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Living labs: Implementing open innovation in the public sector

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ABSTRACT

Public sector innovation is an important issue in the agenda of policymakers and academics but there is a need for a change of perspective, one that promotes a more open model of innovating, which takes advantage of the possibilities offered by collaboration between citizens, entrepreneurs and civil society as well as of new emerging technologies. Living labs are environments that can support public open innovation processes.
This article makes a practical contribution to understand the role of living labs as intermediaries of public open innovation. The analysis focuses on the dynamics of these innovation intermediaries, their outcomes, and their main challenges. In particular, it adopts a qualitative approach (fourteen semi-structured interviews and one focus group were conducted) in order to analyze two living labs: Citilab in the city of Cornellà and the network of fab athenaeums (public fab labs) in the city of Barcelona, both in Spain. After a thorough analysis of the attributes of these living labs, the article concludes that 1) living labs provide the opportunity for public agencies to meet with private sector organizations and thus function as innovation intermediaries, 2) implementing an open innovation perspective is considered more important than obtaining specific innovation results, and 3) scalability and sustainability are the main problems living labs encounter as open innovation intermediaries.

1. Introduction

Innovation is a recurring theme in public administration. It has been used to frame the transformation of public sector organizations in order to enhance the effectiveness, efficiency, and legitimacy of their public value creation processes (Bekkers, Edelenbos, & Steijn, 2011). As needs of citizens are changing, and technology is advancing, there is an immense need for innovation in the public sector. On one hand, citizens have higher expectations about public services and government interventions. On the other, public managers and elected politicians have growing ambitions concerning improved public governance mechanisms and tighter control. Finally, public tasks have become more and more complex and have developed into "tangled problems" or even "wicked problems" – problems that are often too difficult to be solved by a single entity or include many different layers of complexity (Sørensen & Torfing, 2011, 2010).

Recently, government organizations have started to adopt open innovation approaches to provide an additional gateway for innovation creation that allows citizens to suggest solutions to public management problems (Mergel, 2015).

Open innovation is a concept that was originally adopted in the private sector. According to Chesbrough (2006), it has to do with "the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively" (p. 1). Open innovation is, therefore, about inviting problem solvers help reinvent products, services, or even business models that might contribute to the survival of the organization (Chesbrough, 2006, 2003).

However, how open innovation can become a true and effective tool for governments is still an underexplored topic (Bakici, Almirall, & Wareham, 2013; Feller, Finnegan, & Nilsson, 2011; Mergel, 2015). The few works that have tackled it have mainly addressed one main question: how can a successful private sector practice be introduced in public sector organizations? They have analyzed drivers of adoption, the implementation process, the role of agents, and results and impact (among other, Bakici et al., 2013; Bommert, 2010; Dias & Escoval, 2012; Feller et al., 2011; Hennala, Parjanen, & Uotila, 2011; Hilgers & Ihl, 2010; Lee, Hwang, & Choi, 2012; Mergel, 2015, 2013; Mergel & Desouza, 2013).

Of particular importance is the role of agents as (open) innovation intermediaries. Innovation intermediaries have been defined as external organizations and individuals that support companies in their innovative activities by gathering, developing, controlling and disseminating external knowledge by providing various resources and regulating the innovation networks (Bakici et al., 2013; Howells, 2006). The literature reveals a wide variety of innovation intermediaries (Howells, 2006) that range from public and private incubators to technological top institutes (Bakici et al., 2013). Living labs have also been considered an important open innovation intermediary (Almirall & Wareham, 2011, 2008; Bakici et al., 2013).

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Despite the lack of a shared and coherent definition (Bergvall-Kåreborn, Ihlström Eriksson, Ståhlbröst, & Svensson, 2009), living labs can be understood as settings or environments for open innovation, which offer a collaborative platform for research, development, and experimentation in real-life contexts, based on specific methodologies and tools, and implemented through specific innovation projects and community-building activities (Schaffers & Turkama, 2012). Living labs are driven by two main ideas: 1) involving users as co-creators of innovation outcomes on equal grounds with the rest of participants and 2) experimentation in real-world settings (Almirall, Lee, & Wareham, 2012).

This paper looks deeply into the concept of living labs as public open innovation intermediaries by analyzing two case studies: Citilab in the city of Cornellà and the network of public fab labs in the city of Barcelona, both in Spain. The three main research questions this paper answers include: 1) how do living labs function as public open innovation intermediaries?, 2) what are some of the observable outcomes in terms of public innovation?, and 3) what are the main challenges encountered by living labs as open innovation intermediaries?

The remainder of this paper is organized as follows. In the next section, we introduce the concept of living labs as public open innovation intermediaries. Next, the data and methods to collect the information are explained. Subsequently, we present and discuss the results of the fieldwork. Finally, we describe the theoretical and practical implications of our findings and answer our research questions.

2. Living labs as open innovation intermediaries in the public sector

Simply put, innovation intermediaries can be defined as organizations involved in supporting the innovation process (Howells, 2006). The literature on private open innovation has widely emphasized the role of intermediaries in bridging and coordinating a firm's innovation network (among other, Amico-Roxas, Piroli, & Sorrentino, 2011; Chesbrough, 2006; Howells, 2006; Winch & Courtney, 2007).

López-Vega (2012) indicates that innovation intermediaries have, indeed, a variety of profiles and functions. After a thorough literature review, the author concludes that these functions might be grouped under three general headings: connection (for example, linking innovation providers and seekers or providing interfaces between users and firms), collaboration and support (for example, mobilizing university research, integrating knowledge from stakeholders, or supporting commercialization), and provision of technological services (for example, testing and training or assessing technology). As Chesbrough (2006) mentions, intermediaries can operate in different ways: some function as agents (representing one side of a transaction) and others as brokers (representing both sides of a transaction).

Innovation consultants, science and technology parks, incubators, and regional innovation agencies have been considered the most prevalent types of innovation intermediaries (Howells, 2006; López-Vega, 2012). Most of these intermediaries have collaborated with private rather than public organizations (Bakici et al., 2013). Nevertheless, in the last years, a new open innovation intermediary has emerged in Europe: living labs. Living labs are intermediaries that focus on the mediation between users, public, or private organizations, capturing and codifying users insights in real-life environments (Almirall & Wareham, 2011, 2008; Cleland et al., 2012; Fosltad, 2008).

Traditionally, living labs have focused on supporting companies and creating an ecosystem of innovation that benefits both private companies and public organizations. However, lately, they have also emphasized the need to open innovation processes to citizens (Serra, 2014). According to Manzini and Staszowski (2013), "the experiments that these spaces facilitate open two symmetrical opportunities. One is the possibility for bottom-up social innovations to move faster in their trajectory from the first 'heroic' stage (when social inventions are still prototypes) to the following stages when more mature enterprises are created and, if necessary, when enabling products and services are conceived and enhanced. The other opportunity is for public agencies to meet with people and other organizations and experiment together with new policies and governance tools" (p. vi). As a result, living labs can be considered active organizations in the promotion of innovations in the public sector.

Living labs concur with the open innovation paradigm in drawing on the notion of external ideas as a resource for innovation (Bergvall-Kåreborn et al., 2009; Katzy & Mensik, 2007). In living labs, different stakeholders interact and collaborate in innovation processes using a methodology based on knowledge exchange, co-creation/co-production techniques, and participatory methods (Baccarne, Mechant, & Schuurman, 2014; Vicini, Bellini, & Sanna, 2012).

On one hand, living labs are conceived as a strategic opportunity to improve the creation of multistakeholder partnerships with citizens at the center. Thus, they have often been defined as public, private and people partnerships (PPPP) for user-driven open innovation (Nesti, 2015). Along the same lines, Cleland, Mulvenna, Galbraith, Wallace, and Martin (2010) state that living labs are increasingly well-established innovation intermediaries that support the implementation of the quadruple helix model, an innovation approach based on cooperation between firms, universities, public organizations and users (Arnkil, Järvensivu, Koski, & Piirainen, 2010).

On the other, living labs strongly rely on the concepts of co-creation and co-production (Fosltad, 2008; Nesti, 2015). Ballon, Pierson, and Delaere (2005), for instance, refer to a living lab as an experimentation environment in which technology is given shape in real life contexts and in which end-users are considered co-producers. CoreLabs (2007) considers a living lab a system enabling people, users/buyers of services and products, to take active roles as contributors and co-creators in the research, development and innovation process. What all these and other definitions share is the idea that living labs are environments where the active involvement of stakeholders, and particularly of users, in the process of producing innovation takes place.

Despite previous works, still, there is not enough research that specifically refers to living labs as open innovation intermediaries and explores their specific role in innovation processes in the public sector (Bakici et al., 2013). It is therefore a legitimate and interesting task to undertake to understand their dynamics and contribution to public innovation.

3. Research design: data collection and analysis

Given the exploratory nature of the research, this article adopts a qualitative approach to understand how living labs function as public open innovation intermediaries (Yin, 2009). Two living labs were selected on the basis of their relevance and accessibility[1]: Citilab in the city of Cornellà and the network of public fab labs (fab athenaeums) in the city of Barcelona, both in Spain.[2] On one hand, Citilab was the first living lab in Spain and has become one of the most important living labs in Europe, formally and explicitly recognized as such. On the other, the public network of fab labs is the only successful case of fab labs funded and run by a city council. It is, therefore, a worldwide pioneering initiative. As a result, both living labs can be considered as innovations themselves in their local/national contexts (actually, the network of

[1] Research access was straightforward as a result of the past and current links of the researcher and her institution with both the Barcelona City Council and the Cornellà City Council.

[2] A fab lab (fabrication laboratory) is a small-scale workshop offering (personal) digital fabrication. The fab lab program began back in 2001 as a collaborative initiative between the Grassroots Invention Group and the Center for Bits and Atoms at the Media Lab in the Massachusetts Institute of Technology. Nowadays there are fab labs all around the world.

public fab labs can be considered an innovation, also, in the international scene). Both of them are particularly focused on the citizen and its contribution to and role in innovation processes; that is, in these living labs, the citizen is a key actor in the open innovation process. However, their approach mainly differs in the tools they use, being digital fabrication the idea around which innovation takes place in fab athenaeums.[3]

The research design was chosen on the basis that it suited research questions and enriched our understanding of the research context.

Fourteen individual semi-structured interviews were conducted with current or former managers, users, and public and private stakeholders of both types of living labs as well as with some open innovation/living labs experts. All of them were contacted by e-mail, provided with an overview of the research project, and asked to take part in the study. Interviews lasted between 1 and 2 h. Ten of them were recorded (we did not got authorization for the remaining four). Table 1 shows the profile of the interviewees.

Additionally, in the case of the network of fab athenaeums, one focus group was also conducted with staff of the Barcelona City Council, its promoter and funder. Our aim was to know about the details of the project, which had only been implemented during 2014. The focus group lasted around 2 h and was recorded.

The resulting data from both interview notes and recordings was transcribed and hand-coded line-by-line using the pre-defined codes from the existing open innovation and living labs literature. Additional codes on public open innovation and innovation intermediaries emerged during the coding process, were categorized and their meaning evaluated, following a grounded theory approach (Glaser & Strauss, 1967).

In order to conduct the assessment, and therefore to develop the interviews' protocol, we relied on Alcotra's harmonization cube good practices criteria, previously developed within the CoreLabs project, and lately adopted by ENoLL, the European Network of Living Labs (Mulder et al., 2007; Mulder, Velthausz, & Kriens, 2008a,b). This framework was developed to assess the performance of living labs according to their relevant dimensions and characteristics (Schumacher, 2012). It therefore focuses on the dynamics and functioning of living labs as well as their outcomes in terms of innovation. As a result, exploring and understanding the dimensions of the cube is useful to understand the role of living labs as open innovation intermediaries.

The cube is a $6 \times 3 \times 3$ model. The six sides of the cube correspond with the six key aspects of a living lab (Schumacher, 2012):

- User involvement: At the core of a living lab lies user involvement or co-creation with users. When assessing user involvement, several aspects have to be taken into consideration. Motivating users to participate in the service design process, training them to achieve a better use of the technological tools and platforms, and understanding cultural differences among users are only a few examples.
- Service creation: It deals with the process of developing new ideas and testing them in the living lab. It is the co-creation process itself that this variable is considering and, therefore, the idea generation process, the market strategies or the supporting technologies to enable cooperation between all parties involved.
- Governance: It has to do with the organization of the living lab as a whole and the interactions among its members.

[3] Simply put, digital fabrication refers to the making of physical objects through the use of computer-controlled tools. According to Pfeitter (2009), "digital fabrication requires a relatively complex set of operations to accomplish. First, a digital model is created using specialized software. The geometric information from the digital model is then translated into instructions for tool paths and related tooling information. Any tooling or material setup is readied, and the instructions are communicated to the tool and then run" (p. 5–6). Digital fabrication tools include laser cutters that makes 2D and 3D structures, 3D printers and a suite of electronic components and programming tools for low-cost, high-speed microcontrollers for on-site rapid circuit prototyping, among other.

Table 1
Interviewees' profiles.

Citilab	Fab athenaeums
1. Director of Citilab	1. Director of the network of fab athenaeums
2. Head of Innovation of Citilab	2. External partner (representative of the Education Consortium of Barcelona – pedagogical program)
3. Head of Social Media Lab of Citilab	3. External partner (representative of Vailets HackLab – family program)
4. User of Seniorlab (citizens' representative)[a]	4. External partner (representative of Tarpuna – social innovation program)
5. User of training programs (citizen's representative)[b]	5. Expert on living labs[c]
6. Board member (representative of the Autonomous Government of Catalonia)	
7. Board member (representative of the Barcelona Provincial Council)	
8. Board member (representative of the Cornellà City Council)	
9. External partner (representative of the Barcelona City Council and expert on innovation)	
10. Expert on living labs (and former Head of Innovation of Citilab)[c]	

[a] Interestingly enough, this individual was a user who became, over time, the manager of the project she was involved with. That is why she was chosen: she was able to actually provide information from the user's perspective but also from the employee's perspective.
[b] Interestingly enough, this individual was a user who became, over time, the manager of the project he was involved with. That is why he was chosen: he was able to actually provide information from the user's perspective but also from the employee's perspective.
[c] This person was interviewed for both the Citilab and the network of fab athenaeums cases.

- Innovation outcomes: These refer to the results of the living lab and they can be many things: knowledge, new products or services, or intellectual property rights.
- Infrastructure: It deals with the services and technologies needed to perform measurements and analyze the collected data, such as networks, servers, statistical tools, and end user applications performing the measurements.
- Methods and tools: This last variable deals with how to organize and operate the tools in order to achieve knowledge about the use and experience of users.

Additionally, and transversally to the six dimensions, the three rows of the cube refer to the three development phases of a living lab: set up, sustainability, and scalability. Finally, the three columns reflect three common aspects of a living lab: the organizational, the technological, and the contextual issues of a living lab.

4. Results

As noted, two living labs were selected on the basis of their relevance and accessibility: Citilab in the city of Cornellà and the network of public fab labs (fab athenaeums) in the city of Barcelona, both in Spain. This section shows the results of our qualitative research.

4.1. Citilab

Citilab describes itself as a center for social and digital innovation in Cornellà de Llobregat (Barcelona, Spain). It exploits and spreads the digital impact on creative thinking, design and innovation emerging from the digital culture. Citilab is a mix between a training center, a research center and an incubator for business and social initiatives. This project started with the idea that digital technologies, specifically the Internet, are a way of innovation much more focused on citizens.

This broad idea has been interpreted and explained by our interviewees. For one of them, Citilab is "*a place to share the digital technological culture, in an active way, and having as a starting point the citizens'*

needs" (program manager in Citilab). For another one, "*Citilab represents a change of paradigm. ICT have the power to empower the citizen. The philosophy that underlines Citilab is: do not come here to learn; tell me what you want to do and together we will learn*" (program manager in Citilab). "*Citilab values people's ideas no matter what educational background they have. Also, it is a space for young people that have ideas and want to turn them into start ups*" (director in Citilab).

Despite the different explanations of Citilab's general aim, it can be concluded that it is a space for open innovation with two important characteristics: 1) co-creation is at the heart of the Citilab's philosophy and 2) anyone can innovate (any citizen can be the leader of an innovation project). The different projects that Citilab implements take this approach into account but this is such a general approach that, in the end, many types of projects can be developed. As one of our interviewees explained: "*Citilab is a mix of many things. It does a wonderful job in promoting the use of new technologies, particularly with the youth and with seniors. But it also is a company incubator. Actually, I would sum up Citilab's objectives as: 1) evangelize about ICT, 2) be a civic center for the neighborhood, 3) be an incubator, and 4) put everything together and innovate! Citilab is a facilitator of innovation in the territory and it always takes the citizen into account*" (stakeholder of Citilab and expert on innovation).

Citilab is an organization that is supported by numerous stakeholders, which are part of the co-creation network: the Cornellà City Council, the Autonomous Government of Catalonia, the Barcelona Provincial Council, Siemens, the Politechnical University of Catalonia, WTC Almeda Park SA, the Catalan Foundation for Research and Innovation, and three individuals from the civil society.

Interestingly enough, citizens are a key actor in the network. As one of our interviewees put it: "*sportsmen in the sportslab, musicians in the musiclab or seniors in the seniorlab are relevant actors for Citilab*" (program manager in Citilab). The citizens that participate in different co-creation processes on a permanent basis are called citilabbers. There are around 7000 citilabbers. They have a "Citilab card" that costs no more than 3 Euros a year. They are people under 25 or over 40 and they are very active. But there are other citizens, around 25,000, that annually visit Citilab and take part in one or two of its projects.

Citilab has more than 1000 m^2 divided into three floors with areas for experimentation, businesses and startups, production of multimedia content, and training. Such areas are well equipped with computers and free connection to the Internet.

As a civic laboratory, Citilab encompasses and develops different technology-based business projects with professional activities related to infrastructure, services and applications for collaboration. In Citilab one can reap the benefits of an environment marked by collaboration and technological experimentation, increasing his/her capacity for innovation and allowing him/her to test the solutions in real contexts that make it possible to obtain more qualitative conclusions.

According to our interviewees, the main factors that contribute to this process are:

- Citizens' motivation. Because the idea around Citilab is citizen co-creation and citizen involvement, it is key that citizens remain motivated. Motivation makes them lead their own processes. One of the members of the board said: "*Citilab is not an adults' nursery. People go to Citilab because they have access to talent, to technology, to knowledge. Citilab give these citizens huge possibilities to develop their own ideas*". This said, citizens do not have many incentives to get in touch with Citilab. Not many people know Citilab so getting there is a first step. Some citizens just join Citilab because they can connect to the Internet. However, once there, they realize they can do a lot more. So, it is the own co-creation process what motivates them to keep co-creating and innovating. For one of the users' representatives, "*seniorlab, for example, has contributed to change the image seniors have of themselves. They first came here to learn but, slowly, they feel more and more useful. This feeling motivates them to keep coming to Citilab*". Another one explained: "*we do not give any awards to citizens. Knowledge and a feeling of belonging to the group that implements the project is what motivates people*".
- Support of the Cornellà City Council. As one of Citilab's board members explained: "*the City Council made the decision to open Citilab more than 10 years ago but, no matter the difficulties, it has committed to keep it over time*". The Cornellà City Council has politically supported the initiative and this has resulted in funding it. Related to this, civil servants' commitment has been very important. Civil servants have been flexible and have adapted to the different stages Citilab has gone through. One of the members of the board stated that "*civil servants have believed in this initiative. They strongly believed in what Citilab was and where it headed to. They have also been patient with Citilab's circumstances*".
- The infrastructure. Many interviewees have identified the building itself as one critical success factor. For them, how the building is structured encourages innovation, active learning, and networking. As one of the workers put it: "*this is a relaxing environment, which invites to co-create*". The three different open spaces (one per floor) contribute to this feeling: "*Citilab is an open space and it is open to everything*" (program manager in Citilab), we were told. So, the physical place seems to also matter.

However, some challenges remain unsolved:

- Sustainability. Since the Spanish Ministry of Industry decided not to invest in Citilab anymore, economic difficulties have been always present. The Spanish economic crisis has added more problems to this because the institutional supporters (some of which are public organizations) have not been able to do one's bit. It is the Cornellà City Council the only real contributor in this respect. But, as the City Council's representative stated, "*the City of Cornellà will not be able to sustain its investment much longer if there is no clear return. Also, Citilab's managers have to take into account that we have many projects that require money and many citizens' needs that have not been met yet. Thus, it is not easy to justify investment in Citilab*". This lack of resources has many consequences. One of Citilab's program managers told us: "*you cannot do any research if you do not have resources. If nobody pays to think, who is going to think? It is very difficult to get results if you do not invest in research*". But, what's more, the lack of resources limits Citilab's credibility to innovate or to co-innovate with citizens.
- Lack of clarity about the return on investment. This is another frustration both for civil servants and for those actors that economically support Citilab. It is very expensive to open the building each day. One of the members of the board explained: "*it is very frustrating to spend 800,000 Euros a year on Citilab and not be able to see a short-run improvement. This is particularly important now. When there were a lot of resources, this did not matter so much*".
- Scalability of results. This seems to be another concern. The area of influence of Citilab is quite small. In one of our interviewees' words: "*the main problem Citilab has is that it is not placed in Barcelona*" (stakeholder of Citilab and expert on innovation). Where Citilab is placed also hinders its visibility, which, for us, has also to do with limited scalability.
- Political identification. For many people, Citilab is a socialist project, supported by the Socialist Party and by the different socialist governments that ruled the country. This political identification has been a barrier to gain institutional support in the current environment. Citilab is seen as a left-wing initiative in a left-wing city.

All of our respondents indicated that Citilab can be considered as successful. Many international awards support this perception.

However, they thought that Citilab has been mainly successful in its methodology, in its idea of involving citizens. The former head of innovation told us: "*in Citilab, the process has been more important than the results. Citilab does not aimed at having a catalog of co-created public services. Its objective is to open citizens' mentalities*". Less is said regarding the specific outputs and outcomes of Citilab and Citilab's projects. One of the program managers added: "*Citilab is successful because it is receptive and actively listens to citizens' needs. We are open to any suggestions*". Another one stated: "*most of the organizational models are not open to co-creation. Citilab is and this is what makes it a successful initiative*". One of the experts on innovation we talked to also explained: "*Citilab has contributed to the co-creation philosophy. It has shown co-creation is possible*".

The international positioning of Citilab is another reason argued: "*Citilab has been able to survive, to be known in the social network, and in the universities environment*", one of the members of the board stated. Along the same lines, one program manager explained: "*Citilab is now on the map. It is a good practice of social innovation in Europe. Actually, it is much better known outside than inside*". This last remark is important. International recognition is considered a success, but one could also argue that Citilab has not had much impact in Spain or, what's worst, in its closer context. One of our respondents explained: "*Citilab should expand its area of influence beyond Cornellà. Maybe thinking about Catalonia is too ambitious but, at least, it should be well known and recognized in the province of Barcelona*".

On a more personal level, on the citizen side, citizens' representatives indicate that users are very satisfied. Some of them, the ones who were not familiar with technology, such as seniors in the seniorlab, are not afraid of it anymore and they realize that technology can open other doors and opportunities for them. This is why Citilab is successful for them. In this respect, Citilab has contributed to increase the number of citizens with innovation competencies and skills.

Finally, there is the perception that the different projects addressed to citizens have been, more or less, successful because, as we were saying, citizens are satisfied. However, according to our respondents, services addressed to companies have not succeeded. For the former head of innovation of this living lab: "*entrepreneurship and start-ups promotion have not worked. Probably, there was not enough capital…*".

4.2. Public fab labs (fab athenaeums)

The network of fab athenaeums is a pioneering initiative promoted by the Barcelona City Council in the framework of its smart city strategy. A fab athenaeum is a space where citizens, but also local associations and groups, universities and businesses, join together to develop social innovation initiatives with the support of a laboratory devoted to digital fabrication. In this respect, it is a workshop equipped with machines to turn ideas into physical things that are useful to society. One of our interviewees went a little further in his description: "*a fab athenaeum is a public fab lab so to speak but with a more social focus*" (director of the network of fab athenaeums).

A fab athenaeum has two specific goals: 1) to spread the basics of digital fabrication to everyone, no matter his/her origins, background, or ICT skills and 2) to develop projects with a transforming social return to the neighborhood, the city, the world. It is this need to have a social return to the neighborhood that makes each fab athenaeum unique for each of them adapts to the social and economic needs of the specific neighborhood it is located. In other words, there are thematic fab athenaeums depending on the attributes of each of the districts.

At the moment, there are three fab athenaeums fully operating in the districts of Les Corts (theme: inclusion), Ciutat Meridiana (theme: employment), and Ciutat Vella (theme: sustainability). However, the final goal is to have, at least, one fab athenaeum per district (there are 10 districts in the city of Barcelona).

To open a fab athenaeum is not easy. Infrastructures play a key role in this respect. The space, the building, matters a lot. One of our interviewees said: "*we cannot teach open innovation in closed rooms*" (partner of the network of fab athenaeums). So big and open spaces are needed. But machines are important as well. Fab athenaeums revolve around the concept of digital fabrication. Therefore, they need flexible manufacturing equipment that may include 3D printers, laser cutters, or digital electronics devices, just to name a few examples.

According to the director of this project, the strategy of the network of fab athenaeums is implemented by means of three different programs:

- The pedagogical program. Its goal is to embed digital fabrication in the education system (from kindergarten to the university). It addresses two target groups. On one hand, teachers. The program offers training to teachers. On the other hand, students. Several activities are designed to encourage creativity, innovation and experimentation, to show the students how to move from the idea to the creation of the object by applying curricular content from different areas in line with their personal abilities. The program is led by the Education Consortium of Barcelona.
- The family program. It aims at closing the student's learning circle by bringing digital fabrication to their homes. Different activities are usually organized on Saturdays throughout the school year for families who, together, can discover and experiment the possibilities of digital fabrication. Vailets Hacklab, a parents' organization based in Barcelona, that aims at promoting robotics and informatics at schools, has mainly been in charge of organizing activities within this program.
- The social innovation program. It aims at strengthening the links between each fab athenaeum and its surroundings. In doing so, it promotes hidden talent of citizens who can become innovators and, therefore, who can address their daily problems using digital fabrication tools and methods. The interaction among local residents and associations is thought to improve their quality of life and social cohesion. Most of the activities that have taken place within this program have been organized by Tarpuna, a cooperative committed to sustainability, equal opportunities and social justice.

The involvement of different organizations in the different programs already shows that the network of fab athenaeums has multiple stakeholders. According to our interviewees, there are three types of stakeholders: academic organizations (that range from public primary and secondary schools to universities), public administrations (including the Barcelona City Council, its promoter), and social organizations. One of them said: "*only in 2014, more than 120 organizations, ranging from little neighborhood associations to big universities, visited the fab athenaeum in Les Corts*" (director of the network of fab athenaeums). What's more, this involvement also shows that the network operates around the idea of user involvement and co-production. One of our interviewees said: "*when the fab athenaeum in Les Corts opened, the first activities were top-down; that is, the City Council organized them. But more and more, individuals, associations, and schools come to the City Council and propose us to do something in the framework of a fab athenaeum. It is them who decide what to do and how to do it and who, finally, do it!*" (partner of the network of fab athenaeums).

This bottom-up approach, which links to the idea of user involvement and co-production, is what keeps the fab athenaeums alive. Most of the people we talked to confirmed that the City Council does not have enough resources to keep the fab athenaeums fully working. One stated: "*it is us who give content to the network and, most of the time, we do it on a voluntary basis*" (partner of the network of fab athenaeums). The City Council is also aware of this limitation but addresses it as an opportunity: "*this is the way in which we build the smart city: with citizens. Innovation has to come from the people*" (director of the network

of fab athenaeums). Additionally, in its expansion plan, the Barcelona City Council provides for fab athenaeums built on public-private partnerships.

It is soon to assess the success of this project but, as in the case of Citilab, our interviewees referred to the innovation process itself as one of the main results. There are some indicators, which show the level of activity in 2014 (59 initiatives around the pedagogical program, 7 initiatives around the family program, and 57 initiatives around the social innovation program) when the first fab athenaeum was inaugurated. But, as one of the interviewees told us: "*the athenaeum is a laboratory. The process is what matters, how we do things instead of what we do. The objective is to empower people*" (director of the network of fab athenaeums). Another one added: "*the most important is that citizens realize that they can actually become co-producers, which is more than just giving an opinion or voting*" (partner of the network of fab athenaeums).

Despite these thoughts, our interviewees believed that, still, there are some barriers that have to be overcome. They particularly referred to:

- Human resources. The team in charge of this network is very small. Also, within the different organizations in charge of each of the programs, there are problems with the needed staff. This lack of people, which is very clear in the Education Consortium of Barcelona, limits the number of activities and initiatives that can be organized. One of the interviewees said: "*only one person is leading the pedagogical program in one fab athenaeum. If the network is going to expand, it will just not be enough*" (partner of the network of fab athenaeums).
- Sustainability. As previously stated, fab athenaeums require an initial economic investment. Therefore, despite the plans to expand the network, getting the necessary resources might not be easy. Also, this project has clearly received the support of the political structure of the Barcelona City Council that governed the city between 2011 and 2015. The new government has not made any explicit statements about its continuity yet. What's more, in the last year, there have not been any further developments of the smart city strategy that framed this initiative.
- Lack of visibility. Fab athenaeums have been defined as co-creation spaces. However, they are not known by citizens, its main target group. Probably due to the little human resources involved in the project, there has not been a chance to work on dissemination. But, also, despite its philosophy, a fab athenaeum is still perceived as a place for technology experts. In one of the interviewee's words: "*the idea that everyone can become an innovator is not easy to spread. The citizens do not have this perspective*" (partner of the network of fab athenaeums). Finally, although several activities have been organized in the fab athenaeums, a network of people and organizations (the fab athenaeums community) has not been developed around these activities. According to one of the interviewees, this has hindered visibility.
- Scalability. Prototypes are not scalable yet. One of the interviewees said: "*with the resources available for the fab athenaeums, nothing will be solved. In a fab athenaeum, ideas and prototypes will be born but these will become important when they are externalized and they become bigger*" (partner of the network of fab athenaeums).
- Management. Fab athenaeums are public spaces for the community. They give support to innovation processes within the city. They build with citizens and not only for citizens. In doing so, the city council becomes a platform, a convener and an enabler rather than the first mover of civic action. This implies a change of paradigm. But public administrations are not ready for this change. Their logic is top-down, one of control and distrust. For one of our interviewees: "*the Barcelona City Council needs to learn that managing the interactions among the different actors is much more interesting than managing the equipment itself. This is what co-production and social innovation are about*" (partner of the network of fab athenaeums).

Table 2
Comparing Citilab and the network of fab athenaeums.

Dimension	Citilab	Fab athenaeums
User involvement	Co-creation is at the heart of the Citilab's philosophy. Individual users' motivation is key in this process	Co-creation is at the heart of the network of fab athenaeums' philosophy. Motivation to innovate mainly comes from the partnering organizations in charge of specific programs who are good at involving end users
Service creation	It is encouraged but it is usually the result of individual processes	It is encouraged and it is usually the result of collaborative processes. Several prototypes have been developed in the three operating fab athenaeums
Infrastructure	Citilab requires a big building with open spaces. Although some equipment is necessary, it is not very sophisticated and, therefore, not very expensive	Fab athenaeums require big and open buildings. The equipment is usually big, specific (digital fabrication tools), and expensive
Governance	Citilab is a public-private partnership although the support of the Cornellà City Council is key. The organization of activities revolves around individuals and their specific projects although some communities have been set up	The network of fab athenaeums is a public initiative. In the future, some fab athenaeums will be public-private partnerships. The organization of activities depends on associations that have been willing to take the lead in the different programs
Innovation outcomes	The innovation process matters more than the specific innovations. Sustainability and scalability of results are a concern	The innovation process matters more than the specific innovations. Sustainability and scalability of results are a concern
Methods and tools	Open innovation methodologies, design thinking, digital tools	Open innovation methodologies, design thinking, digital fabrication tools

4.3. Comparison and discussion

Table 2 compares Citilab and the network of fab athenaeums in terms of the most important dimensions of a living lab.

There are quite a lot of similarities between the two case studies. Both Citilab and the network of fab athenaeums clearly promote the concept of user involvement and co-production. They both believe that anyone can innovate and can address his/her specific challenges or those of his/her neighborhood. In this respect, both are a platform that encourages and supports citizens' innovation in their respective cities. They do so according to the open innovation approach and, therefore, using external ideas (mainly, citizens' ideas) as a resource for innovation in the territory (be it the neighborhood, the district, the city, the region), confirming the findings of other works regarding the use of open innovation approaches and methodologies in living labs (Baccarne et al., 2014; Bergvall-Kåreborn et al., 2009; Katzy & Mensik, 2007; Vicini et al., 2012).

However, in the case of Citilab, interactions take place particularly among individual citizens, and only sometimes, among companies. Individuals, with a common interest, exchange knowledge in the framework of specific projects, such as the seniorlab or the musiclab. More collaborative is the innovation process that takes place in fab athenaeums. Citizens with different backgrounds and interests, with different professions and training levels, interact in order to co-create an artifact that may be useful to address the district's problems, the only

thing they usually have in common. Also, user involvement takes a stronger bottom-up approach than in Citilab. In the latter, individuals approach the living lab and they usually end up taking part in already set workshops and other activities. As we have showed, it is not the case of fab athenaeums that heavily rely on the initiatives proposed by different stakeholders.

Finally, it is worth noting that in both Citilab and the network of fab athenaeums, the main user is the citizen. Open innovation and co-creation processes are specially focused on involving the citizen, which confirms the trend observed regarding the evolution of living labs (Serra, 2014).

In terms of infrastructure, both initiatives need big and open buildings, which are coherent with the open innovation philosophy they are based on. In fact, fab athenaeums require even bigger spaces due to the size of some of the digital fabrication machines they include. The physical space is key in both projects. The infrastructure needs to show the open culture (open innovation, open knowledge, open governance, open hardware and software) that drives innovation inside its walls (Bria et al., 2015).

However, the governance structure is quite different. Citilab is a public-private partnership, despite the predominance of the Cornellà City Council, which guarantees its sustainability. This is coherent with Schumacher (2012), which considers all leading living labs as private-public partnership initiatives but, also, with that of Nesti (2015) and Cleland et al. (2010). Fab athenaeums are public initiatives and the participation of companies is still not clear. Future plans include public-private partnerships but, at the moment, we would say the network is a public-people partnership. Therefore, although open innovation-based organizations should be based on the quadruple helix model (among other, Arnkil et al., 2010; Cosetta & Palumbo, 2014; Füzi, 2013; Hafkesbrink & Schroll, 2011), the involvement of different types of stakeholders is not that easy, limiting the innovation capacity of such environments.

Last, in both cases, despite the ultimate goals of the initiatives (to make an impact in terms of innovation), the innovation outcomes do not seem relevant. What matters is the process of empowering people, of making them realize that they can innovate and that they can have an idea to solve a problem that may affect them. Actually, this perspective makes sense, for both initiatives have scalability problems, probably due to the lack of greater firms' involvement and the lack of visibility. However, there seems to be a need to go further and to guarantee sustainability in terms of generation of innovation outcomes that make a difference, of political support, and of availability of economic and human resources. In terms of Manzini and Staszowski's (2013) dual perspective on living labs, at the moment, Citilab and the network of fab athenaeums are spaces where public agencies meet with people and other organizations to interact, exchange ideas, experiment together rather than to come up with scalable consolidated solutions. And this is valuable for itself.

5. Conclusions

The main objective of this article was to examine the role of living labs as public open innovation intermediaries. The findings and the comparison of both initiatives draw two first general conclusions. On one hand, we can confirm that Citilab and the network of fab athenaeums can be actually considered as living labs given their emphasis on open innovation and co-production methodologies, particularly focused on involving the citizen, who appears to be the main user of these spaces.

However, only one of the two living labs' facets pointed out by Manzini and Staszowski (2013) and Almirall et al. (2012) seem to be really consolidated in the case of Citilab and the network of fab athenaeums: they serve as places where organizations and individuals meet to exchange ideas and knowledge and to participate in co-creation processes, but experimentation in real-world settings is still underdeveloped.

On the other hand, most innovation processes that take place in their premises pursue the satisfaction of the specific needs of the neighborhood and the city and, therefore, aim at improving the citizens' quality of life. This is particularly true in the case of fab athenaeums. They therefore contribute to public innovation in terms of social innovation for the problems they address are social and the processes are bottom-up (Bekkers, Tummers, & Voorberg, 2013; Phills, Deiglmeier, & Miller, 2008).

Our analysis also provides answers to our three research questions:

1) How do living labs function as open innovation intermediaries? The two living labs are key enablers of innovation processes and they bridge the gap between public organizations and other innovation stakeholders, particularly, the citizens (Bakici et al., 2013). It is precisely the opportunity that public agencies have to meet with people and other organizations that make these living labs innovation intermediaries (Manzini & Staszowski, 2013). In both living labs, innovation processes take place following open innovation methodologies and co-creation approaches, what contributes to an evolution from traditional public innovation to collaborative public innovation (Bekkers et al., 2013).
   As innovation intermediaries, the living labs of our study fulfill the three main functions outlined by López-Vega (2012): they connect users (both individuals and organizations), they support and facilitate the exchange of ideas and knowledge, and they provide technological services, which mainly have to do with training.
   However, their role as public open innovation intermediaries is limited and could be further enhanced for intermediation only takes place among specific stakeholders, not taking advantage of the multistakeholder and quadruple helix perspectives suggested by Nesti (2015) and Cleland et al. (2010), among others. Citilab is a public-private partnership that involves public administrations, companies, non-profits and universities. But they do not collaborate in innovation processes. Also, there is exchange of information among citizens or among the companies that the living lab hosts. But there is not transversal work. In the three operating fab athenaeums, the participation of people is clear and extending. But the role of companies and universities is still to be seen.
2) What are some of the observable outcomes in terms of public innovation? In both cases, our findings show that the process matters more than obtaining specific innovation results. The novel solution to public challenges is precisely the adoption of open innovation, co-creation, and participatory approaches and methods. This is not new in the field of open innovation in the public sector, as De Vries, Bekkers, and Tummers (2016) and Gascó (2015) show. The former refer to the lack of reported goals/outcomes when embarking on the innovation journey and they underline the relevance of the process itself: "this could imply that the process of generating or adopting an innovation is seen as sufficiently important in itself" (p. 15). From our point of view, this perspective may legitimate the role of living labs as open innovation intermediaries despite their results.
3) What are the main challenges encountered by living labs as open innovation intermediaries? The lack of innovation outcomes conditions impact and sustainability. Thus, the will to empower citizens, the focus on the innovation process, is well founded but the area of influence of both Citilab and the fab athenaeums is still very small. Both types of living labs need to attract more users and stakeholders to their premises, to become more visible. Probably this will be harder for Citilab, the only living lab in Cornellà. The development of a network of fab athenaeums will facilitate reaching a wider audience throughout Barcelona. But other than attracting citizens, there is a need to make a real impact. Living labs should develop their experimentation component, as previously noted. But these experiments need, later on, to be deployed and operationalized at a wider scale. So far, Citilab and the network of fab athenaeums have served

as laboratories both for prototyping and sensitizing citizens. But this is not enough. Only scalability of results, which requires the participation of more stakeholders in the innovation process, does.

As Bakici et al. (2013), our analysis also shows that intermediation is a complex process to manage. The lack of resources, the different expectations of the participants in the innovation processes, and the need to control that public agencies have are only some of the additional challenges that living labs have to face.

In the light of these conclusions, more systematic research is particularly needed regarding the challenge of scalability. Quantitative and qualitative studies would be useful in order to explore and understand the needs and expectations of different stakeholders in public open innovation processes. Specifically, qualitative research should aimed at obtaining the insights of companies and universities, main actors in the quadruple helix model, about their role in the innovation process, in the generation of relevant innovation outcomes and, therefore, in the sustainability of living labs.

Public sector innovation is an important issue in the agenda of policymakers and academics but there is a need for a change of perspective, one that promotes a more open model of innovating, which takes advantage of the possibilities offered by collaboration between citizens, entrepreneurs and civil society as well as of new emerging technologies. Living labs are environments that can support public open innovation processes. This article makes a practical contribution to understand the role of living labs as intermediaries of public open innovation, emphasizing important issues regarding the process of intermediation, the outcomes and the main challenges.

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