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Managing proof-of-concept (PoC) programs in public research organizations: a dynamic capabilities perspective

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Abstract

Purpose – This paper aims to explore how the implementation of gap funding instruments such as Proof-of-Concept (PoC) programs can contribute to developing dynamic capabilities in Public Research Organizations (PROs). The research investigates the processes and practices underlying PoC programs that may provide potential foundations for dynamic capabilities (i.e. organizational microfoundations) in PROs operating within a technology transfer setting.

Design/methodology/approach – We conducted an exploratory qualitative study through 37 interviews with the employees of PROs involved in the valorization of 155 technologies within 24 PoC programs. We iteratively triangulated those data with secondary sources.

Findings – We identified four key processes (i.e. management, selection, monitoring and valorization) and their associated practices that act as organizational microfoundations, enhancing the emergence of dynamic capabilities in PROs. We articulated six propositions to advance theoretical understandings about gap funding instruments and dynamic capabilities in technology transfer settings.

Originality/value – This study extends prior research on gap funding instruments by examining the less explored processes and practices underpinning PoC programs, demonstrating their role in enhancing PROs to foster external engagement and adaptation to fast-changing environments. Furthermore, it contributes to dynamic capabilities literature by unpacking those microfoundations that enable PROs to build sensing, seizing and reconfiguring capabilities when interacting with the external environment.

Keywords Dynamic capabilities, Technology transfer, Proof-of-Concept, Universities, Public research organizations

Paper type Research paper

1. Introduction

The transfer of technology from Public Research Organizations (PROs) [1] to the external environment, and more specifically, the instruments to facilitate this process have been the object of a growing and passionate debate in the past decades among both researchers (e.g. Siegel *et al.*, 2003; Gattringer *et al.*, 2014; Battaglia *et al.*, 2021a) and policymakers (European Commission, 2021). Prior research has often argued that the constantly evolving context in which PROs operate has led them to start adopting various types of gap funding instruments to better adapt to the challenges of technology transfer (Kochenkova *et al.*, 2016; Munari *et al.*, 2018).

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This process requires PROs to integrate, build and reconfigure internal and external resources and competencies to address the needs of their dynamic external environment coherently with their mission and objectives (Heaton *et al.*, 2019). Regarding such a process, some scholars recognize that dynamic capabilities (e.g. Teece, 2007) play a pivotal role for PROs in embracing changes (O'Reilly *et al.*, 2019) and more proactively engaging with external stakeholders (Leih and Teece, 2016). However, there is still a general lack of understanding of how those capabilities may be effectively developed and deployed. This is particularly relevant when it comes to considering the underlying processes and practices that may provide potential foundations (i.e. organizational microfoundations) for developing dynamic capabilities in the adoption of gap funding instruments specifically designed to facilitate technology transfer (Passarelli *et al.*, 2018; Hayter *et al.*, 2020).

Among such instruments, one of the solutions that has received growing scholarly attention is represented by the so-called Proof-of-Concept (PoC) programs (Rasmussen and Sørheim, 2012; Passarelli *et al.*, 2020; Munari and Toschi, 2021). They are programs designed to increase the readiness level of early-stage research-based inventions and, therefore, their attractiveness to external actors such as firms or investors (Battaglia *et al.*, 2021b). These programs provide funding and resources to overcome some of the most diffused barriers to innovation (Das *et al.*, 2017), bridging the gap between the very first inventive phases of a solution and its market entry (Kochenkova *et al.*, 2016; Munari *et al.*, 2017). PoC programs are indeed particularly important for inventions generated in the context of public research since PROs often lack the resources to take them toward higher levels of maturity and make them more commercially attractive (Munari *et al.*, 2016; Passarelli *et al.*, 2020; Paget *et al.*, 2024).

Given the emerging relevance of gap funding instruments in research and practice (Munari and Toschi, 2021) and the need to unpack the organizational microfoundations that lead to the emergence of dynamic capabilities when PROs pursue technology transfer (Yuan *et al.*, 2018; Heaton *et al.*, 2019), PoC programs can represent a valuable setting to address this issue. Investigating how processes and practices related to the implementation of PoC programs may contribute to reshaping PROs' capabilities (Munari *et al.*, 2017; Battaglia *et al.*, 2021b), our work attempts to answer the following explorative research question: *How does the implementation of PoC programs contribute to the development of dynamic capabilities in PROs?* We carried out an exploratory qualitative study on 24 PoC programs involving 155 technologies within a national policy action in Italy between 2019 and 2022. We interviewed 37 PROs' managers involved in the implementation of these programs and triangulated such primary sources with secondary ones collected at the end of the programs. The Italian scenario and the time frame selected may represent a unique perspective on a national context which has experienced fast growth despite its position as a latecomer with respect to other countries. In particular, the years that we investigated reflect a process of important transformation characterized by both an internally pushed rearrangement of PROs' organizational structures (Battaglia *et al.*, 2017) and an external pull by specific policy instruments (Micozzi *et al.*, 2021).

Our research revealed the existence of four processes and a set of practices that act as organizational microfoundations through which PoC programs enhance the emergence of dynamic capabilities in PROs. Based on those findings, we articulated six propositions to advance our theoretical understanding of gap funding instruments and dynamic capabilities in technology transfer settings.

We therefore contribute to research on gap funding instruments by investigating the less studied but no less important processes and practices that underpin PoC programs, revealing how they can contribute to PROs' external engagement toward a successful transfer of their technologies (Grimaldi *et al.*, 2011; De Moortel and Crispeels, 2018; Giuri *et al.*, 2019). While previous research recognized PoC programs among the possible instruments that can complement the technology transfer activities of PROs (Rasmussen and Rice, 2012; Munari *et al.*, 2016), we argue that the implementation of those programs can represent a preliminary

step toward a reconfiguration of PROs to address the challenging nature of their fast-changing external environment (Flores *et al.*, 2024). Furthermore, while qualitative scholars have examined PoC programs separately (e.g. Passarelli *et al.*, 2018; Battaglia *et al.*, 2021b), there is no evidence of a qualitative study that investigates them from a microfoundations perspective and considering such a range of comparable projects and PROs.

We also contribute to the literature on dynamic capabilities (Teece, 2007) by unpacking the microfoundations that enable PoC programs to facilitate the emergence of sensing, seizing and reconfiguring capabilities in the technology transfer process. We extend the research effort of Giudici *et al.* (2018) on rethinking dynamic capabilities as the result of interactions with external actors, offering empirical evidence in the unique context of PROs, often overlooked by dynamic capabilities scholars (Yuan *et al.*, 2018).

2. Literature review

2.1 Gap funding instruments in PROs

The progressive establishment of a knowledge-based economy has further increased the importance of the role of public research and its organization (Bercovitz and Feldman, 2006; Battaglia *et al.*, 2017; Baglieri *et al.*, 2018). Similarly, national innovation systems increasingly depend on the valorization of science and technology developed within PROs and on their capacity to generate impact (Fini *et al.*, 2018; Plantec *et al.*, 2023). Within this framework, technology transfer from public research has fully assumed a strategic value for all global economies (Benneworth and Cunha, 2015; De Moortel and Crispeels, 2018) and the so-called "third mission" of PROs has made significant inroads in addition to teaching and research activities (Cesaroni and Piccaluga, 2016). This ongoing process directly reflects a constant transformation of PROs in terms of technology transfer to better deal with the emerging needs related to the constantly evolving context in which PROs operate (Battaglia *et al.*, 2017; Cucino *et al.*, 2021). However, these dynamic contexts are characterized by extreme complexity, especially when considering the transfer of early-stage technologies (Calza *et al.*, 2020; Kruger and Steyn, 2020; Heaton *et al.*, 2023).

For this reason, policymakers and PROs have been investing in the creation of specific instruments to facilitate the technology transfer process with the specific aim of bridging the financing gap from the public side by increasing the attractiveness of technologies for potential investors or other external stakeholders (Rasmussen and Rice, 2012; Audretsch and Caiazza, 2016). As discussed by Munari *et al.* (2018), these solutions are commonly recognized as gap funding instruments, but they tend to vary in several ways, according to the PROs involved, the investors or the industrial counterpart with whom PROs interact and the context in which the PROs operate.

Munari *et al.* (2016) claim that there is a wide variety of gap funding instruments in Europe and abroad. Comparing investments in PROs between Europe and the USA, Croce *et al.* (2014) provide a detailed description of the phenomenon of technology transfer-oriented Venture Capital that acts as private investments designed to support PROs' entrepreneurship financing the development of early-stage technologies. Those kinds of solutions are designed to deal with the transfer process of PROs' technologies that otherwise would not be appealing to investors or firms (Munari and Toschi, 2011). Another gap funding instrument is represented by university seed funds, which are funds, managed by universities, in which financial resources directly come from the PROs where the technology was invented (Herber *et al.*, 2017). Rasmussen and Sørheim (2012) recognize them as an increasingly important source of early-stage funding for PROs' innovation. Furthermore, among the different gap funding instruments developed, we can also mention incubation or acceleration programs for the enhancement of academic entrepreneurship (Mustar and Wright, 2010; Pauwels *et al.*, 2016; Kruger and Steyn, 2020) and many other direct or indirect measures (Kochenkova *et al.*, 2016; Hayter *et al.*, 2020).

2.2 Proof-of-concept programs

In the context of gap funding instruments that we schematized in Table 1, PoC programs have assumed increasing relevance in the past decades (Hayter and Link, 2015; Munari *et al.*, 2018). In fact, they represent pre-seed instruments that aim to decrease the technological uncertainty of research-based inventions in their early stages by supporting the process of technology development and bridging the public–private financing gap to increase inventions' attractiveness for investors (Gulbranson and Audretsch, 2008; Rasmussen and Sørheim, 2012). This is because academic research rarely generates inventions with the technological maturity of a prototype, making a set of integrated supporting instruments necessary to reach that level (Paget *et al.*, 2024). Therefore, besides financial resources, PoC

Gap funding instruments	Description	PRO's role	Funding round	Empirical referents
Technology transfer-oriented venture capital	It is a private equity financing program provided by firms or funds. Unlike other venture capitals, they are specifically vertical on technology transfer and, therefore, only invest in science-based technologies or entrepreneurial ideas	Facilitator; programs developer; technology identifier	Seed	Munari and Toschi (2011), Croce *et al.* (2014)
University seed fund	It is an early-stage fund that has the deliberate and explicit mission of investing in PROs entrepreneurship to foster the commercialization of their endeavors	Funder; programs developer; programs manager	Seed	Herber *et al.* (2017), Rasmussen and Sørheim, 2012, Munari *et al.* (2018)
Incubation programs for research-based invention	It assists academic spin-offs in the embryonic phase, with a flexible time horizon, offering on-demand training and support. It aims to enable start-ups to develop their business ideas	Facilitator; programs developer; technology identifier	Pre-seed and seed	Mustar and Wright (2010), Kruger and Steyn (2020)
Acceleration programs for research-based invention	It assists more established academic spin-offs to grow rapidly and develop a sustainable business model. The aim is the creation of an Minimum Viable Product (MVP) and the development of a viable plan to bring the product to market in a 3–6 month timespan	Facilitator; programs developer; technology identifier	Seed	Gulbranson and Audretsch (2008), Pauwels *et al.* (2016)
Proof-of-concept program	It integrates financial support, specialized knowledge and training with the aim of fostering the development of novel research-based inventions and discoveries, showcasing both their technical and commercial viability	One of the possible funders; programs developer; programs manager	Pre-seed	Passarelli *et al.* (2018), Battaglia *et al.* (2021b), Munari and Toschi (2021)

Source(s): Authors' own work

Table 1.
Overview of gap funding instruments

programs involve internal or external professionals who may bring their heterogeneous and complementary capabilities, such as a combination of expertise, training, as well as specific support for project management, competence-building, networking and other activities related to commercial negotiations and business development (Maia and Claro, 2013; Passarelli *et al.*, 2018). In this way, they enhance the reduction of the technological and commercial risk of research-based inventions, transforming those technologies into industrial applications (Croce *et al.*, 2014; Das *et al.*, 2017; Munari *et al.*, 2017). Concretely, PoC programs have been designed to advance early-stage technologies to working prototypes that can be produced on an industrial scale and have an impact on society (Kochenkova *et al.*, 2016; Munari and Toschi, 2021).

These programs are designed both within PROs or externally and are based on public or private schemes (Rasmussen and Sørheim, 2012; Munari *et al.*, 2017; Passarelli *et al.*, 2018). They may lead technologies developed within PROs toward different kinds of outcomes. Given that many of these technologies are patented, among the most common outcomes is the commercialization through licensing contracts with external actors, or the constitution of a spin-off company able to generate value by exploiting the early-stage technology developed within the program (Battaglia *et al.*, 2021b). Researchers have investigated how those outcomes are influenced by internal and external characteristics, at the PRO, individual or external levels (Battaglia *et al.*, 2021a; Munari and Toschi, 2021).

Another less studied, albeit important outcome of these programs, may be related to the development of capabilities that would not have been accessible without implementing the programs. This is something related to the learning side of the process (Hockaday, 2020), where not only well-established scholars but also early-career researchers may be trained to valorize technologies toward the external environments (Plantec *et al.*, 2023). In fact, PoC programs require the integration as much as the development of internal and external resources, and this process often leads PROs to rethink and reconfigure the way they carry out technology transfer activities through innovative processes and practices (Hayter *et al.*, 2020; Battaglia *et al.*, 2021b). This depends on two characteristics of PoC programs. First, the programs' nature stimulates the involvement of internal and external actors (Kochenkova *et al.*, 2016). Second, their flexibility leads PROs to exploit different types of resources and capabilities to find the best path to engage with the external environment; however, such a path is very rarely the same and is often customized to the characteristics of the technologies (Rasmussen and Rice, 2012; Munari *et al.*, 2018) and to the specificities of the external stakeholders with which they interact (Passarelli *et al.*, 2018). Therefore, as will be further discussed, we argue that there is a role for PoC programs that goes beyond the sole technology transfer and opens to the development of new PROs' capabilities to address the dynamic nature of their external environment.

2.3 Fostering dynamic capabilities in public research organizations dealing with technology transfer

Dynamic capabilities are well recognized in the literature to describe the ability of a certain organization to "integrate, build, and reconfigure internal and external competencies to address rapidly changing [dynamic] environments" (Teece *et al.*, 1997). Through dynamic capabilities, organizations reconfigure their strategy and resources to better accomplish a sustainable competitive advantage over time (Teece, 2018). Teece (2007) encompasses this concept into three dimensions: (1) sensing and shaping opportunities and threats; (2) seizing opportunities; and (3) reconfiguring, thus maintaining competitiveness through enhancing, combining, protecting and reorganizing an organization's intangible and tangible assets. Pavlou and El Sawy (2011) outlined some key steps in creating a model for the conceptualization and operationalization of dynamic capabilities. First, the organizations

use their sensing capabilities to identify, interpret and pursue opportunities arising from both internal and external stimuli. Second, they employ their seizing capabilities to determine what organizational capabilities must be rebuilt or reconfigured into new knowledge. Third, they use their reconfiguring capabilities to comprehend and implement the necessary changes to their operational capabilities, as well as to execute and use those reconfigured operational capabilities.

Dynamic capabilities may be rooted in the institutional nature of organizations (Zollo and Winter, 2002) or relationally built through constant interactions with the external environment (Giudici *et al.*, 2018). However, while previous research has widely investigated how to foster dynamic capabilities in organizations belonging to the private domain, such as small and medium enterprises (SMEs) and multinationals (see for example, Teece, 2018), still little is known about the case of organizations operating in the public domain (Bejinaru, 2017; Loureiro *et al.*, 2023; Spanó *et al.*, 2024), especially, when we consider those processes and practices that may provide potential foundations for developing dynamic capabilities (i.e. organizational microfoundations) and leading to a PRO's superior performance in a technology transfer setting (i.e. the set of technology transfer activities performed by PROs) (Yuan *et al.*, 2018; Heaton *et al.*, 2019). In fact, PROs (1) are often designed to satisfy multiple and often conflicting goals imposed upon them by numerous stakeholders that leave them to prefer the status quo rather than embracing changes of any kind and (2) suffer relatively less competitive pressure than the private sector in terms of the risk of closure or takeover (Piening, 2013; Heaton *et al.*, 2023). These aspects often conflict with the challenging needs of the PROs' external environment characterized by being dynamic and fast-changing (Heaton *et al.*, 2019; Flores *et al.*, 2024). This is one of the main reasons why PROs increasingly started to adopt gap funding instruments, not only to deal with the need to develop their technologies toward their commercialization but also to engage with external actors more proactively and flexibly (Hockaday, 2020; Battaglia *et al.*, 2021b).

Therefore, PoC programs, being among the most diffused gap funding instruments (Munari *et al.*, 2018), may represent a suitable setting to investigate how to foster dynamic capabilities in PROs by looking at their organizational microfoundations in such a technology transfer initiative.

3. Research methodology

3.1 Research setting

Given the aim of our research question and the general lack of studies on the organizational microfoundations of dynamic capabilities in a technology transfer setting such as PoC programs, we chose to design an exploratory qualitative study. This methodological approach better suits research of this sort because it is recognized to be suitable for developing theory from practice, supporting scholars in addressing a research question by exploring and conceptualizing concepts as much as relationships among concepts within a particular context (Eisenhardt and Graebner, 2007). By inductively analyzing interviews' content and recognizing specific patterns among the different observations, we abstracted the knowledge into a general framework which facilitates the description of this phenomenon and its interpretation according to the grounded theory interpretative approach (Strauss and Corbin, 1998).

Specifically, we consider a set of 37 PROs that managed 24 PoC programs valorizing 155 technologies within the framework of a PoC national policy action in Italy launched by the Italian Patent Office (UIBM) of the Ministry of Economic Development (MISE) in 2020 [2]. These PROs participated individually or jointly. As previously described, these 24 programs have been selected by an external commission at a national level.

In our study, we opted to consider the Italian national context because Italian PROs have always been characterized by a high research quality and strong commitment toward technology transfer activities (Grimaldi *et al.*, 2011), even if recognized as latecomers with respect to other European players (Micozzi *et al.*, 2021). This is a common rationale for other countries in which PROs are still in the early stages of development of their technology transfer activities and capabilities (Kochenkova *et al.*, 2016) and can therefore benefit from a perspective on the Italian context. In fact, in the last decade, Italian PROs experienced fast growth, developing their organizational structures (Battaglia *et al.*, 2017) and benefitting from policy instruments (Micozzi *et al.*, 2021) to facilitate their engagement within a peculiar national context (Cesaroni and Piccaluga, 2016), mostly characterized by SMEs often associated with low-tech industries (Grimaldi *et al.*, 2011). The current timeframe in which Italian PROs operate and that our study accounts for directly reflects years of evolution in the process of technology transfer that took time to settle, and we argue that it may be representative of their long-term transformation process.

Among the PROs involved, 30 are universities, 4 are research hospitals (IRCCS) and 3 are national public research centers. Table 2 reports the key characteristics of the PROs interviewed by indicating if they participated in an individual or joint form, their geographical region and other information on their characteristics.

Our qualitative study is exploratory in nature for two main reasons. First, whenever we consider the literature on gap funding instruments, regarding PoC programs, qualitative studies are quite limited. The very few exceptions (e.g. Passarelli *et al.*, 2018; Battaglia *et al.*, 2021b) only consider the case of a single program implemented by one organization. Therefore, the possibility to compare more programs within the same research for the first time requires an exploratory approach. Second, microfoundations that lead to the emergence of dynamic capabilities when PROs pursue technology transfer remain overlooked in the literature (Yuan *et al.*, 2018; Heaton *et al.*, 2019). Therefore, we argue that an exploratory study may better set the basis for possible future research on this topic.

3.2 Data collection

According to the methodology developed by Gioia *et al.* (2013), the primary data collection was based on 37 semi-structured interviews with the technology transfer professionals in charge of organizing and managing the PoC program for each PRO involved. In total, 24 of them worked as managers in the Technology Transfer Office (TTO), a well-known internal organizational structure of the PROs whose aim is to facilitate the interaction with the external environment by promoting researchers' inventions and intellectual property (IP) (Battaglia *et al.*, 2017). And 13 of them worked as managers in PROs, dealing with the organization of specific technology transfer activities or more general activities related to PROs external engagement (e.g. third mission, public engagement or entrepreneurship and innovation). The level of analysis of our research was the PRO, while the unit of analysis was represented by professionals who operate inside the organization.

To better observe the internal operative and managerial mechanisms of the PoC programs, we started to analyze the phenomenon when all the PROs were already in the midst of the activities, that is, a few months after the PROs' internal selection process. Overall, 8–10 months had passed since the beginning of the process of raising the technology readiness and technology transfer for all the 24 admitted PoC programs. Interviewees included not only the responsible for the program but also, according to the different PROs, some representatives of the research team and some employees of the TTOs. All the interviews have been recorded and transcribed. We used the Microsoft Teams platform, and we used codes to preserve the respondents' anonymity.

PROs	PRO typology (lead partner)	Joint form	Italian area	N. of technologies involved in the PoC programs
University of Genova	University	NO	Northwest	6
University of Milano-Bicocca	University	NO	Northwest	7
Milan Polytechnic	University	NO	Northwest	8
University of Milano	University	NO	Northwest	12
University of Torino	University	NO	Northwest	9
Turin Polytechnic	University	NO	Northwest	7
Rizzoli Orthopedic Institute	IRCCS	NO	Northeast	1
University of Bologna	University	NO	Northeast	12
University of Parma	University	NO	Northeast	4
Oncology Reference Center IRCCS "Burlo Garofolo"	IRCCS	YES	Northeast	2
University of Trieste University of Udine SISSA–Trieste International School of Advanced Studies	University	YES	Northeast	4
University of Padova	University	NO	Northeast	9
ENEA	National Public Research Centre	NO	Centre	3
INFN	National Public Research Centre	NO	Centre	8
CNR	National Research Centre	NO	Centre	8
Sapienza University of Roma	University	NO	Centre	8
Tor Vergata University (Rome)	University	NO	Centre	5
Pediatric Hospital Bambino Gesù	IRCCS	NO	Centre	5
Tuscia University	University	NO	Centre	2
Marche Polytechnic University	University	NO	Centre	9
University of Pisa University of Firenze University of Siena	University	YES	Centre	11
Scuola Superiore Sant'Anna University of Palermo	University	YES	Centre	10
University of Calabria	University	NO	South	1
Vanvitelli University of Campania University of Salento Bari Polytechnic University of Napoli Federico II University of Salerno University of Bari University of Sannio Parthenope University	University	YES	South	12

Note(s): For programs in joint form, the lead partner is highlighted in italic
Source(s): Authors' own work

Table 2.
List of the PROs' interviewed

We collected our qualitative data between October and December 2021 through 37 online calls that lasted from 60 to 90 min each. During this process, we conducted direct interviews with PROs' employees, guided by a specific interview protocol (Appendix). We grouped questions into four categories: (1) background information on the respondents and the PRO considered, (2) organization and management of the PoC program, (3) technology selection and implementation and (4) technology transfer toward the external environment. The interview protocol was adjusted and refined when new themes emerged.

While our main sources were the direct observations from 37 PROs' employees interviewed, we also collected secondary sources from archival documents on the program made available by MISE and filled by program managers to perform data triangulation (Eisenhardt and Graebner, 2007). The combination of multiple data sources allows for triangulation of the information available to better address the research question (Edmondson and McManus, 2007). These documents mainly consisted of reports written by professionals dealing with technology transfer inside the PROs in the last months of 2022. They included information on the PoC programs' structures, activities and outcomes, investigating the peculiarities of the technologies involved in the programs and the practices implemented in the technology transfer process. Besides providing additional information on the PoC programs' processes and practices, the information provided in those reports also revealed the success of the initiative. We mainly used them to expand our understanding of how PoC programs worked in practice and to triangulate facts and observations that emerged from primary sources. Given their pertinence to the answers provided by the respondents, they were useful in validating our framework. In fact, at the end of the programs, among the 155 technologies involved, 35% of them were central to the creation of a PRO's spin-off, while 26% of them were central to the signing of licensing contracts with firms. Also, 35% of the technologies were at the heart of collaborative research contracts with industrial and institutional players.

3.3 Data analysis

According to the grounded theory approach developed by Strauss and Corbin (1998) and to more recent approaches in qualitative management research (Gioia *et al.*, 2013), we inductively coded the transcripts of the interviews to identify relationships between emerging themes and existing literature. This iterative approach led us to update data analysis step-by-step, enabling the emergence of theoretical insights while accessing new knowledge (Eisenhardt and Graebner, 2007).

Through an open coding approach (Strauss and Corbin, 1998) in line with the well-known Gioia methodology (Gioia *et al.*, 2013), each author independently carried out three different rounds of data analysis to enhance the trustworthiness of the coding procedure and to ensure additional rigor to our analysis.

First, we systematically coded the transcripts of interviews into first-order concepts, proceeding with a line-by-line *in vivo* approach. According to standard practice with studies on dynamic capabilities and PoC programs (e.g. Giudici *et al.*, 2018; Battaglia *et al.*, 2021b), we started by reading several times the data collected and outlining all those sentences that seemed related to the scope of our research. We carried on this process manually, collecting data in Excel spreadsheets. Through this approach, we aggregated the different sentences, and we constructed different categories that emerged from respondents' interviews. Being informed by the dynamic capabilities framework and the need to unpack the organizational microfoundations that emerged from our literature review, we coded for passages and circumstances where these aspects emerged more frequently. This led us to identify a set of concepts that commonly emerged among the different PROs employees interviewed. We searched for recurring patterns describing how firms organized and managed the PoC programs, and how they implemented them. Second, we grouped the various identified concepts into second-order themes that we recognized as practices. Finally, we inductively collapsed these emerging practices into four aggregated dimensions that appeared to be logically related to them as processes, reducing data analyzed into a general framework. At this stage, the authors came together to repeatedly conduct this final aggregation process, discarding higher-order themes that did not align with our research aim.

This process of inductively coding from primary sources, being informed by the theoretical framework of the dynamic capabilities, led us to recognize a set of practices and

processes that fell under the definition of organizational microfoundations that we provided in our literature review and to ground them into six theoretical propositions that we formulated to abstract our findings and foster their generalizability and that we represented in a grounded model (Figure 2) according to the prescriptions of Eisenhardt and Graebner (2007).

The coding procedure led to the emergence of 16 first-order concepts, 9 second-order themes (i.e. practices) and 4 aggregated dimensions (i.e. processes). According to Corley and Gioia (2004), we schematized the data analysis process in Figure 1, including first-order concepts, second-order themes and four aggregated dimensions.

4. Findings

Based on our inductive analysis of our sources and the emerging themes, we structured findings into four aggregated dimensions related to the organizational microfoundations that lead to the emergence of dynamic capabilities when PROs implement PoC programs. According to our open coding approach, we considered these four organizational microfoundations as different intertwined elements that, for the sake of clarity, we present sequentially. In this section, we present a description of each one of the microfoundations that resulted from our studies, and we illustrate how they relate to the emergence of dynamic capabilities. Our sources reveal the perceived strengths of PoC programs in a way that reflects what are conceptualized as sensing, seizing and reconfiguring capabilities in Teece (2007). Therefore, we highlighted the presence of organizational microfoundations related to the management processes, selection processes, monitoring processes and valorization processes.

4.1 Management processes

4.1.1 Routinizing existing and new practices. Regarding the management process, PROs have adopted similar practices for the implementation of the planned program activities. The aim was to structure the programs according to a multilevel perspective, coordinating both the scientific-institutional and the organizational-operative levels (Battaglia *et al.*, 2021b; Munari and Toschi, 2021). For many respondents, this was the first PoC program that they implemented. One of the PROs' managers claimed: *"Being the first time that we have to design a program like this, we combined already existing [PROs'] assets within a new multi-step process to increase the coordination of the activities."* Starting from these insights, we observed the emergence of a set of new and well-established practices that came together in a standardized three-phase process. The aim was to routinize existing and new practices to better manage different technologies and, eventually, replicate the programs' structure in a second moment.

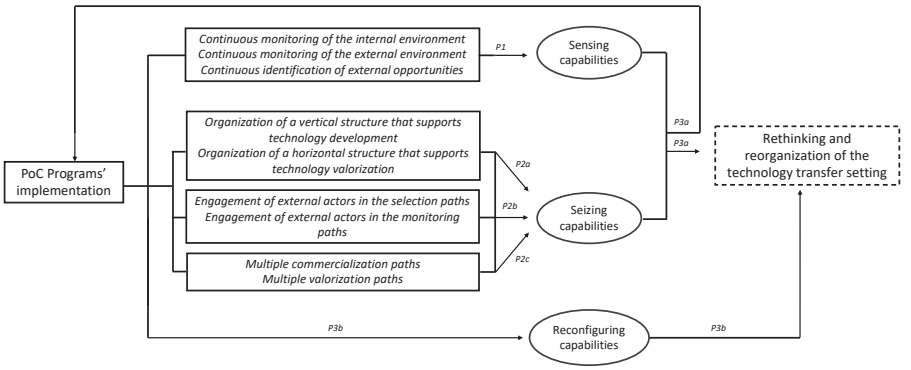
The first phase is related to the promotion and dissemination of the PoC call for proposals within every single PRO. This process mainly took place through the different channels available (e.g. PROs' websites, e-mails, events, individual meetings), combined with specific dissemination activities on the programs' related information. As stated by one of the program managers, a key challenge was to make researchers aware of the existence of such programs: "We also had to properly structure the initiative to let our researchers know about this funding opportunity." The various program managers contacted researchers and investors to describe the potential and the mechanisms of this national policy. This preliminary phase led to an internal screening of PROs' technologies and resources eligible for the program.

The second phase had the objective to scout, assess and submit the different technologies proposed. PROs supported researchers in the writing process, identifying the most relevant

Figure 1.
Data structure

Source(s): Authors' own work

research results, their readiness level and their commercial potential. Once the applications were collected, the third phase referred to a technological and market assessment. For each proposal, program managers reviewed and evaluated the valorization programs according to in-depth IP and market analyses. In many cases, they involved experts' panels as external evaluators. As one of our respondents stated: *"We also involve external evaluators in the experts' panel, such as investors or professionals from industry. They support us in the*



Source(s): Authors' own work

Figure 2.
Grounded model

scouting of the technologies with greater chances to be externally valorized, identifying some key market players to contact." The aim was to combine their perception and those of the inventors with an external opinion about the commercial potential of the technologies, combining an academic and a commercial/industrial perspective. The experts provided a preliminary overview of the activities' technical feasibility in terms of markets, valorization channel, timing and technology readiness level.

In conclusion, the scientific development activities were carried on by the research teams, according to the steps identified to increase the technology readiness level. For the whole length of the programs, TTOs coupled these stages with a set of activities related to technology valorization and commercialization. These activities emerged as crosscutting with respect to the other steps. They included the planning of the valorization process, the development of reports and other informative materials, the administrative support, interaction with the investors, as much as the activation of preliminary promotional paths.

4.1.2 Reorganizing internal structure. When discussing the management model in the interviews, another emerging element is related to the reorganization of the internal structure of PROs. Usually, in the case of PoC programs, PROs identify, within their TTOs, one person responsible for the valorization process. As claimed by a PRO's technology transfer manager, *"It has been important to identify a responsible for the process of valorization that acted as an interface among the different people involved in the program."* This person assumes a specific role, starting the interaction with the financing institution, all the administrative colleagues, as well as with the research team related to every single technology. As described by one of our respondents dealing with those activities: *"I was responsible for a coordination structure that linked the research teams with their departments, TTOs, and investors."*

Within each research team associated with a technology, one technical-scientific manager has been identified. As the representative of the research team, this person coordinates all research activities necessary for the technological advancement carried on by PhDs, researchers, collaborators and other members of the team.

Each PRO also identified one person responsible for the administrative procedure, in charge of managing administrative, monitoring and organizational activities within each PRO's department. For this reason, these administrative structures also assumed a relevant position within this process, moving from peripheral to core. This rearrangement of the structures to address the programs' objectives allows TTOs to assume the role of an internal bridge between researchers, departments and other PROs' offices, working in parallel to manage day-to-day operations.

Given the heterogeneity and the complexity of the tasks required within a PoC program (Hayter *et al.*, 2020), interviewees agreed that this new structure is likely to determine organizational benefits in project management supporting the coordination of heterogeneous activities that involve very different organizational actors. As stated by one of the managers operating in the TTOs, *"Our office is a connection point between downstream and upstream activities, supporting the process management and coordinating heterogeneous activities carried on by heterogeneous actors."* Such coordination allows the organizational actors to work in parallel, facilitate communication, improve management autonomy and quickly take action to solve problems.

4.1.3 Selecting and involving people. Interviews also shed light on the presence of a combination of internal and external professionals who carried out specific supporting activities to the technical-scientific processes implemented within the PoC programs. Among them, the program managers assumed a pivotal role. A TTO manager claimed that *"It is often complex to align all the tasks to the deadline and to keep up with scheduled activities, we identified a program manager to administrate all the program's tasks."* They operate in the monitoring process of the PoC activities with a unitary strategic vision of the overall valorization process and its management dynamics. The program manager is responsible for leading and managing all the scheduled activities, including program planning, budget, as well as risk and contact management. Working in synergy with the TTOs and the departments, this person is responsible for verifying the strategic fit of all the activities and, eventually, implementing appropriate corrective measures.

Another relevant role that has been identified is that of the product manager, who has a combination of marketing, business analysis and commercial expertise. One of the program managers we interviewed observed that *"According to their specific technological background, the product managers represented a key human resource in the definition of the technologies' value proposition. [. . .] They combined scientific and business knowledge to enhance the brokerage activities between researchers and the market, with specific support in the negotiation process."* This professional directly deals with the market identification for the technological innovation, the researchers' training activities, the business model definition and the identification of the communication strategy toward firms or other potential investors, directly intervening in the different stages of the process.

In addition, in several PROs, researchers have been supported by a tutor who acted both under a mentoring and an advising scheme. *"In the last mile, we often engage with mentors or tutors. These experts have a practitioners background. At the end of the validation process, they support us by providing feedback and preparing our interaction with potential investors,"* noted one of our professionals interviewed. These professionals play the role of consultants to empower the autonomy of each research team and deliver specific training related to economic and managerial perspectives to disseminate and exploit the program's results. In conclusion, the Technology Validation Manager also emerged as the one engaged to carry on technology validation activities and certificate technological advancement. This role has been designed to work full-time on the PoC program, conducting additional analysis to integrate the results of each technology and identify additional trajectories for innovation development.

4.2 Selection processes

Another relevant component that emerged from our interviews is related to the selection process. Our respondents recognize it as very challenging, with sentences such as *"In an organization as large as ours, it is challenging to manage the internal selection. It is not always easy to identify the technology with the readiness level most suitable for a technology transfer*

process of this sort." PROs employed two main approaches: an internal one and a mixed selection commission. The first kind of practice is motivated by the PROs' strategic choice to speed up the selection process. An internal commission tends to be more aware of the technologies' portfolio of a specific PRO and its reference context and to work faster. The actors involved in this process are often the PROs' patent commission or the professionals of the TTOs. The second kind of practice considers the presence of a mixed commission, including both internal and external actors. In this second case, PROs aimed to receive feedback also from professionals from industry and finance. Such information may represent a preliminary set of evidence for the external engagement process and should facilitate the selection of those technologies with the highest commercial potential. In addition, the participation of external experts may generate a multiplier effect in terms of technology's dissemination and exploitation efficacy. Therefore, the implementation of programs of this sort relates to a double challenge that involves professionals working in TTOs not only to organize the internal actors responsible for the selection process but also to involve, and therefore engage, with external ones which may represent the first entry point to the external environment.

About the different selection criteria adopted by PROs, the following ones are those which emerged more frequently: (1) the ownership, considering the status of the patent from the perspective of the stage of the life-cycle, the level of innovation and the claims; (2) the technology, addressing aspects related to development, prototyping and industrialization; (3) the program's sustainability, in terms of human, financial and structural resources needed for the PoC's implementation; and (4) the valorization potential, considering potential future paths for the technology's valorization from the perspective of a university-to-industry collaboration.

4.3 Monitoring processes

Interviews also shed light on the monitoring side of the PoC programs. Every PRO scheduled slots for reviewing the progress of every single technology, with periodical meetings with research teams to exchange information on the program in both formal and informal ways. A dual monitoring system emerged. The first was more science-based and included assessments of the correspondence between planned activities and those implemented, analyses of the issues that emerged within the operative phases and the planning of corrective mechanisms consistent with the budget. As stated by one of the managers: *"Even if we have periodical formal checks and meetings, we privileged informal monitoring mechanisms with researchers. Our offices are always in close contact with the representatives of the research teams through e-mails and calls."*

The second was related to supporting and guiding researchers from a commercial point of view. As recognized by a program manager: *"We needed to monitor the progress from both the technological and the commercial perspective. These two activities go hand in hand and can reciprocally contribute to better direct PoC activities."* This process took place through constant monitoring of the commercial exploitation of the technologies according to their technological advances. Those kinds of monitoring activities require both updating the PROs' patent portfolios and the follow-up of all the dissemination materials for the industry. Within this process, it is important to identify and monitor all the distinctive characteristics of the solution and its target market to properly quantify the business potential of the early-stage technology developed according to specific market needs.

To better carry on these activities, PROs designed a flexible monitoring process able to adapt to the peculiarities of each single program and to better convey innovation to the market. All those activities have been tracked within periodical reports. In some cases, PROs collect information on dissemination materials on the status of the activities to better promote the technologies to the market.

4.4 Valorization processes

The last set of practices that emerged is related to the PoC valorization processes. As previously discussed, this national action has been designed to increase the technology readiness level of PROs' technologies to better transfer them to the industry. Usually, this is a medium-long-term process that is unlikely to be realized within the period set by the program (Marullo *et al.*, 2021). However, PROs started to work in this perspective, carrying on a vast set of actions such as organizing meetings with firms or investors, presenting technologies to fairs and carrying on scouting activities. One of the program's managers claimed: *"Most of our work is proactive. We build reports and pitches that we use to go out to the market, [. . .]. We carry on several meetings to make preliminary arrangements that evolve with the development of the technology."*

It emerged that, before starting the valorization process, PROs identified the technological and commercial potential of each single program based on assessments of the technological scenario, the strategic positioning of the research's results to identify a set of possible industrial applications of the innovation, the potential internal and external partners for early-stage technology validation and commercial exploitation, as well as the benchmark of similar companies that developed and adopted similar innovation to analyze, combine or imitate their business and collaboration models. This valorization path *"is an iterative process, we start by identifying our market niche and we go through all its different industrial players. [. . .] It varies according to the different industries and players with which we work. Every time we learn a lot and we integrate new skills and competences that can be useful for the next time."*

This set of possible valorization approaches and outcomes represents one of the pivotal aspects when implementing programs of this sort. More specifically, according to our respondents, different valorization activities may be implemented. The sentence of this TTO manager is perhaps the most representative: *"Often, researchers have already stated preferences on the valorization of their technologies and manifest a higher commitment toward more long-lasting solutions such as the institution of a spin-off or prefer to go for a licensing partner."* Licensing, cross-licensing, follow-on investments, innovation and R&D contracts with industries, as well as the creation of start-ups and academic spin-offs, are just examples of the vast set of valorization outcomes that may be pursued (Styhre and Norbäck, 2018). As practitioners in the technology transfer field, interviewees tend to agree that PROs' researchers privilege the licensing path at the end of a PoC program. As discussed in Garengo (2019), this can happen because firms may lack the scientific skills and infrastructure to implement the technology that universities transfer to them and to fully integrate these solutions within their value chain. During the interviews, the constitution of start-ups or academic spin-offs also emerged as a relevant valorization outcome. According to our respondents, this organizational solution emerged as a long-lasting driver for technology transfer processes since it leads to higher market visibility from a network-based perspective.

4.5 Dynamic capabilities microfoundations in a technology transfer setting

The emergence of the four aggregated dimensions in our exploratory study led us to recognize a set of processes and practices that can act as organizational microfoundations for developing dynamic capabilities in PROs. As previously observed, this is not a sequential process. Rather, each dimension we presented may take place at different moments according to the TTO expertise, the strategic objectives that PROs aim to pursue with the implementation of the programs, as much as the different technologies involved. As recognized by our respondents, the flexible nature of PoC programs may be a double-edged sword if not properly managed and integrated into the other technology transfer

activities that the PROs perform. As claimed by the TTO manager of a small university: *"We have learnt over time that the activities we were carrying out in the PoC programs were not disconnected from the traditional activities of our office. [. . .] On the contrary, those programs were useful not only to get to know new actors with whom collaborate but also to come knocking on the door of old partners and other organizations with whom we wanted to start projects."*

This flexibility is also reflected in the way those programs may contribute to the development of dynamic capabilities in PROs. We observed that our respondents describe the implementation of those programs in a way that reflects what we conceptualize as sensing capability. In fact, the implementation of these programs led PRO professionals to scout internal technologies and team of researchers that could be involved in the programs and benefit from them (i.e. internal opportunities). On the other hand, the nature of these programs forces PROs' managers to "get out of the building" and look for potential partners to implement the solutions and actors that would benefit from them (i.e. external opportunities). Therefore, our respondents recognized that PoC programs may represent a useful instrument for PROs to identify changes, trends and emerging opportunities.

All these phases and practices that underpin the management processes represent a set of organizational microfoundations of sensing capabilities that can be replicated. Thus, we propose:

Proposition 1. The implementation of PoC programs enhances sensing capabilities, fostering continuous monitoring of the internal and external environment as much as a continuous identification of external opportunities.

Once those opportunities are identified, our respondents recognize that PoC programs represent an optimal setting to exploit them by addressing the technology transfer goals of the PROs and the needs of the external environment. This takes place mainly because, at the center of every process, there is a technology whose transfer may benefit from the organizational structure that characterizes PoC programs' implementation. The structure is both vertical, with specific product managers and research teams that directly deal with technology development and horizontal, with program managers who pursue the technology valorization. As one of the PRO managers claimed: *"I believe that these programs are successful because they put together people from different worlds, forcing the scientific actors to collaborate side by side with the commercial ones"*. This also emerges with the involvement of internal and external actors in the selection and monitoring process. One of the TTO managers interviewed claimed that *"We learn a lot from the board of experts we involved in the monitoring process, we meet with them once a month and they give us insights and tips useful to understand how to engage with specific industry segment and market players. [. . .] They provide us with contacts of potential partners and suggest the best approach to valorize each technology"*. Furthermore, our respondents recognize that the success of the PoC programs is not only related to the traditional commercialization outcomes identified in technology transfer literature (i.e. licensing contracts and spin-off creation) (Cesaroni and Piccaluga, 2016; Styhre and Norbäck, 2018). In fact, the peculiar funding structure of the programs we investigated as much as the early stage of the technologies involved may lead to other external engagement outcomes that aim to valorize technologies in different ways. As mentioned, an example of this sort may be access to follow-on investments or strategic engagement with industrial and institutional actors in collaborative innovation and R&D contracts. These practices that underpin the management, selection, monitoring and valorization processes represent a set of organizational microfoundations of seizing capabilities that can be replicated and lead to a PRO's superior performance in a technology transfer setting. Thus, we formulate the following three propositions:

Proposition 2a. The implementation of PoC programs enhances seizing capabilities to take advantage of the opportunities identified, through the organization of a vertical structure that supports technology development and a horizontal structure that supports technology valorization.

Proposition 2b. The implementation of PoC programs enhances seizing capabilities to take advantage of the opportunities identified, through the engagement of external actors in the selection and monitoring paths.

Proposition 2c. The implementation of PoC programs enhances seizing capabilities to take advantage of the opportunities identified, through multiple commercialization and valorization paths.

Finally, our respondents recognized how those aspects led to a reorganization of the programs, to better address the needs and the challenges that emerged and also of the way technology transfer activities are implemented. Many of our respondents recognized that the actors of the PoC programs, such as program managers, product managers, tutors and technology validation managers, may be involved in other technology transfer activities of the PROs after the end of the initiative. This is also true for the vertical (i.e. technological) and horizontal (i.e. commercial) structure that we previously discussed or for the external partners engaged in the selection and monitoring processes. These are just possible examples of how the implementation of such initiatives may lead PROs to rethink and reorganize not only the PoC programs but also the way they carry out and organize their technology transfer activities. One of the most representative sentences was said by one of the PROs managers, claiming: *"I think that we [PROs] must do our job and they [industry] must do their job. PoC programs are an opportunity both for us and for them to get in touch in a faster way with someone we do not know that much. Nowadays, it is all about contamination, right? [. . .] We can exploit PoC to learn from them and absorb the best we can. Then, it is up to us to think about what we can keep and integrate into our daily activities or not. We already rearranged something internally, we hope that this is just the beginning."* These practices that underpin the selection, monitoring and management processes represent a set of organizational microfoundations of reconfiguring capabilities that can lead PROs to rethink and reorganize their technology transfer setting. Thus, we formulate the following two propositions:

Proposition 3a. The implementation of PoC programs enhances sensing and seizing capabilities that may be beneficial not only to the programs themselves but also to the whole PROs technology transfer setting.

Proposition 3b. The implementation of PoC programs enhances reconfiguring capabilities for PROs through a constant rethinking and reorganizing of their technology transfer setting according to the opportunities identified and addressed.

According to the theory-building prescriptions of Eisenhardt and Graebner (2007), we schematized our propositions in a grounded model in Figure 2.

5. Discussion

5.1 General discussion

Starting from the need to unpack the organizational microfoundations that lead to the emergence of dynamic capabilities in PROs within technology transfer settings (Yuan *et al.*, 2018; Heaton *et al.*, 2019), we considered the case of PoC programs, which are a gap funding instrument that has recently gained emerging relevance in theory and practice (Munari and

Toschi, 2021). Specifically, this work represents an explorative attempt to understand how the implementation of PoC programs can contribute to the development of dynamic capabilities in PROs. Our findings offer a peculiar vantage point on how the implementation of PoC programs can trigger this process in technology valorization activities, revealing four processes and a set of practices that may act as organizational microfoundations of dynamic capabilities for PROs. We schematized them in Table 3.

First, in terms of sensing, we observed that the implementation of PoC programs leads PROs to activate management processes and their related practices to scout internal and external opportunities. This is why we argue that PoC programs may act as a sensing instrument to identify technological and commercial opportunities. This process is recognized as pivotal for the subsequent technology valorization process, better selecting technologies and assessing their valorization potential, setting the basis for better technology valorization. Prior literature generally overlooked the size of the sensing potentialities of the programs, focusing on technology testing and development toward commercialization (Rasmussen and Rice, 2012). While Battaglia *et al.* (2021b) account for the relational aspects of the programs, they are mainly related to the reduction of the organizational mismatch between PROs and the external environment, as much as to the creation of a network with external partners but only when it is time to commercialize the technologies. Our study reveals that sensing capabilities are key from the very beginning of the activation of PoC programs and are related to the implementation and routinization of existing and new practices oriented to monitor and identify opportunities in the internal and external environment (*Proposition 1*).

Second, in terms of seizing, we observed how the implementation of PoC programs enabled PROs to reorganize their structure, involve internal and external actors in selection and monitoring paths, as much as pursue multiple valorization paths to better deal with the constantly changing needs of the external environment. While recent research explores this aspect in terms of outcomes (e.g. Munari and Toschi, 2021; Battaglia *et al.* 2021a), we show how PROs commit their resources, adapting their structure to the emerging needs and introducing new competencies through the implementation of these programs. In doing so,

Organizational microfoundations		Dynamic capabilities
Processes	Practices	enhanced
Management processes	Reorganization of existing practices and integration of new practices to better assess: promotion and dissemination, internal scouting, technological and market assessment and scientific development	Sensing
	Integration in the offices of new people with new capabilities, such as product managers, program managers, tutors and technology validation managers	Seizing Reconfiguring
	Implementation of a vertical and horizontal structure controlled by a valorization process manager in which administrative staff and research team work together	Seizing Reconfiguring
Selection processes	Involvement of external actors in the selection process	Seizing
Monitoring processes	Setting up a dual monitoring system, including both scientific and commercial assessment	Seizing
Valorization processes	Technology valorization through licensing, cross-licensing, follow-on investments, spin-off and start-up creation, innovation and R&D contracts	Seizing

Source(s): Authors' own work

Table 3. Organizational microfoundations of dynamic capabilities in PROs

we reveal a set of practices related to management, selection, monitoring and valorization processes that PROs implemented to take advantage of the internal and external opportunities identified through sensing capabilities (*Propositions 2a, 2b, 2c*). These organizational microfoundations represent a preliminary contribution to the need to investigate how those programs should be effectively designed by PROs, addressing the avenues for future research discussed in Battaglia *et al.* (2021b).

Third, in terms of reconfiguring, we show the beneficial role that the activation of sensing and seizing capabilities plays not only in a constant rethinking and reorganizing of the PoC programs themselves but also in the technology transfer setting of the PROs (Propositions 3a, 3b). We argue that this is the very first time that an instrument as such is considered a triggering point of this reorganization process. Even if the transformation of technology transfer processes in PROs may require time, the introduction of programs of this sort not only facilitate this reconfiguration, as previously suggested (Munari *et al.*, 2016; Passarelli *et al.*, 2018) but may also activate it. This perspective supports the recent vision of PoC as an integrated tool, rather than a standalone instrument, which emerged in Munari *et al.* (2018) and Battaglia *et al.* (2021b).

5.2 Theoretical implications

By addressing our research question, this work contributes theoretically to two streams of research. First, we contribute to the emerging literature on gap funding instruments (Munari *et al.*, 2018) with a specific focus on PoC programs (Passarelli *et al.*, 2020). As previously discussed, past research explored them mostly in terms of outcomes (e.g. Munari and Toschi, 2021; Battaglia *et al.*, 2021a) and considered only separate cases of such programs (Munari *et al.*, 2017; Passarelli *et al.*, 2018). Instead, in our work, we considered together several comparable programs and PROs (i.e. 24 PoC programs) and we revealed how they work from a process perspective and how their implementation may transform PROs' technology transfer setting. We also revealed how the implementation of those programs can trigger a reconfiguration of PROs' activities to address the challenging nature of their external environment.

Second, we contribute to the literature on dynamic capabilities (Teece, 2007) in two ways. Our work delves into the organizational microfoundations that underlie the emergence of sensing, seizing and reconfiguring capabilities in PROs. While it is recognized that those microfoundations may be rooted in the institutional nature of organizations (Zollo and Winter, 2002), we contribute to the emerging stream of dynamic capabilities literature that investigates how they can be built through interactions with the external environment (Giudici *et al.*, 2018). Furthermore, the results discussed in our study represent a contribution to that stream of dynamic capabilities literature that explores their emergence in the case of organizations operating in the public domain (Bejinaru, 2017; Loureiro *et al.*, 2023; Spanó *et al.*, 2024). We revealed those processes and practices that may provide potential foundations for developing dynamic capabilities (i.e. organizational microfoundations) and leading to a PRO's superior performance in their technology transfer settings (Yuan *et al.*, 2018; Heaton *et al.*, 2019).

5.3 Practical implications

Our qualitative study also provides implications for TTO managers and PRO decision-makers to better understand how to implement PoC programs from an operative perspective (Munari *et al.*, 2018; Passarelli *et al.*, 2018) to foster the emergence of dynamic capabilities in contexts of this sort. For PROs already well-established in a technology transfer setting, we provide a flexible combination of processes and practices that act as organizational microfoundations and that may be integrated into already existing processes and structures

to trigger a transformation of their technology transfer setting and to foster the emergence of dynamic capabilities. For well-established PROs, the practices collected in Table 3 and unveiled in our findings may represent both an example of the processes that underpin those programs and a checklist to understand whether a PoC program is properly implemented or not. This can reduce the risk of failure while maximizing their potential for technological development and research valorization. Furthermore, building on those practices may be useful also to preliminary estimate the resources required for the development of those programs and the associated costs.

For PROs with still underdeveloped technology transfer settings, PoC programs may act as a first option to start the process of external engagement, developing their technologies while implementing their capabilities. This aspect directly reflects the importance of structuring PoC programs according to the specific characteristics and organizational structures of the different PROs. For PROs which are still in their early stage of development, the practices collected in Table 3 and unveiled in our findings can serve as guiding principles, offering a roadmap to systematically build and refine their technology transfer processes and nurture dynamic capabilities.

Other relevant implications can be found for policy designers who may implement those instruments in different local contexts (Kochenkova *et al.*, 2016). Our work explores how a national technology transfer policy has been implemented by different PROs across a national context. Our study may represent a basis for future schemes for research valorization at a national or multi-PRO level oriented to foster the development of PROs' technologies and technology transfer settings.

5.4 Research limitations and future research directions

This work is not free from limitations, mostly related to its explorative nature. First, there is an issue related to the generalizability of the results. Even if we considered several PROs, they are all related to a single national context at the level of analysis proposed. Therefore, we argue that our research may be replicated by considering PoC programs or comparable gap funding instruments implemented in different local contexts (Munari *et al.*, 2015). While it is likely that different institutional settings may lead to recognizing different organizational microfoundations, we also argue that the rationale that underpins the cases we considered may be similar to PROs that dealt for the first time with programs as such. We also encourage further studies that challenge our propositions with respect to technology transfer settings that differ in their stage of development. We expect them to evolve differently when considering more developed or less mature technology transfer settings.

Second, our propositions are mainly exploratory. We hope that the articulation of these propositions may inspire future confirmatory research on our findings, fostering their "testability" and allowing the creation of a bridge from qualitative evidence to theory-testing research (Eisenhardt and Graebner, 2007). Those propositions may represent the starting point for the framing of hypotheses that can aim to challenge or augment the validity of our findings that are exploratory in nature and, therefore, require further validation and expansion. In particular, they could be the basis for further expanding the theoretical framework, moving the focus from how these instruments may provide potential foundations for dynamic capabilities to how they can help PROs in nurturing dynamic managerial capabilities (Teece, 2018), focusing more on the managerial competences side rather than the organizational one.

Third, our work does not account for the differences in the sectors with whom PROs interact. For example, interaction with industrial partners in life sciences requires resources and capabilities that differ from others (Munari and Toschi, 2021). Therefore, we argue that future research may qualitatively investigate those programs through polar case studies

considering PROs' interaction with different industrial players and observing more easily contrasting patterns among the cases (Eisenhardt and Graebner, 2007). We expect that our propositions may be more easily validated in non-life science sectors where PoC programs on average are easier to implement (Munari and Toschi, 2021).

6. Conclusion

In this paper, we explored how the implementation of PoC programs contributes to the development of dynamic capabilities in PROs. We performed a qualitative analysis under the lens of investigation of the dynamic capabilities, running interviews with the employees of 37 PROs involved in the valorization of 155 technologies within 24 PoC programs funded by an Italian policy initiative, between 2020 and 2022.

Our work reveals four processes and a set of practices that act as organizational microfoundations for the emergence of dynamic capabilities in PROs. We articulated six propositions to facilitate the schematization and the discussion of our findings, as much as to facilitate future qualitative research on the topic. Our study attempts to enhance the understanding of the literature on gap funding instruments and dynamic capabilities, providing implications also for practitioners and policy designers.

Notes

1. In this article, with the term "Public Research Organizations," we include higher education institutions, such as universities, research organizations, i.e. national research centers, and research hospitals active in research and training with substantial funding from public sources (European Commission, 2007).
2. https://uibm.mise.gov.it/images/documenti/Progetti_PoC.pdf

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Appendix
Interview protocol

(1) Background information

- Background information about the respondents and their role in the PRO.
- Background information about the PRO and its technology transfer structure and activities.

(2) PoC Programs – organization and management

- How is the PoC program organized by your PRO? Please, outline the internal organization of the PoC program with reference to the human resources involved and possible improvement actions.
- Do you have scientific and management leaders? Are they internal or external figures? What is their background?
- What are the main difficulties you have found in managing the PoC program?
- What management solutions do you think could be codified and proposed to others implementing those programs?

(3) PoC programs – selection and implementation

- How did your PRO select the technology to involve in the program?
- How did you organize the readiness level advancement of different technologies? Do you have working groups groups for each patent? Whom are they composed of? How do you organize the activities of the groups (regular meetings, communications, internal reports)?

- Is the time available for the implementation of PoC programs sufficient?
- Please, briefly explain the selection process and the operational management of PoC programs and working groups.

(4) Technology transfer

- How did you try to get in touch with companies/others potentially interested in your technologies? With what outcome? What type of collaborations with research and/or industrial partners did you formalize, if any?
- If you have not yet had contact with companies or other organizations potentially interested in your technologies, how do you intend to promote these activities in the future?

Source(s): Authors' own work.

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