grants is an innovation policy instrument through which a policymaker defines the innovation problem to be solved or the scientific and technological field it wants to address via a broad brief. The firms (or researchers) answer the call by submitting a proposal that describes the project they would put in place to solve the innovation problem. Then, the public institution selects the best proposal(s) and finances or co-finances the execution of the project(s). Examples of Calls for Grants are the Seventh Framework program of the European Community or the calls for projects by the US National

Figure 3 Taxonomy of competition-based approaches to foster innovation by policymakers



Source: Author's elaboration

Science Foundation. Calls for grants are particularly useful in reducing the cost of specific innovation projects, for example, those related to environmental issues, which firms would not otherwise pursue.

4.2.1.2 Prize. A prize is an innovation policy instrument through which a policymaker offers a reward to the actor who is able to provide the best solution to a detailed innovation problem, which is shared via a precise brief. The (inducement) prize pushes several actors to compete to develop a solution to a specific innovation problem, and usually, the cumulative investments made by the participants in the prize are larger than the prize itself (Liotard and Revest, 2018). In other words, by increasing the demand for innovation, the prize stimulates the development of different solutions characterised by different development paths. A relevant example of this instrument is the L-Prize initiative promoted by the US Department of Energy.

4.2.1.3 Award. An award is an innovation policy instrument that targets a specific solution to be developed. Unlike a Prize, the solution is not developed starting from a precise brief but from considerations related to a broad field or a wide social problem (i.e. a broad brief). A relevant example is the #EuvsVirus, which awards the efforts carried out by multi-disciplinary and multi-nationality teams with innovative solutions to fight against the social, economic and health consequences of coronavirus pandemic. In this vein, a public institution can support research and innovation by offering, even on a recurrent basis (e.g. annual basis), an award related to different disciplines or social problems (e.g. sustainability and health care).

4.2.1.4 Public procurement. A public procurement is an innovation policy instrument that requires participants (e.g. firms) to submit a proposal to solve an innovation problem defined by a public institution, which is shared via a detailed brief. Participants should be able to demonstrate the feasibility of the proposed solution. For instance, in 2011, the Lombardy region launched a Public procurement initiative to promote the development of energy-efficient components for its public transportation system. Within the proposal, participants were asked to prove the technical feasibility of the developed solution.

4.2.2 Indirect strategies. Through an indirect strategy, policymakers play an enabling role by providing *ad hoc* services (especially Web-based ones) to support other actors (e.g. firms) in exploiting competition-based approaches to foster their innovation activities. Hence, such actors define the problems, and their main benefits in exploiting such mechanisms refer to the possibility of tackling their innovation problems, developing new expertise and interacting with solvers. Four different competition-based approaches are identified in this domain: Competition, Development platform, Knowledge repository and Partner searching.

4.2.2.1 Competition. A competition is an innovation policy instrument that requires the public institution to make a Web platform available to other actors (e.g. firms) that enables them to search for working solutions to their innovation problems, which are shared via a precise brief. Firms can organise a contest involving potential solvers through the Web platform. This approach resembles the innovation contest adopted by innovation intermediaries, such as Qmarkets and Wazoku, in the private sector. An interesting example refers to the Open Innovation platform created by the Lombardy Region. Through such instruments, policymakers can build innovation contest systems for specific fields, co-finance the monetary rewards for projects of interest for the territory or even post their own briefs to tackle specific territorial problems. Hence, this approach may be useful for a Region to increase the demand for innovation by creating a market for innovation.

4.2.2.2 Development platform. A development platform is an innovation policy instrument through which a policymaker provides a Web platform that makes it easier to connect the demand and offer for innovation. Moreover, other complementary assets that can be offered by policymaker refer to facilities and/or public spaces, as well as data and other infrastructures that could be made available for actors (e.g. firms) interested in leveraging them to develop innovative products or services. This instrument enables firms to create

and sell working solutions to a specific market without following a precise brief. In the private sector, one of the most famous examples of this approach is represented by the Apple Store, where developers sell working applications (i.e. solutions) they develop for the iPhone or iPad without following a precise brief and advertise them through the store. Similarly, the US Government exploited this approach via the US National Innovation Marketplace. By leveraging this platform, "your invention might be found by a buyer searching the marketplace".

4.2.2.3 Knowledge repository. A knowledge repository is an innovation policy instrument that requires the public institution to make a Web platform available to other actors (e.g. firms) that can advertise their expertise or propose innovation projects without sharing a precise brief. This instrument supports innovation by making it easier for such actors to understand the expertise that can be found in a territory. The innovation effort is left to these actors in terms of identifying the innovation problem on which to work, as well as determining the effort to develop the solution. A relevant example of this instrument developed in the Lombardy region refers to QuESTIO (Quality Evaluation in Science and Technology for Innovation Opportunity), that is, a tool designed by the Lombardy region to promote the innovation ecosystem through the mapping of Research and innovation centres, productive activities and technology clusters in the Lombardy region. The tool aims to offer visibility to registered subjects, mapping skills, infrastructures, networks and collaborations of productive activities active in the field of innovation, as well as promote the exchange of knowledge between innovation centres and production activities, the development of collaborations and networks, both within the technical-scientific community and towards the business world and the innovation services offered by individuals.

4.2.2.4 Partner searching. Partner searching is an innovation policy instrument through which a public institution may support other actors (e.g. firms) in finding the right partners to collaborate with to solve specific innovation problems. The public institution makes a Web tool available to actors having a specific innovation problem to be solved, to support them in searching for the most appropriate innovation partner. Example of this innovation policy instrument is Eupartnersearch. This platform allows organisations and people to not only disseminate their projects and related progresses for free to accelerate and make easier the finding of experienced partners but also find project ideas to support. In particular, this platform fosters the exchange of ideas and the establishment of partnership among European entities as well as the development of new practice for training and education. In the private sector, many platforms that offer similar services do exist. For instance, Crowdspring allows firms to publish a precise brief that describes the innovation problem to be addressed (i.e. a design issue such as logos, websites, product packaging or product designs). Then potential solvers (i.e. designers) communicate their interest in the innovation problem by sharing a concept based on the brief and receive feedback from the firm to improve it. Finally, the firm chooses the best proposal and manage price negotiation to close the agreement with the selected solver.

4.3 The positioning of competition-based approaches among innovation policy instruments

The eight competition-based approaches identified are then discussed against the taxonomy of innovation policy instruments proposed by Edler and Georghiou (2007) introduced in Section 2.2.

Regarding the direct strategy, two of the identified competition-based approaches were already included in this taxonomy, that is, Call for grants (as "Grant for Industrial R&D") as supply-side measure and Public procurement (as "Public Procurement Policies" within the above-mentioned taxonomy) as demand-side measure. Instead, Award and Prize represent two additional innovation policy instruments based on competition-based approaches that were not included in the taxonomy. In particular, both instruments offer a reward for the

achievement of a predefined innovation objective, thus creating or reinforcing the demand for innovation. Therefore, such measures can be mainly considered as demand-side measures.

Considering the indirect strategy, Knowledge repository and Partner searching – which favour innovation by making it easier for actors such as firms to access external partners and expertise (i.e. supply-side measures), thus improving the environment (i.e. the innovation system) in which they exert their innovation effort – were already included in the taxonomy, as "Information & Brokerage Support". Instead, Competition and Development platform were not included in the taxonomy. These measures stimulate innovations by providing platforms through which firms can foster their innovation activities, therefore being supply-side measures. Thus, similarly to the service measures that Edler and Georghiou (2007) have identified, Competition and Development Platforms can be conceived of as service supply-side measures, as they represent a platform-based service offered by a public institution to make the market for innovations more effective. Table 5 summarises the relationships between the existing taxonomy and the competition-based policy measures identified in the study.

Finally, Figure 4 shows how the competition-based approaches identified are integrated within the Edler and Georghiou (2007) taxonomy of innovation policy instruments to obtain a more comprehensive taxonomy of such instruments.

5. Conclusions

In the past years, competition-based approaches have gained increasing attention by innovation management scholars and practitioners (Letina and Schmutzler, 2019), as they can have a pivotal role in supporting companies in advancing research and technology and acquiring externally generated knowledge to address unsolved innovation issues, as well as increasing public and sectoral awareness on specific issues affecting the society (Kay, 2011). However, despite they have been recognised as valuable policy instruments that policymakers can exploit to support innovation and in particular external knowledge search, a limited attention has been devoted so far to such approaches from the policymakers' perspective. In particular, there is a lack of studies characterising the peculiarities of competition-based approaches suitable for policymakers with respect to those exploited by the private sector, as well as positioning them among innovation policy instruments (Kay, 2011). Therefore, this study explored the crucial and under-researched topic of which competition-based approaches can be exploited by policymakers as innovation policy instruments to foster external knowledge search by developing a novel taxonomy including eight competition-based approaches. Moreover, the identified competition-based approaches are contextualised among the innovation policy instruments by enriching a well-established taxonomy of such instruments.

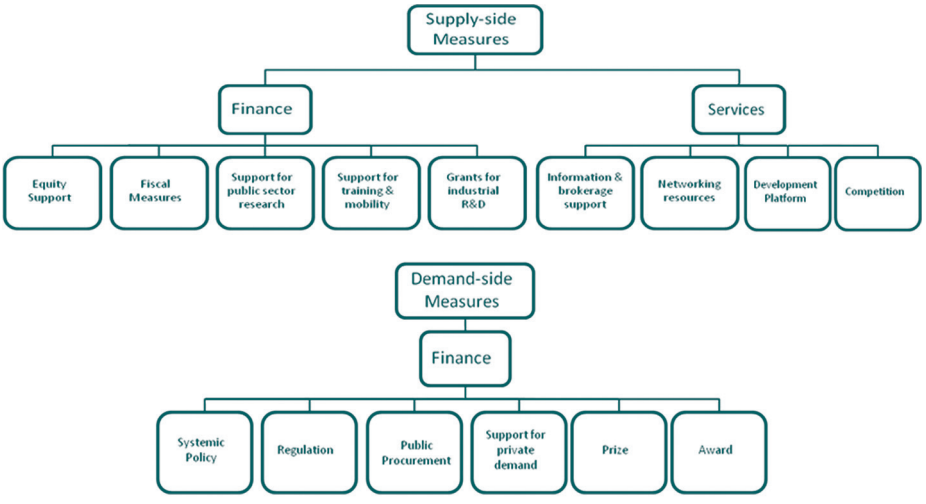
Our study provides different theoretical contributions. First, we add to the current innovation policy literature, by identifying a set of (eight) competition-based approaches that policymakers

Table 5 Relationship between the identified competition-based approaches and the innovation policy instruments proposed by Edler and Georghiou (2007)

Competition-based approaches		Innovation policy instrument proposed by *Edler and Georghiou (2007)*
Direct strategy	Call for Grants	Grant for Industrial R&D
	Public Procurement	Public Procurement
	Prize	*New category*
	Award	*New category*
Indirect strategy	Knowledge repository	Information & Brokerage support
	Partner searching	Information & Brokerage support
	Development Platform	*New category (Services)*
	Competition	*New category (Services)*

Source: Authors' elaboration

Figure 4 Innovation policy measures framework considering competition-based approaches



Source: Author's elaboration – extension of the framework proposed by Edler and Georghiou (2007)

can implement to stimulate innovation; only four of these approaches were already addressed within the extant literature (Edler and Georghiou, 2007). Accordingly, the study contributes to the extant literature by filling the gap on the lack of a comprehensive categorisation of the different competition-based approaches that can be exploited by policymakers to stimulate innovation and their positioning among the broader innovation policy instruments, thus providing policymakers with a reference framework to develop innovation policies based on competition-based approaches to stimulate innovation by policymakers, consistently with their strategies and objectives (Jugend *et al.*, 2020). Second, the study adds to the sparkling debate on open innovation by proposing specific (innovation policy) instruments that may help policymakers and practitioners to promote innovation projects consistently with open innovation principles (Chesbrough, 2006, 2009). Such instruments have been recognised as a critical aspect to stimulate a higher diffusion of open innovation, even among SMEs (Vanhaverbeke *et al.*, 2018). Third, our study shows how a policymaker may foster innovation by designing and implementing different types of competition-based approaches. Therefore, we contribute to the innovation policy literature by discussing on how policy strategies, as well as the scope breadth and output required, do affect the specific competition-based approach to be chosen (Adamczyk *et al.*, 2012; Kokshagina *et al.*, 2017). For these reasons, the present study also contributes to the extant literature on knowledge management by unveiling the features of different types of competition-based approaches that can be exploited by policymakers, which may affect the most suitable knowledge management approaches and tools to be adopted to manage them in an effective way (Natalicchio *et al.*, 2017).

Our study provides a number of practical contributions too, especially for policymakers. First, policymakers can support their innovation policy decisions by considering the full array of alternatives (i.e. innovation policy instruments) included in the enriched taxonomy. This is particularly useful to identify the most suitable policy instruments consistently with policy strategies and objectives, also in the light of resource constraints catheterising the public sector. Second, the research indicates a new set of instruments that policymakers can use to stimulate innovations on the demand side, in addition to supply side. In particular, policymakers can increase the demand for innovations by creating specific

platforms in which firms can exchange innovations among themselves, without a direct financial support from the public institution. Third, public institutions may consider adopting some of the identified and presented instruments related to a competition-based approach to accelerate the discovery and implementation of innovative solutions to tackle the emerging crisis and the subsequent recovery.

This study is not exempt from limitations. First, the paper has an exploratory intent, and the sample of analysed cases is quite small. To address this limitation, we aimed to maximise the generalizability of our study by reviewing the most diffused competition-based experiences involving policymakers and other key informants in one of the most advanced regions in Europe such as Lombardy and by further involving European experts through a survey. Interestingly, the result of the survey supports the findings of previous empirical investigations. Nevertheless, given the qualitative nature of the data as well as the sample size, future confirmatory quantitative research could be useful to further increase the generalizability of our findings (Yin, 1984). Moreover, given that the empirical investigation is based on the involvement of key informants based in Italy (and especially in Lombardy) as well as in Europe, further studies may test the applicability of the different competition-based approaches proposed in different cultural contexts to bring into light similarities and differences and, thus, potentially increasing the generalizability of results.

Second, a discussion on the applicability and effectiveness of the proposed instruments with reference to different types of actors involved (e.g. SMEs vs large corporations) is missing, also in the light of firms' capabilities in accessing such instruments (Fiorentin *et al.*, 2021). We hope that our work will inspire other researchers to engage in such an effort, which we consider highly relevant for informing policymakers interested in promoting innovation policies. For instance, it would be very interesting to analyse the problem from the SMEs' perspective. Indeed, extant literature recognises that the external knowledge search may be risky (Fleming, 2001) and require dedicated resources that SMEs not always own (Leckel *et al.*, 2020; Hervas-Oliver *et al.*, 2021). Interestingly, from discussions with the key informants in the Lombardy region, it emerged that SMEs could encounter difficulties in benefitting from some competition-based approaches, such as public prizes because, because of the related costs they must sustain up-front, without being sure of winning the competition. Another related issue that opens up interesting avenues for future research refers to the identification of knowledge management approaches and tools that must be adopted to manage the different competition-based in an effective way, whose identification could require more fine-grained analyses that deeply explore the features of different types of competition-based approach (e.g. by using the design elements proposed by Doppio *et al.*, 2020).

Finally, we acknowledge that the different competition-based approaches for policymakers to foster innovation that we propose are presented and discussed as single approaches. It would be interesting to investigate how to combine different approaches in a structured way to obtain a higher effect on specific innovation problems (Borrás and Edquist, 2013).

Note

1. Annuario Statistico Regionale Lombardia (2022) available at: www.asr-lombardia.it//asrlomb/it/13548regioniprodotto-interno-lordo-principali-regioni-europee?t=Tabella&restrictBy=CCANNO_63889777=2020

References

Adamczyk, S., Bullinger, A.C. and Möslein, K.M. (2012), "Innovation contests: a review, classification and outlook", *Creativity and Innovation Management*, Vol. 21 No. 4, pp. 335-360.

Aschhoff, B. and Sofka, W. (2009), "Innovation on demand – can public procurement drive market success of innovations?", *Research Policy*, Vol. 38 No. 8, pp. 1235-1247.

Baruffaldi, S. and Landoni, P. (2012), "Return mobility and scientific productivity of researchers working abroad: the role of home country linkages", *Research Policy*, Vol. 41 No. 9, pp. 1655-1665.

Billings, A., Glazunov, S. and Houston, M. (2001), "The role of taxes in corporate research and development spending", *R&D Management*, Vol. 31 No. 4, pp. 465-477.

Borrás, S. and Edquist, C. (2013), "The choice of innovation policy instruments", *Technological Forecasting and Social Change*, Vol. 80 No. 8, pp. 1513-1522.

Boudreau, K.J. and Lakhani, K.R. (2009), "How to manage outside innovation", *MIT Sloan Management Review*, Vol. 50 No. 4, pp. 69-76.

Boudreau, K.J. and Lakhani, K.R. (2013), "Using the crowd as an innovation partner", *Harvard Business Review*, Vol. 91 No. 4, pp. 60-69.

Boudreau, K.J., Lacetera, N. and Lakhani, K.R. (2011), "Incentives and problem uncertainty in innovation contests: an empirical analysis", *Management Science*, Vol. 57 No. 5, pp. 843-863.

Brunt, L., Lerner, J. and Nicholas, T. (2008), "Inducement prizes and innovation", CEPR Discussion Paper. No. DP6917. Centre for Economic Policy Research, London.

Bullinger, A.K., Neyer, A.K., Rass, M. and Moeslein, K.N. (2010), "Community-based innovation contests: where competition meets cooperation", *Creativity and Innovation Management*, Vol. 19 No. 3, pp. 290-303.

Burstein, M.J. and Murray, F.E. (2016), "Innovation prizes in practice and theory", *Harvard Journal of Law & Technology*, Vol. 29 No. 2, p. 401.

Caragliu, A., Coletti, M., Landoni, P. and Sala, A. (2022), "Why and how innovation vouchers work: disentangling the roles of serendipity and funding", *Journal of Urban Technology*, Vol. 29 No. 3, pp. 1-24.

Chesbrough, H. (2006), *Open Business Models: How to Thrive in the New Innovation Landscape*, Harvard Business School Press, Boston, MA.

Chesbrough, H. (2009), "Open R&D and open innovation: exploring the phenomenon", *R&D Management*, Vol. 39 No. 4, pp. 311-316.

Chesbrough, H. and Bogers, M. (2014), "Explicating open innovation – clarifying an emerging paradigm for understanding innovation", in Chesbrough, H., Vanhaverbeke, W. and West, J. (Eds), *New Frontiers in Open Innovation*, Oxford University Press, Oxford.

Colombo, G., Buganza, T., Klanner, I.M. and Roiser, S. (2013), "Crowdsourcing intermediaries and problem typologies: an explorative study", *International Journal of Innovation Management*, Vol. 17 No. 2, p. 1350005.

Danto, E.A. (2008), *Historical Research*, Oxford University Press, New York, NY.

Doppio, N., Väinämö, S. and Haukipuro, L. (2020), "Design elements of innovation contests supporting open innovation in SMEs-an action research study", *Journal of Innovation Management*, Vol. 8 No. 4, pp. 26-56.

Edler, J. and Fagerberg, J. (2017), "Innovation policy: what, why, and how", *Oxford Review of Economic Policy*, Vol. 33 No. 1, pp. 2-23.

Edler, J. and Georghiou, L. (2007), "Public procurement and innovation – resurrecting the demand side", *Research Policy*, Vol. 36 No. 7, pp. 949-963.

Edler, J., Gök, A., Cunningham, P. and Shapira, P. (2016), "Introduction: making sense of innovation policy", *Handbook of Innovation Policy Impact*, Edward Elgar Publishing, Cheltenham, pp. 1.-17.

Eisenhardt, K.M. (1989), "Building theories from case study research", *The Academy of Management Review*, Vol. 14 No. 4, pp. 532-550.

Eisenhardt, K.M. and Graebner, M.E. (2007), "Theory building from cases: opportunities and challenges", *Academy of Management Journal*, Vol. 50 No. 1, pp. 25-32.

Fernández-Esquinas, M. and Ramos-Vielba, I. (2011), "Emerging forms of cross-sector collaboration in the Spanish innovation system", *Science and Public Policy*, Vol. 38 No. 2, pp. 135-146.

Ferradas, M.I.R., Tanco, J.A.A. and Sandulli, F. (2017), "Relevant factors of innovation contests for SMEs", *Business Process Management Journal*, Vol. 23 No. 6, pp. 1196-1215.

Fiorentin, F., Suárez, D. and Yoguel, G. (2021), "Who benefits from innovation policy? The role of firms' capabilities in accessing public innovation funding", *Innovation and Development*, Vol. 13 No. 1, pp. 1-18.

Fleming, L. (2001), "Recombinant uncertainty in technological search", *Management Science*, Vol. 47 No. 1, pp. 117-132.

Franzò, S., Doppio, N., Natalicchio, A., Frattini, F. and Mion, L. (2023), "Designing innovation contests to support external knowledge search in small and medium-sized enterprises", *Technovation*, Vol. 121, p. 102684.

Gök, A., Li, Y., Cunningham, P., Edler, J. and Laredo, P. (2016), "Towards a taxonomy of science and innovation policy instruments", *EU SPRI Conference Lund*, June 2016.

Grant, R.M. (1996), "Toward a knowledge-based theory of the firm", *Strategic Management Journal*, Vol. 17 No. S2, pp. 109-122.

Herstad, S.J., Bloch, C., Ebersberger, B. and van de Velde, E. (2010), "National innovation policy and global open innovation: exploring balances, trade-offs and complementarities", *Science and Public Policy*, Vol. 37 No. 2, pp. 113-124.

Hervas-Oliver, J.L., Sempere-Ripoli, F. and Boronat-Moll, C. (2021), "Technological innovation typologies and open innovation in SMEs: beyond internal and external sources of knowledge", *Technological Forecasting and Social Change*, Vol. 162, p. 120338.

Howells, J. (2006), "Intermediation and the role of intermediaries in innovation", *Research Policy*, Vol. 35 No. 5, pp. 715-728.

Huston, L. and Sakkab, N. (2006), "Connect and develop", *Harvard Business Review*, Vol. 84 No. 3, pp. 58-66.

Jeppesen, L.B. and Lakhani, K.R. (2010), "Marginality and problem-solving effectiveness in broadcast search", *Organization Science*, Vol. 21 No. 5, pp. 1016-1033.

Jugend, D., Fiorini, P.D.C., Armellini, F. and Ferrari, A.G. (2020), "Public support for innovation: a systematic review of the literature and implications for open innovation", *Technological Forecasting and Social Change*, Vol. 156, p. 119985.

Kay, L. (2011), "The effect of inducement prizes on innovation: evidence from the Ansari X prize and the Northrop Grumman Lunar Lander challenge", *R&D Management*, Vol. 41 No. 4, pp. 360-377.

Kay, L. (2012), "Opportunities and challenges in the use of innovation prizes as a government policy instrument", *Minerva*, Vol. 50 No. 2, pp. 191-196.

Klein Woolthuis, R., Lankhuizen, M. and Gilsing, V. (2005), "A system failure framework for innovation policy design", *Technovation*, Vol. 25 No. 6, pp. 609-619.

Kokshagina, O., Gillier, T., Cogez, P., Le Masson, P. and Weil, B. (2017), "Using innovation contests to promote the development of generic technologies", *Technological Forecasting and Social Change*, Vol. 114, pp. 152-164.

Lanzolla, G., Pesce, D. and Tucci, C.L. (2021), "The digital transformation of search and recombination in the innovation function: tensions and an integrative framework", *Journal of Product Innovation Management*, Vol. 38 No. 1, pp. 90-113.

Lauritzen, G.D. (2017), "The role of innovation intermediaries in firm-innovation community collaboration: navigating the membership paradox", *Journal of Product Innovation Management*, Vol. 34 No. 3, pp. 289-314.

Laursen, K. and Salter, A. (2006), "Open for innovation: the role of openness in explaining innovation performance among UK manufacturing firms", *Strategic Management Journal*, Vol. 27 No. 2, pp. 131-150.

Leckel, A., Veilleux, S. and Dana, L.P. (2020), "Local open innovation: a means for public policy to increase collaboration for innovation in SMEs", *Technological Forecasting and Social Change*, Vol. 153, p. 119891.

Letina, I. and Schmutzler, A. (2019), "Inducing variety: a theory of innovation contests", *International Economic Review*, Vol. 60 No. 4, pp. 1757-1780.

Lichtenthaler, U. (2013), "The collaboration of innovation intermediaries and manufacturing firms in the markets for technology", *Journal of Product Innovation Management*, Vol. 30 No. 51, pp. 142-158.

Lichtenthaler, U. and Ernst, H. (2008a), "Intermediary services in the markets for technology: organisational antecedents and performance consequences", *Organization Studies*, Vol. 29 No. 7, pp. 1003-1035.

Lichtenthaler, U. and Ernst, H. (2008b), "Innovation intermediaries: why internet marketplaces for technology have not yet met the expectations", *Creativity and Innovation Management*, Vol. 17 No. 1, pp. 14-25.

Liotard, I. and Revest, V. (2018), "Contests as innovation policy instruments: lessons from the US federal agencies' experience", *Technological Forecasting and Social Change*, Vol. 127, pp. 57-69.

Masters, W.A. and Delbecq, B. (2008), "Accelerating innovation with prize rewards history and typology of technology prizes and a new contest design for innovation in African agriculture", IFPRI Discussion Paper 00835.

Matricano, D., Candelo, E., Sorrentino, M. and Martínez-Martínez, A. (2019), "Absorbing in-bound knowledge within open innovation processes. The case of Fiat Chrysler automobiles", *Journal of Knowledge Management*, Vol. 23 No. 4, pp. 786-807.

Mazzucato, M. (2011), *The Entrepreneurial State*, Demos, London.

Mele, G., Sansone, G., Secundo, G. and Paolucci, E. (2022), "Speeding up student entrepreneurship: the role of university business idea incubators", *IEEE Transactions on Engineering Management*.

Mergel, I. and Desouza, K.C. (2013), "Implementing open innovation in the public sector: the case of challenge", *Gov. Public Administration Review*, Vol. 73 No. 6, pp. 882-890.

Murray, F., Stern, S., Campbell, G. and MacCormack, A. (2012), "Grand innovation prizes: a theoretical, normative, and empirical evaluation", *Research Policy*, Vol. 41 No. 10, pp. 1779-1792.

Natalicchio, A., Ardito, L., Savino, T. and Albino, V. (2017), "Managing knowledge assets for open innovation: a systematic literature review", *Journal of Knowledge Management*, Vol. 21 No. 6, pp. 1362-1383.

Nelson, R.R. (1959), "The simple economics of basic scientific research", *Journal of Political Economy*, Vol. 67 No. 3, pp. 297-306.

Patrucco, A.S., Trabucchi, D., Frattini, F. and Lynch, J. (2022), "The impact of Covid-19 on innovation policies promoting open innovation", *R&D Management*, Vol. 52 No. 2, pp. 273-293.

Pollok, P., Lüttgens, D. and Piller, F.Y. (2019), "How firms develop capabilities for crowdsourcing to increase open innovation performance: the interplay between organizational roles and knowledge processes", *Journal of Product Innovation Management*, Vol. 36 No. 4, pp. 412-441.

Randhawa, K., Josserand, E., Schweitzer, J. and Logue, D. (2017), "Knowledge collaboration between organizations and online communities: the role of open innovation intermediaries", *Journal of Knowledge Management*, Vol. 21 No. 6, pp. 1293-1318.

Randhawa, K., Wilden, R. and Gudergan, S. (2018), "Open service innovation: the role of intermediary capabilities", *Journal of Product Innovation Management*, Vol. 35 No. 5, pp. 808-838.

Ritala, P. and Stefan, I. (2021), "A paradox within the paradox of openness: the knowledge leveraging conundrum in open innovation", *Industrial Marketing Management*, Vol. 93, pp. 281-292.

Rodriguez Ferradas, M.I., Alfaro Tanco, J.A. and Sandulli, F. (2017), "Relevant factors of innovation contests for SMEs", *Business Process Management Journal*, Vol. 23 No. 6, pp. 1196-1215.

Rolfstam, M. (2009), "Public procurement as an innovation policy tool: the role of institutions", *Science and Public Policy*, Vol. 36 No. 5, pp. 349-360.

Rothwell, R. and Zegveld, W. (1981), "Government regulations and innovation – industrial innovation and public policy, London", in Rothwell, Roy and Zegveld, W. (Eds), *Industrial Innovation and Public Policy*, Frances printer, London, pp. 116-147.

Schenk, E., Guittard, C. and Pénin, J. (2019), "Open or proprietary? Choosing the right crowdsourcing platform for innovation", *Technological Forecasting and Social Change*, Vol. 144, pp. 303-310.

Schroeder, A. (2004), *The Application and Administration of Inducement Prizes in Technology*, Independence Institute, Golden, CO.

Stuart, T.E. and Podolny, J.M. (1996), "Local search and the evolution of technological capabilities", *Strategic Management Journal*, Vol. 17 No. S1, pp. 21-38.

Terwiesch, C. and Xu, Y. (2008), "Innovation contests, open innovation, and multiagent problem solving", *Management Science*, Vol. 54 No. 9, pp. 1529-1543.

Tseng, C.-Y., Pai, D.C. and Hung, C.-H. (2011), "Knowledge absorptive capacity and innovation performance in KIBS", *Journal of Knowledge Management*, Vol. 15 No. 6, pp. 971-983.

Van Looy, B., Landoni, P., Callaert, J., Van Pottelsberghe, B., Sapsalis, E. and Debackere, K. (2011), "Entrepreneurial effectiveness of European universities: an empirical assessment of antecedents and trade-offs", *Research Policy*, Vol. 40 No. 4, pp. 553-564.

Vanhaverbeke, W., Frattini, F., Roijakkers, N. and Usman, M. (Eds) (2018), *Researching Open Innovation in SMEs*, World Scientific, Singapore.

Vignieri, V. (2020), "Crowdsourcing as a mode of open innovation: exploring drivers of success of a multisided platform through system dynamics modelling", *Systems Research and Behavioral Science*, Vol. 38 No. 1, pp. 1-17.

West, J. and Lakhani, K.R. (2008), "Getting clear about the role of communities in open innovation", *Industry & Innovation*, Vol. 15 No. 2, pp. 223-231.

Williams, H. (2012), "Innovation inducement prizes: connecting research to policy", *Journal of Policy Analysis and Management*, Vol. 31 No. 3, pp. 752-76.

Yin, R.K. (1984), *Case Study Research*.

Zahra, S.A. and George, G. (2002), "Absorptive capacity: a review, reconceptualization, and extension", *The Academy of Management Review*, Vol. 27 No. 2, pp. 185-203.

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