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LIVING LABS UNDER CONSTRUCTION: PARADIGMS, PRACTICES, AND PERSPECTIVES OF PUBLIC SCIENCE COMMUNICATION AND PARTICIPATORY SCIENCE

Living labs contributions to smart cities from a quadruple-helix perspective

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Abstract

This paper explores living labs' contributions to smart cities from a quadruple-helix perspective. The selected exploratory case studies (Living Lab Florianópolis, Living Lab of the Itaipu Technological Park and Porto Digital) depict an institutional context characterized by a low interaction between the quadruple-helix components. The data were obtained through document analysis and interviews with living lab organizers and participants. The results suggest living labs can contribute by a) selecting the most promising projects to promote, b) connecting several agents and sharing informational through collaborative practices and events, c) facilitating mediation between participants in living labs and government agencies, universities and local companies to conduct tests, and d) inserting the fourth helix as a tester but not as a co-creator. These findings explain the participation of quadruple-helix components in the stages of project selection, development, and testing developing living labs. Finally, this article contradicts the predominant notion that living labs remain based on user-oriented innovation processes, purporting a producer-oriented trajectory.

Keywords Participation and science governance; Science education; Social inclusion

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Introduction

Communication is a central piece in the development of smart cities, as decision makers use new information and communication technologies (ICT) to optimize the city management [Mora, Deakin & Reid, 2019; Esashika, Masiero & Mauger, 2021]. For example, the most notable applications in infrastructure are real-time data analysis, the Internet of Things (IoT), autonomous cars as well as cloud and cognitive computing [Kummitha & Crutzen, 2017]. A smart city implements ICT in a way that positively affects the local community [Caragliu, Del Bo & Nijkamp, 2011]. Despite the recognition of technology as one of the main drivers of smart cities, some authors criticized the excessive focus on digital technologies [Calzada & Cobo, 2015; Jazeel, 2015]. Other scholars criticized the exclusion of human and

democratic aspects from the smart cities [Joss, Cook & Dayot, 2017; Engelbert, van Zoonen & Hirzalla, 2019].

New smart city projects balance human, technological, and participatory governance aspects [Meijer & Bolívar, 2015]. A central issue of these new projects is the development of innovations with different stakeholders [Leydesdorff & Deakin, 2011; Deakin, 2014]. In this context, living labs appear as a possible response to this new smart city stage, given their ability to aggregate different points of view, especially citizens [Mora et al., 2019]. Living labs cover a broad spectrum of fields and sectors but are notable for their contributions to open and user innovation [Westerlund & Leminen, 2011].

The academic and managerial literature describes processes carried out in living labs and suggests some benefits [Ståhlbröst, 2013; Evans, Jones, Karvonen, Millard & Wendler, 2015; Ballon, Van Hoed & Schuurman, 2018]. However, little is known about their real contribution to the progress of registered projects [Hossain, Leminen & Westerlund, 2019]. There are several ways to address this issue. In this article, we apply the quadruple-helix model to find answers to our primary goal, which is to be aware of how living labs contribute to the development of projects for smart cities.

This paper explores how living labs contribute to smart cities from the quadruple-helix perspective. We investigate the experiences of Living Lab Florianópolis, Itaipu Technological Park, and Porto Digital. The article is organised into five sections, considering the introduction. The second section presents the central theoretical background of the research, and the following describes the case study used and context. The fourth discusses some results that were not previously considered by the literature. Furthermore, the fifth is a conclusion, reviewing the main findings, observations, and implications for theory and practice.

Literature review

2.1 Smart cities

After two decades of research, there are still many controversies about the concept of smart cities. However, there are several points of convergence among the authors who analysed this concept. For example, the definitions are situated between two different paradigms, technology-driven [Hall et al., 2000] and human-driven [Caragliu et al., 2011].

The first paradigm is based on the predominance of technological aspects, such as using the most advanced information communication technology — ICT tools to provide more data and connectivity to managers and citizens [Calzada & Cobo, 2015]. There is a prominence for using Internet of Things — IoT to connect offline aspects of the city to data networks and big data to process them in real-time [Silva, Khan & Han, 2018]. The second paradigm is based on the role of communities and citizens for smart city development. In this case, technology is an instrument for increasing citizens' capacity to innovate and participate in the solution of urban problems [Angelidou, 2014; Beretta, 2018]. In this sense, more than adopting the most advanced ICTs to become smart cities, cities should seek to develop their citizens' capacities and skills so they can create technologies to deal with the urban problems experienced [Kummitha & Crutzen, 2017].

Several smart cities adopted living labs as a policy for local stakeholders' involvement, as opposed to the techno-centric or top-down approach [Mora et al., 2019; Spagnoli, van der Graaf & Brynskov, 2019]. Examples of cities that implemented solutions of this nature are: Busan Living Lab (Busan, South Korea), Citilab Cornellà (Barcelona,Spain), Andorra Living Lab (Andorra la Vella, Andorra), PraXlabs (Siegen, Germany), Basaksehir Living Lab (Istanbul, Turkey). Living labs can be understood as an organization dedicated to developing technological and non-technological solutions for smart cities [Coorevits, Georges & Schuurman, 2018]. The most widely held notion of living labs is considering then as a methodology in which stakeholders form public-private partnerships collaborate in the creation, prototyping, validation, and testing new technologies [Bergvall-Kareborn & Stahlbrost, 2009; Dell'Era & Landoni, 2014; Herrera, 2017]. In this notion, there is a prominence for the co-creative process, which characterises open innovations, including the end-user in technological solutions [Burbridge, 2017; Ballon et al., 2018].

Living labs prove to be an alternative to promote entrepreneurship and innovation in cities, contributing to a smart economy, directing people's knowledge, skills and creativity to create new processes, products, and services [Perng, Kitchin & Mac Donncha, 2018]. Among the living lab projects carried out in smart cities, there are some related to sustainable development [Leminen, Westerlund & Nyström, 2012], social activism [Hughes, Foth, Dezuanni, Mallan & Allan, 2017], and entrepreneurship [Rodrigues & Franco, 2018]. Public policies have introduced living labs to develop solutions for smart cities. An example of such an initiative is the Joint Programming Initiative (JPI) Urban Europe and Horizon 2020 [Pallot, Alishevskikh, Holzmann, Krawczyk & Ruland, 2014]. This Program foresees that living labs will be used in processes where the local population will act as a co-creator, exploring, examining, experimenting, and testing new ideas, scenarios, processes, systems, concepts, and creative solutions in complex and real contexts [Voytenko, McCormick, Evans & Schliwa, 2016].

2.2 Living labs

The concept of "living labs" is credited to William J. Mitchell, who carried out one of the earliest experiences at Massachusetts Institute of Technology in 2003 [Nesterova & Quak, 2016]. The initial idea was to develop R&D activities in real situations, making it possible to analyze users' feedback regarding innovation. Despite almost twenty years, the literature has not yet converged on the living lab concept. It is defined by some as innovation arena [Almirall & Wareham, 2011]; project [Ståhlbröst, 2012], network [Leminen & Westerlund, 2012; Van Geenhuizen, 2016] or methodology [Bergvall-Kareborn & Stahlbrost, 2009; Dell'Era & Landoni, 2014; Herrera, 2017].

Among the roles played by livings labs, several authors highlight the contribution to citizen-development and experimentation in new urban technologies [Evans et al., 2015; Ballon & Schuurman, 2015; Veeckman & van der Graaf, 2015]. Others emphasize the performance of living labs in the innovation management and technology used in smart cities [Hielkema & Hongisto, 2013; Letaifa, 2015; Larios, Gomez, Mora, Maciel & Villanueva-Rosales, 2016]. However, it is not clear how living labs contribute to the collaborative projects in smart cities, although several

studies report some benefits of living labs to some stakeholders [Voytenko et al., 2016; Rodrigues & Franco, 2018].

The role of living labs in smart cities' innovation networks resembles a boundary spanner or border crossers as an organization that understands the requirements of different stakeholders [Schaffers & Turkama, 2012; Canzler, Engels, Rogge, Simon & Wentland, 2017]. Champenois and Etzkowitz [2018] emphasize that independent hybrid organizations could be created at the intersection of institutional spheres to facilitate overcoming innovation barriers. Living labs can be viewed as the intercommunication intermediates of the different quadruple-helix components [Voytenko et al., 2016; Engelbert et al., 2019]. In this sense, they play the role of these hybrid organizations in quadruple-helix networks.

Følstad [2008] did a systematic review of the literature and identified four common characteristics in living labs studies: 1) discovery of unexpected uses for technologies and services; 2) a user's validation of solutions; 3) an experimentation or experience in a real context, and 4) conducting medium and long-term studies with users. In another review, Hossain et al. [2019] complemented these characteristics by highlighting multiple stakeholders' interactions and forming networks in living labs. All these features are guided by principle as involvement of multiple stakeholders [Rodrigues & Franco, 2018], the reciprocity of interests [Nyström, Leminen, Westerlund & Kortelainen, 2014], the search for the development of sustainable products and services [Ståhlbröst, 2012], the approach of innovation to real systems [Mora et al., 2019], and open innovation processes [Nilssen, 2019]. Based on these principles living labs carry out, several processes, as shown in Table 1.

Some criticisms of living labs can be seen in the literature, especially regarding their ability to develop innovations guided by end-users. For Kommonen and Botero [2013], there is a confusion about user involvement and user-driven innovation, the first considered a reactive and the second an active role in innovation development. Vanmeerbeek, Vigneron, Delvenne, Rosskamp and Antoine [2015], when analysing 20 European living labs' processes, found that the involvement of end-users was reactive, basically in the feedback of concluded projects. The results also suggest that living labs are adopting a perspective oriented by producers than by end-users. Other obstacles are the difficulty of establishing a mutual understanding between different stakeholders [Ogonowski, Ley, Hess, Wan & Wulf, 2013]. Managing contractual conflicts and the existence of different cognitive representations among stakeholders are common [Zuzul, 2019]. The relationship among them is not always harmonious and functional.

Another concern about living laboratories is their long-term sustainability. Many ended their activities in the last decade, after the boom of the 2000s, presenting problems related to the lack of resources to finance their activities [Nesti, 2017, 2018]. Another aspect related to this is the perception that the tests developed by the living labs are expensive, which can deter sponsor support for initiatives [Wilson, Patel, Pettitt & Saikayasit, 2008]. Finally, Mastelic, Sahakian and Bonazzi [2015], when analysing the living laboratories that make up the European Network of Living Laboratories (ENoll), identified an absence or underrepresentation of indicators to assess the cost structure, customer segmentation and revenue flow of the living laboratories.

Table 1. Living labs processes. Source: Authors' elaboration.

Process	Description	Source
Multiple stakeholders' involvement	Living labs are based on the quadruple helix model of partnership whereby government, industry, the public, and academia work together to generate innovative solutions.	Bergvall-Kareborn and Stahlbrost [2009], Nyström, Leminen, Westerlund and Kortelainen [2014], Dell'Era and Landoni [2014], Ståhlbröst and Holst [2017], Herrera [2017] and Rodrigues and Franco [2018]
Promotion of training and collaborative events	Promoting training courses and events to create the conditions for new solutions, entrepreneurial, sharing ideas (hackathons, networking, mentoring, training, workshops, meetings, boot camps, design sprints, and design thinking sessions).	Cosgrave, Arbuthnot and Tryfonas [2013], Ståhlbröst [2013] and Perng, Kitchin and Mac Donncha [2018]
Tests inserted in real places	Living labs are geographically embedded in real places, territorializing urban innovation at a manageable scale.	Evans and Karvonen [2011], Voytenko, McCormick, Evans and Schliwa [2016], Mora, Deakin and Reid [2019] and Hossain, Leminen and Westerlund [2019]
User-centric development	Users are involved throughout all the phases of the trial process (planning, implementation, evaluation, feedback). The technological solution is revised and continuously improved to meet stakeholder needs.	Bergvall-Kareborn and Stahlbrost [2009], Almirall and Wareham [2011], Almirall, Lee and Wareham [2012], Schuurman, Baccarne and Marez [2012], Burbridge [2017] and Ballon, Van Hoed and Schuurman [2018]

2.3 Quadruple-helix

The quadruple-helix model is an improvement of the triple-helix (TH) to analyze production and diffusion of knowledge in innovation ecosystems [Etzkowitz & Leydesdorff, 2000]. The TH model emerged from the analysis of the interaction between industry, government, and university as crucial players in explaining innovation conditions in a knowledge-based society [Etzkowitz, 2003]. This approach focuses on components considered essential for regional development [Jensen & Tragardh, 2004]. In this model, the industry is the locus of production, the government is the source of contractual and guaranteeing productive relations, and the university is the source of new knowledge and technologies.

The industry plays the role of creating new products, services, markets, forming communities and generates new entrepreneurs [Herliana, 2015]. The helix industry can act as a facilitator in sharing ideas from local companies, mentoring businesses, and training new entrepreneurs. Luengo-Valderrey, Pando-García, Periáñez-Cañadillas and Cervera-Taulet [2020], highlight that businesses have enjoyed the information gathered from the relationship with the other two institutional actors while Sá, Casais and Silva [2019] mention that TH networks encourage entrepreneurs to act, get financial support, and establish partnerships.

The government acts in TH networks mainly as catalysts and, eventually, as entrepreneurs. As a catalyst, it stimulates the private sector and universities, favoring financing, given incentives, and protection. In this sense, it can also contribute by regulating public policies that favour national and regional innovation ecosystems [Lee & Kim, 2016] or by consuming products and services developed by entrepreneurs [Herliana, 2015]. As an entrepreneur, the government acts directly in technological solutions and new businesses, mainly in situations that present market failures [Sarpong, AbdRazak, Alexander & Meissner, 2017].

The role of universities is seen as a driver of innovation, edging away from the "ivory tower" model, [Gunasekara, 2004]. In this new role as an enabler of innovation, there is an expectation that the university will actively act in the development of its region through activities such as technology transfer, and in the development of curricula oriented to the needs of the local industry [Goddard, Coombes, Kempton & Vallance, 2014]. Universities are providers of highly skilled workers, expert advice to local development agencies and firms, and they attract new firms [Cai & Liu, 2015]. Despite the relevance of universities' role, recent research points to technology centres, public research organisations, and consultant agencies as enablers of TH networks [Luengo-Valderrey et al., 2020].

Leydesdorff and Deakin [2011] used the TH model to analyze the knowledge-based economy in urban contexts. The main argument is that cities are dense networks with the presence of TH components producing spaces for knowledge exploration. Other authors proposed civil society as a fourth helix, acting as innovation user and co-creator [Carayannis & Rakhmatullin, 2014]. End-users are essential stakeholders in co-creating and accepting innovations [Schuurman, Baccarne & Marez, 2012; Kummitha & Crutzen, 2017; Brock, den Ouden, van der Klauw, Podoynitsyna & Langerak, 2019]. A central issue in the discussion about the quadruple-helix model in smart cities is how to engage citizens in the innovation processes. Baccarne, Logghe, Schuurman and De Marez [2016], recommend using living labs as one solution to introduce citizens in these activities.

Smart cities, especially from a human perspective, can be seen as open environments oriented towards user-driven innovations [Schaffers et al., 2011]. In this context, civil society becomes an essential component of innovation ecosystems, making it possible to provide instant feedback to local governments, businesses, and universities [Selada, 2017]. It is possible to envision the formation of quadruple-helix innovation networks around smart cities, with the aggregation of the citizen's component as co-creator of products and services implemented in urban life. The development of living labs based on quadruple-helix networks may foster the relationship between all constituencies in building out new smart cities' solutions [Mora et al., 2019] and improve the connection between actors involved in smart cities [Nilssen, 2019].

Methods

3.1 Research framework

We conducted exploratory case studies [Eisenhardt, 1989] to investigate living labs' contributions to smart cities from a quadruple-helix perspective. The study's primary goal is to discuss how living labs contribute to smart cities from a quadruple helix perspective. Figure 1 represents the research framework

considering that the quadruple-helix components support all the activities carried out by living labs. They are also the main stakeholders of our three selected cases to be investigated. They are important players in living labs and as quadruple-helix networkers that contribute to the development of innovative activities in a determined ecosystem scope capable of delivering new projects for smart cities.

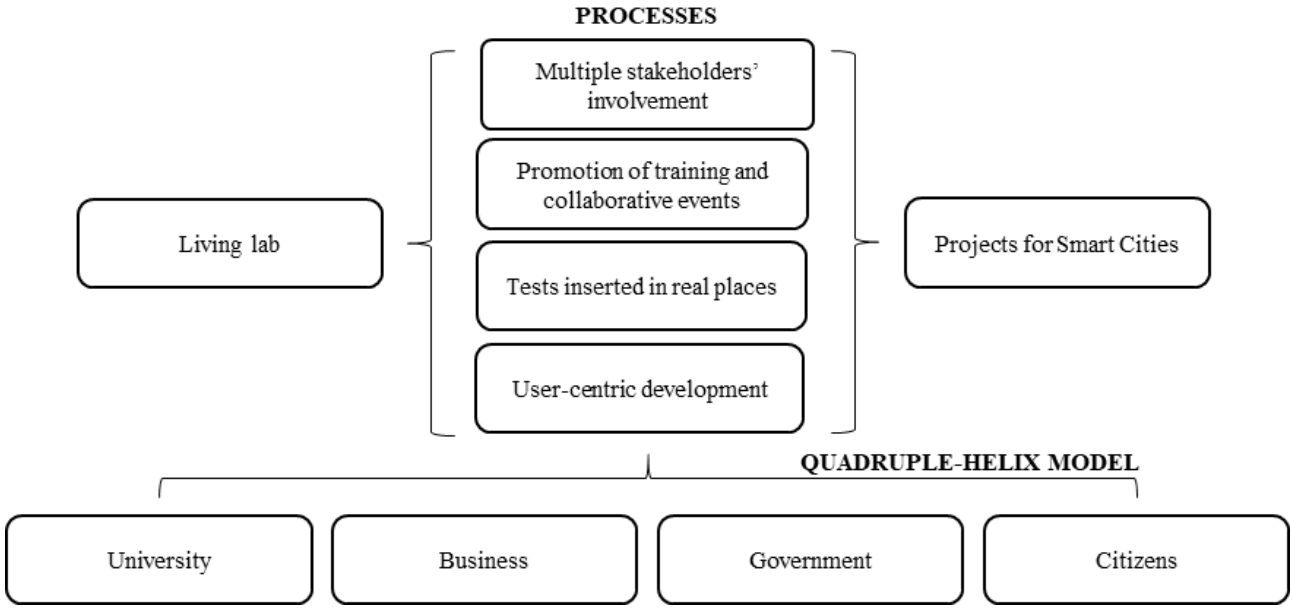

Figure 1. Research framework. Source: Authors' elaboration.

3.2 Context

The selected cases (Living Lab Florianópolis, Living Lab of the Technological Park of Itaipu and Porto Digital) have already been recognised internationally for their contributions to open innovation and the development of cities, at the Smart City Expo, the Knowledge Cities World Summit and the Open and Agile Smart Cities. The Living Lab Florianópolis is an initiative created in 2018 by the Florianópolis Innovation Network, a partnership between the City Hall and the Catarinense Technology Association (ACATE). This living lab aims to implement new ideas for innovative urban growth, using infrastructures to test the feasibility of promoted solutions. In this first experience, 10 projects were developed in the living lab.

The Itaipu Technological Park was created in 2003 to increase tourism, technological, and sustainable development in Brazil and Paraguay. Since 2018, it has a living lab focused on smart cities, inserted in a context with physical space for test-beds, labs, universities, and a business incubator to carry out research and innovation in renewable energies, internet of things, smart buildings, ICT and sustainable urban mobility. The living lab of the Park has 11 completed projects and 13 projects are being developed.

Porto Digital is also a technological park that includes more than 300 companies and institutions of ICT, Creative Economy, and Technologies for Cities. It was created in 2000 to be a public policy for developing the information technology sector in Pernambuco. Since 2019 it has congregated the Open Innovation Lab, the

Connected Urban Objects Laboratory, and the Application Testing Laboratory and incubates many startups to develop new city's technologies. It should be noted that the incubated companies can use any structures and laboratories available at Porto Digital. The structure also has a multifunctional team that articulates tests and partnerships with local government, other companies, and organized civil society. They select about 15 projects per semester to receive support. Table 2 presents a sample of projects covered by the three living labs selected for this study.

Table 2. Sample of living lab projects. Source: author's elaboration.

Living lab	Project	Description
Living Lab Florianópolis	Mobilis	Electric vehicles for rent and sharing.
	Sigmais	Sensing for monitoring vehicle traffic and managing parking.
	Smart Green	Automation for energy and intelligent public lighting.
Technological Park of Itaipu	NeoAutus	Projects and services in IoT.
	Mobhis — Automação Urbana	Automation technologies.
	AIS Ambientes Virtuais	Immersive experiences (virtual and augmented reality).
Porto Digital	Solis Imperium	Solar energy solutions.
	REPlant	Urban farming app.
	Navegue	Solution for expanding the use of river transport.

3.3 Data collection

Secondary data ware prospected from sites, news, and living labs internal documents. The primary data were collected through eighteen semi-structured interviews with organizers and participants of living labs, distributed proportionally in the three cases (9 — living labs organizers, 9 — living lab participants). The sample includes government representatives, citizens, companies and universities, in each case analyzed. In the group of organizers, we allocated representatives of government, citizens and invited academics. We proportionally included business representatives in the group of participants. All questions are related to the projects, processes, and events carried out by living labs as well as appreciations on their contributions to smart cities. Some interviewees asked to answer in writing, instead of conventional interviews. We transcribed and analysed all the interviews, which lasted from 45 to 60 minutes.

3.4 Data analysis

To analyse the collected data, we use the content analysis approach, method characterised by the subjective analysis of the contents expressed in the text, operationalized through systematic classification, codification, and identification of themes or patterns [Hsieh & Shannon, 2005]. We used an inductive approach to select the categories from the analysis of the contents of the documents and interviews. In the sentences, we identified critical elements for explaining aspects related to the research framework.These excerpts were coded by themes and later grouped into categories presented and discussed in sub-items (4.1; 4.2; 4.3; 4.4) of

the following section. Content analysis involves the researcher's subjective judgment. To avoid reliability problems, two researchers worked independently on the coding and categorisation of texts.

Results

4.1 Multiple stakeholders' involvement

In the cases analyzed, we observed that the involvement of multiple stakeholders in living labs starts with the evaluation committee. According to criteria established in the call for proposals, these committees are responsible for the analysis of eligible projects. In the three cases there is the participation of several entrepreneurs, teachers, public managers, citizen´s organisations, investors, and members of auxiliary organisations, such as incubators and accelerators. There is a similarity in the composition of the committees, including all representatives considered in the quadruple helix model. In all cases, professionals from the government, industry, universities, and society were active participants in the screening and selection of the proposals submitted to each living lab considered in this study. A comparison of the selection initiatives among the three cases is shown in Table 3.

Other aspects related to performing the committees' activities are foreseen in the calls: thematic adherence and the project evaluation criteria. The thematic adherence of the project conditions its acceptance to compatibility with the development of smart cities. Among the themes presented in the cases studied, we found the orientation for the development of projects related to sustainability (water, energy, and environment), security, public management, participatory governance, tourism, creative economy, culture and entertainment, mobility, and quality of life. It should be noted that these themes identified in the three cases are compatible with those described by Mora et al. [2019] on the development of smart cities.

Regarding the selection criteria, there is an emphasis on analysing the participants' profile, the innovation introduced by the project, the market potential, and the social benefits of the solution. In the three cases, there is an orientation of the solutions developed for the market, showing a business emphasis in the living labs, as highlighted in Vanmeerbeek et al. [2015]. It is also a critical process for discussing the contributions offered by living labs, given selecting the most promising projects, which favour the optimisation of resources. In this context, it is worth mentioning that we have identified the role of the government as an activator, in view of its cooperation in the financing and organization of living labs. Finally, we should note that the concern with the financial return of living labs is one of the open questions in the literature [Nesti, 2018].

Also, several interviewees pointed out the role of universities in the methodology's development and as a strategic partner in providing new information and knowledge during the development of selected proposals by the living lab. Interviewer # 10 (organizer/university) expresses the point when he says that "*At the Living Lab Florianópolis, the Federal University of Santa Catarina, through the research group VIA Estação Conhecimento, specialized in innovation and entrepreneurship habitats, developed the method used in the Program. Also, the university acted as a connector of actions for the viability of solutions*". Respondents mentioned the

Table 3. *Selection of initiatives — comparison between cases.* Source: author's elaboration.

Case	Committee	Themes	Selection criteria
Living Lab Florianopolis (excerpt from the Call 1-2018 for Living Lab Florianópolis Program).	"Selection: an Evaluation Committee analyses and evaluates the content of the approved documents and will be composed of actors from the innovation ecosystem (entrepreneurs, teachers, public managers, investors)".	"The themes of solutions, possible demands and opportunities that the program search select are: Water, energy and the environment; Security; Public administration; Tourism, creative economy, culture, entertainment; Transport and mobility; Quality of life and health; Commerce solution".	"The selection criteria are: a) Profile: characteristics of the company/organization and team competence. b) Innovation: the presence of new or distinctive features and comparison with other solutions with similar purposes; c) Adequacy: the solution meets the requirements of the beneficiaries, the rules, and laws necessary for its implementation; d) Usefulness: adding value from the solution to the market/society; e) Market: viability of the solution's commercialization model".
Porto Digital(excerpt from the Call for Porto Digital Entrepreneurship Programs: 2020.1 Incubation).	"An Evaluation Committee will be created to analyse the proposals made up of representatives of the NGPD Business Team, besides partners, investors, researchers, entrepreneurs, and external experts".	"Smart Cities: creating innovation in environmental sustainability, tourism, digital accessibility, urban mobility, citizen empowerment, drinking water, energy, and sanitation."	"Evaluation Criteria: Profile and availability of entrepreneurs; Knowledge of the Problem and Market; Product/Degree of innovation; Impact; Business & Management Model; Business & Capital Opportunity".
Itaipu Technological Park (excerpt from the call for corporate innovation program focusing on the development of new companies 001/2020).	"The proposals sent by the entrepreneurs will be evaluated and selected through a panel made up of business specialists to be defined later by the PTI-BR Foundation".	"Thematic lines: Agribusiness; Energy; Tourism and Cities; Critical Infrastructure Security".	"In the selection of proposals for the Incubation phase, three criteria will be considered: a) Technical: [...] will evaluate the proposals under four axes: Market, Management, Finance, and Technological. b) Entrepreneur (attendance, commitment, quality of deliveries). c) Solution (potential for scale solution, cost x benefit, MVP quality)".

importance of university for proposals being developed in the living labs, as expressed in the excerpt from Interviewer # 17 (participant/business): "*Many solutions are based on academic research. However, it is necessary to bring this 'laboratory solution' to a 'market solution'*".

4.2 Promotion of training and collaborative events

We identified in the cases that the events organised by the living labs have a connecting role between the incubated projects and other components of the quadruple-helix, encouraging the emergence of alliances.These practices bond participants to other actors in the innovation ecosystem, who are usually invited to

lead workshops during the incubation. In these activities several companies, universities, research centres, development agencies, public institutions, and private partners participates.Interviewer # 16 (organizer/citizen) states: *"Our event trail takes place weekly (jam sessions, workshops), to awaken possibilities and connect actors, the place where connections happen."* These practices are also in line with participants' expectations of accessing a larger network of companies and discovering future markets [Perng et al., 2018].

This role of connector established by living labs is contingent in the cases studied. The living lab team seeks an association between the actual needs of each project and the general practices. There is a current events agenda that meets all projects and specific agendas for each project. This aspect favours projects in more advanced stages of development, which report the benefits of events for the formation of new partnerships and greater visibility, as expressed in the excerpt from Interviewer # 6 (participant/business): *"No improvement at the product level, but it generated more visibility and strengthened some partnerships"*. By Interviewer # 7 (participant/business): *"One of the Living Lab's major strengths was establishing partnerships, connecting networks that remained in contact after the laboratory experiment"*. These results corroborate the view that living labs can increase the visibility of projects in the media and in the community [Ståhlbröst, 2013].

The Itaipu Technological Park has a distinct initiative, which increases the possibility of integration between projects and local institutions. Before the publication of the call, there is the possibility that public and private organisations in the region register their technological needs, which can be solved by the selected groups. Therefore, since the beginning of the process, there is a link between the projects and the local ecosystem actors. Interviewees' highlighted the contribution of local businesses to the projects registered in the living labs, as Interviewer # 14 (organizer/government) mentioned: *"In the Program, those who facilitate and mentor are ecosystem companies. We have a significant exchange between entrepreneurs and the ecosystem itself"*. These companies provide the incubated projects with informational, relational, physical, and financial resources. As pointed out by Champenois and Etzkowitz [2018] when studying hybrid organizations for innovation, we found in the cases that the role of mentors, successful companies, was relevant for the development of projects registered in living laboratories, according to the participants view.

4.3 Tests inserted in real places

In the three cases the real environments for testing were considered by the interviewees of great importance, corroborating the findings of other investigations [Voytenko et al., 2016; Hossain et al., 2019]. At this stage, there is essential government participation in providing adequate space to carry out the experiments. We emphasise that this role of the government is fundamental, since they can make it possible to carry out tests and government representatives in living labs facilitate this articulation. Interviewee # 7 exemplifies the results of this interaction: *"During the Living Lab, the joint work between the living lab team and the city hall was essential to making the tests of the companies feasible, given the variety of products. It was an extremely complex activity, as each company required the creation of a different testing environment"*.

One aspect that makes testing complex is the variety of needs for each project. Interviewee's # 10 illustrates the need for articulation with various government agencies to carry out tests: "*One example was the company Sigmais, which, during its participation in the Living Lab, inserted a vehicle counting device at the entrance and exit of Santa Catarina Island. The Florianopolis secretariat of mobility later used these numbers for decision making. Another example was ManejeBem, which used vegetable gardens at health centers in the city to provide remote cultivation advice. The company Wifeed used a busy street in the city center to install its Internet Hotspots with a media platform [. . .]*". Although living lab is characterised in the literature as a place to test solutions [Evans & Karvonen, 2011; Voytenko et al., 2016; Mora et al., 2019; Hossain et al., 2019], little has been explored about why participants take trial solutions in this context. This highlighted section points out that living labs are used to simplify interactions with other agents to carry out experiments, especially with the local government.

In the specific case of the Itaipu Technological Park, some spaces allow the installation of prototypes in the park's structure that simulate real environments. Interviewee # 17 confirms the disposition: *"The technological park allows the installation of prototypes in the park itself and helps in articulating partners for the prototype installation/validation."* Despite the emphasis on government participation as the primary test enabler, we also see contributions from universities and local companies. In these cases, understood as exceptions, universities, and businesses provide physical structures, machines, and human resources for more specific tests. These are situations related to projects that depend on technologies and knowledge available in these components of the quadruple-helix.

4.4 User-centric development

The living labs' contribution to the promotion of a "feedback culture" stands out from the interviewees' statements. This feedback is an essential part of product development to decide whether to continue, pivoting, or abandoning the project. The excerpt from the interviewee # 7 illustrates this topic: "*One of Living Lab's most relevant contributions was the development of a feedback culture, in which customers provide their impressions about the functioning of the products developed [. . .]. Customer feedback is fourth helix participation, considering that it is a collaboration for product development*".

Many interviewees recognised this stage as a period of sped up learning of technical and behavioural issues that can directly affect the adoption or not of the solutions developed. This point is well characterised by interviewee's # 12: *"We did a series of tests and surveys with end-users. We face a problem of low engagement. We found that some people did not maintain the app because of the lack of space in the phone's memory, among other hypotheses that we had not tested yet"*. Most times, this was the first opportunity to test the product or service with the end-users.

Interviewees have reported a short iterative process close to the end-user. They described that updates on the projects were made available for testing as soon as they created the functionalities, allowing for a continuous feedback cycle. They also mention continuity of this cycle after the closing of the living lab, establishing an approximation in the relationship between customers and suppliers. The

excerpt from the interviewee # 4 clarifies this point: *"We developed the product with the customer. With each update, the tool received feedback on its functionality, making it better. We used the customer environment as a testing platform, launched the platform, defined the testing time, and met to discuss the results. Even after launch, we train customer employees to understand the tool".*

It should be noted that the interaction of the end-user passively took place. In the primary data as well as in the secondary data analised, we found no evidence of end-users acting as co-creators in the various solution development stages, as suggested by most studies on living labs [Bergvall-Kareborn & Stahlbrost, 2009; Almirall & Wareham, 2011; Almirall, Lee & Wareham, 2012; Schuurman et al., 2012; Ballon et al., 2018; Hossain et al., 2019]. The end-users were characterized more than a passive tester, distinguishing itself from the expectation of user-driven innovation.

Conclusions

The paper explores the living labs contributions to smart cities from the quadruple-helix perspective. Three living lab case studies (Living Lab Florianópolis, Porto Digital, and Itaipu Technological Park) were developed to conclude that in the four processes analysed living labs contribute for smart cities: a) selecting the most promising projects to be promoted; b) connecting several agents through collaborative practices and events; c) facilitating mediation between participants and government agencies, universities and local companies; and d) incorporating the society — the fourth helix, as a tester, but not as a co-creator.

Regarding the selection of projects, we highlight the involvement of multiple components of the quadruple-helix from the initial stages in the living labs. In particular, the role of the university role focused on technical guidance and methodological definitions used in the living lab processes. In this sense, we verified a fundamental contribution of the university to qualify the selection of projects developed within living labs. It is also worth mentioning the government role as a financier and promoter of the living labs, being also considered a relevant component for activation the initiative.

Regarding the connection of agents, we found that the events were essential to connect the participants to the other local actors involved in innovation processes. Again, we were able to observe here the performance of the various components of the quadruple-helix leading workshops and lectures, which facilitated the establishment of contacts and partnerships to make projects viable. The role of local companies as mentors during the living lab programs analyzed stands out.

In addition, we identified the contribution of living labs as a mediator for testing. The articulation of the organizers with the local government, universities and local businesses provided access to the physical spaces, machines and human resources needed to carry out trials of the solutions. We also highlight the role of the government, which, by engaging with the team of living lab organizers, reduces the barriers faced by participants.

It should be noted that the incorporation of civil society in the process did not occur as provided in the literature. In the three cases studied, there was the involvement of end-users in the innovation process, as testers and providing

feedback to the projects. However, far from being a user-driven innovation process. In other words, the end-user played only a secondary role during the development process, more of a tester than of a co-creator.

Finally, conclusions from case studies tend to be difficult to generalize due to the specificity of the context and/or the targeted sample. In this paper, data collected from Brazil allows a generalization to countries with a similar cultural context. Regarding the sample, the four groups assessed fit with samples from past research, allowing generalization. In addition, the four identified processes can be used as a reference for further studies, considering that there are positive indications of the effective contributions of living labs to smart cities development. Our results suggest the need for future research, investigating the role of citizens as co-creators, in view of their passive role in a producer-oriented process promoted by living labs.

Appendix A. Interview questionnaire

Research — "Living labs contributions to smart cities from a quadruple-helix perspective". We intend this questionnaire to assess the effective contribution of living labs to the development of solutions for smart cities. In this sense, we are contacting entrepreneurs and organizers who took part in incubation calls in which there was the support from a living labs.

This questionnaire is anonymous and confidential, and we will use only the answers for scientific purposes. This questionnaire is an integral part of a PhD research work in Administration, from the Faculty of Administration, Accounting and Economics of the University of São Paulo, under the guidance of Professor Gilmar Masiero.

We thank you in advance for your availability and collaboration in this study. We are available to answer questions.

1. During the incubation period, were any of these activities offered?
   - ( ) Mentoring.
   - ( ) Design thinking sessions.
   - ( ) Meetups and networking meetings.
   - ( ) Hackathons.
   - ( ) Workshops.
   - ( ) Others.
2. How did the activities mentioned above help entrepreneurs in the development of projects? Could you cite examples of the remarkable experiences you had?
3. Did the incubation experience contribute to the prototyping or improvement of the projects? If so, in what ways could you inform us?
4. During the incubation period, was a structure offered to test the projects in an environment close to reality? If so, could you highlight any experiences?

5. During the incubation period, did the incubated projects receive feedback from the end customers? If so, how did this feedback affect the products / services offered by the projects? Could you give some example (s)?
6. Do you consider that the projects contributed to the development of smart cities in Brazil? if so, in what way?
7. Did the universities play a role or offer contributions to the incubated projects? If so, could you highlight some examples?
8. Has the government, considered in its multiple instances, played any kind of role or offered contributions to the incubated projects? If so, could you highlight some examples?
9. Did local companies and industries play a role or offer contributions to the incubated projects? If so, could you highlight some examples?
10. Did the local citizens play a role or offer contributions to the incubated projects? If so, could you highlight some examples?
11. Did any other institutional actor play a role or offer contributions to the incubated projects? If so, could you detail which actors and their respective contributions?
12. How do you assess the incubation period? What could be improved in the experience?

References

Almirall, E., Lee, M. & Wareham, J. (2012). Mapping living labs in the landscape of innovation methodologies. *Technology Innovation Management Review 2* (9), 12–18. doi:10.22215/timreview/603

Almirall, E. & Wareham, J. (2011). Living labs: arbiters of mid- and ground-level innovation. *Technology Analysis & Strategic Management 23* (1), 87–102. doi:10.1080/09537325.2011.537110

Angelidou, M. (2014). Smart city policies: a spatial approach. *Cities 41*, S3–S11. doi:10.1016/j.cities.2014.06.007

Baccarne, B., Logghe, S., Schuurman, D. & De Marez, L. (2016). Governing quintuple helix innovation: urban living labs and socio-ecological entrepreneurship. *Technology Innovation Management Review 6* (3), 22–30. doi:10.22215/timreview/972

Ballon, P. & Schuurman, D. (2015). Living labs: concepts, tools and cases. *SSRN Electronic Journal*. doi:10.2139/ssrn.2642754

Ballon, P., Van Hoed, M. & Schuurman, D. (2018). The effectiveness of involving users in digital innovation: measuring the impact of living labs. *Telematics and Informatics 35* (5), 1201–1214. doi:10.1016/j.tele.2018.02.003

Beretta, I. (2018). The social effects of eco-innovations in Italian smart cities. *Cities 72*, 115–121. doi:10.1016/j.cities.2017.07.010

Bergvall-Kareborn, B. & Stahlbrost, A. (2009). Living lab: an open and citizen-centric approach for innovation. *International Journal of Innovation and Regional Development 1* (4), 356. doi:10.1504/ijird.2009.022727

Brock, K., den Ouden, E., van der Klauw, K., Podoynitsyna, K. & Langerak, F. (2019). Light the way for smart cities: lessons from Philips Lighting. *Technological Forecasting and Social Change 142*, 194–209. doi:10.1016/j.techfore.2018.07.021

Burbridge, M. (2017). If living labs are the answer — what's the question? A review of the literature. *Procedia Engineering 180*, 1725–1732. doi:10.1016/j.proeng.2017.04.335
Cai, Y. & Liu, C. (2015). The roles of universities in fostering knowledge-intensive clusters in Chinese regional innovation systems. *Science and Public Policy 42* (1), 15–29. doi:10.1093/scipol/scu018
Calzada, I. & Cobo, C. (2015). Unplugging: deconstructing the smart city. *Journal of Urban Technology 22* (1), 23–43. doi:10.1080/10630732.2014.971535
Canzler, W., Engels, F., Rogge, J.-C., Simon, D. & Wentland, A. (2017). From "living lab" to strategic action field: bringing together energy, mobility and information technology in Germany. *Energy Research & Social Science 27*, 25–35. doi:10.1016/j.erss.2017.02.003
Caragliu, A., Del Bo, C. & Nijkamp, P. (2011). Smart cities in Europe. *Journal of Urban Technology 18* (2), 65–82. doi:10.1080/10630732.2011.601117
Carayannis, E. G. & Rakhmatullin, R. (2014). The quadruple/quintuple innovation helixes and smart specialisation strategies for sustainable and inclusive growth in Europe and beyond. *Journal of the Knowledge Economy 5* (2), 212–239. doi:10.1007/s13132-014-0185-8
Champenois, C. & Etzkowitz, H. (2018). From boundary line to boundary space: the creation of hybrid organizations as a Triple Helix micro-foundation. *Technovation 76-77*, 28–39. doi:10.1016/j.technovation.2017.11.002
Coorevits, L., Georges, A. & Schuurman, D. (2018). A framework for field testing in living lab innovation projects. *Technology Innovation Management Review 8* (12), 40–50. doi:10.22215/timreview/1204
Cosgrave, E., Arbuthnot, K. & Tryfonas, T. (2013). Living labs, innovation districts and information marketplaces: a systems approach for smart cities. *Procedia Computer Science 16*, 668–677. doi:10.1016/j.procs.2013.01.070
Deakin, M. (2014). Smart cities: the state-of-the-art and governance challenge. *Triple Helix 1* (1), 1–16. doi:10.1186/s40604-014-0007-9
Dell'Era, C. & Landoni, P. (2014). Living lab: a methodology between user-centred design and participatory design. *Creativity and Innovation Management 23* (2), 137–154. doi:10.1111/caim.12061
Eisenhardt, K. M. (1989). Building theories from case study research. *The Academy of Management Review 14* (4), 532. doi:10.2307/258557
Engelbert, J., van Zoonen, L. & Hirzalla, F. (2019). Excluding citizens from the European smart city: the discourse practices of pursuing and granting smartness. *Technological Forecasting and Social Change 142*, 347–353. doi:10.1016/j.techfore.2018.08.020
Esashika, D., Masiero, G. & Mauger, Y. (2021). An investigation into the elusive concept of smart cities: a systematic review and meta-synthesis. *Technology Analysis & Strategic Management 33* (8), 957–969. doi:10.1080/09537325.2020.1856804
Etzkowitz, H. (2003). Innovation in innovation: the triple helix of university-industry-government relations. *Social Science Information 42* (3), 293–337. doi:10.1177/05390184030423002
Etzkowitz, H. & Leydesdorff, L. (2000). The dynamics of innovation: from national systems and "mode 2" to a triple helix of university-industry-government relations. *Research Policy 29* (2), 109–123. doi:10.1016/s0048-7333(99)00055-4
Evans, J., Jones, R., Karvonen, A., Millard, L. & Wendler, J. (2015). Living labs and co-production: university campuses as platforms for sustainability science. *Current Opinion in Environmental Sustainability 16*, 1–6. doi:10.1016/j.cosust.2015.06.005

Evans, J. & Karvonen, A. (2011). Living laboratories for sustainability: exploring the politics and epistemology of urban transition. In H. Bulkeley, V. C. Broto, M. Hodson & S. Marvin (Eds.), *Cities and low carbon transitions* (pp. 126–141). doi:10.4324/9780203839249

Følstad, A. (2008). Living labs for innovation and development of information and communication technology: a literature review. *Electronic Journal of Organizational Virtualness 10*, 99–131. Retrieved from http://hdl.handle.net/11250/2440026

Goddard, J., Coombes, M., Kempton, L. & Vallance, P. (2014). Universities as anchor institutions in cities in a turbulent funding environment: vulnerable institutions and vulnerable places in England. *Cambridge Journal of Regions, Economy and Society 7* (2), 307–325. doi:10.1093/cjres/rsu004

Gunasekara, C. (2004). The third role of Australian universities in human capital formation. *Journal of Higher Education Policy and Management 26* (3), 329–343. doi:10.1080/1360080042000290186

Hall, R. E., Bowerman, B., Braverman, J., Taylor, J., Todosow, H. & Von Wimmersperg, U. (2000). *The vision of a smart city*. Upton, NY, U.S.A.: Brookhaven National Lab.

Herliana, S. (2015). Regional innovation cluster for Small and Medium Enterprises (SME): a triple helix concept. *Procedia — Social and Behavioral Sciences 169*, 151–160. doi:10.1016/j.sbspro.2015.01.297

Herrera, N. R. (2017). The emergence of living lab methods. In *Living labs* (pp. 9–22). doi:10.1007/978-3-319-33527-8_2

Hielkema, H. & Hongisto, P. (2013). Developing the Helsinki smart city: the role of competitions for open data applications. *Journal of the Knowledge Economy 4* (2), 190–204. doi:10.1007/s13132-012-0087-6

Hossain, M., Leminen, S. & Westerlund, M. (2019). A systematic review of living lab literature. *Journal of Cleaner Production 213*, 976–988. doi:10.1016/j.jclepro.2018.12.257

Hsieh, H.-F. & Shannon, S. E. (2005). Three approaches to qualitative content analysis. *Qualitative Health Research 15* (9), 1277–1288. doi:10.1177/1049732305276687

Hughes, H., Foth, M., Dezuanni, M., Mallan, K. & Allan, C. (2017). Fostering digital participation and communication through social living labs: a qualitative case study from regional Australia. *Communication Research and Practice 4* (2), 183–206. doi:10.1080/22041451.2017.1287032

Jazeel, T. (2015). Utopian urbanism and representational city-ness: on the Dholera before Dholera smart city. *Dialogues in Human Geography 5* (1), 27–30. doi:10.1177/2043820614565866

Jensen, C. & Tragardh, B. (2004). Narrating the triple helix concept in "weak" regions: lessons from Sweden. *International Journal of Technology Management 27* (5), 513. doi:10.1504/ijtm.2004.004287

Joss, S., Cook, M. & Dayot, Y. (2017). Smart cities: towards a new citizenship regime? A discourse analysis of the British smart city standard. *Journal of Urban Technology 24* (4), 29–49. doi:10.1080/10630732.2017.1336027

Kommonen, K.-H. & Botero, A. (2013). Are the users driving and how open is open? Experiences from living lab and user driven innovation projects. *The Journal of Community Informatics 9* (3). doi:10.15353/joci.v9i3.3156

Kummitha, R. K. R. & Crutzen, N. (2017). How do we understand smart cities? An evolutionary perspective. *Cities 67*, 43–52. doi:10.1016/j.cities.2017.04.010

Larios, V. M., Gomez, L., Mora, O. B., Maciel, R. & Villanueva-Rosales, N. (2016). Living labs for smart cities: a use case in Guadalajara city to foster innovation and develop citizen-centered solutions. In *2016 IEEE International Smart Cities Conference (ISC2)* (pp. 236–241). doi:10.1109/isc2.2016.7580773

Lee, Y. H. & Kim, Y. (2016). Analyzing interaction in R&D networks using the triple helix method: evidence from industrial R&D programs in Korean government. *Technological Forecasting and Social Change 110*, 93–105. doi:10.1016/j.techfore.2015.10.017

Leminen, S. & Westerlund, M. (2012). Towards innovation in living labs networks. *International Journal of Product Development 17* (1/2), 43. doi:10.1504/ijpd.2012.051161

Leminen, S., Westerlund, M. & Nyström, A.-G. (2012). Living labs as open-innovation networks. *Technology Innovation Management Review 2* (9), 6–11. doi:10.22215/timreview/602

Letaifa, S. B. (2015). How to strategize smart cities: revealing the SMART model. *Journal of Business Research 68* (7), 1414–1419. doi:10.1016/j.jbusres.2015.01.024

Leydesdorff, L. & Deakin, M. (2011). The triple-helix model of smart cities: a neo-evolutionary perspective. *Journal of Urban Technology 18* (2), 53–63. doi:10.1080/10630732.2011.601111

Luengo-Valderrey, M.-J., Pando-García, J., Periáñez-Cañadillas, I. & Cervera-Taulet, A. (2020). Analysis of the impact of the triple helix on sustainable innovation targets in Spanish technology companies. *Sustainability 12* (8), 3274. doi:10.3390/su12083274

Mastelic, J., Sahakian, M. & Bonazzi, R. (2015). How to keep a living lab alive? *Info DaF 17* (4), 12–25. doi:10.1108/info-01-2015-0012

Meijer, A. & Bolívar, M. P. R. (2015). Governing the smart city: a review of the literature on smart urban governance. *International Review of Administrative Sciences 82* (2), 392–408. doi:10.1177/0020852314564308

Mora, L., Deakin, M. & Reid, A. (2019). Strategic principles for smart city development: a multiple case study analysis of European best practices. *Technological Forecasting and Social Change 142*, 70–97. doi:10.1016/j.techfore.2018.07.035

Nesterova, N. & Quak, H. (2016). A city logistics living lab: a methodological approach. *Transportation Research Procedia 16*, 403–417. doi:10.1016/j.trpro.2016.11.038

Nesti, G. (2017). Living labs: a new tool for co-production? In *Smart and sustainable planning for cities and regions* (pp. 267–281). doi:10.1007/978-3-319-44899-2_16

Nesti, G. (2018). Co-production for innovation: the urban living lab experience. *Policy and Society 37* (3), 310–325. doi:10.1080/14494035.2017.1374692

Nilssen, M. (2019). To the smart city and beyond? Developing a typology of smart urban innovation. *Technological Forecasting and Social Change 142*, 98–104. doi:10.1016/j.techfore.2018.07.060

Nyström, A.-G., Leminen, S., Westerlund, M. & Kortelainen, M. (2014). Actor roles and role patterns influencing innovation in living labs. *Industrial Marketing Management 43* (3), 483–495. doi:10.1016/j.indmarman.2013.12.016

Ogonowski, C., Ley, B., Hess, J., Wan, L. & Wulf, V. (2013). Designing for the living room: long-term user involvement in a living lab. In *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (pp. 1539–1548). doi:10.1145/2470654.2466205

Pallot, M., Alishevskikh, A., Holzmann, T., Krawczyk, P. & Ruland, R. (2014). CONEX: creating serendipitous connections among living labs and horizon 2020 challenges. In *2014 International Conference on Engineering, Technology and Innovation (ICE)* (pp. 1–7). doi:10.1109/ice.2014.6871569

Perng, S.-Y., Kitchin, R. & Mac Donncha, D. (2018). Hackathons, entrepreneurial life and the making of smart cities. *Geoforum 97*, 189–197. doi:10.1016/j.geoforum.2018.08.024

Rodrigues, M. & Franco, M. (2018). Importance of living labs in urban entrepreneurship: a Portuguese case study. *Journal of Cleaner Production 180*, 780–789. doi:10.1016/j.jclepro.2018.01.150

Sá, E., Casais, B. & Silva, J. (2019). Local development through rural entrepreneurship, from the triple helix perspective. *International Journal of Entrepreneurial Behavior & Research 25* (4), 698–716. doi:10.1108/ijebr-03-2018-0172

Sarpong, D., AbdRazak, A., Alexander, E. & Meissner, D. (2017). Organizing practices of university, industry and government that facilitate (or impede) the transition to a hybrid triple helix model of innovation. *Technological Forecasting and Social Change 123*, 142–152. doi:10.1016/j.techfore.2015.11.032

Schaffers, H., Komninos, N., Pallot, M., Trousse, B., Nilsson, M. & Oliveira, A. (2011). Smart cities and the future internet: towards cooperation frameworks for open innovation. In *The future internet* (pp. 431–446). doi:10.1007/978-3-642-20898-0_31

Schaffers, H. & Turkama, P. (2012). Living labs for cross-border systemic innovation. *Technology Innovation Management Review 2* (9), 25–30. doi:10.22215/timreview/605

Schuurman, D., Baccarne, B. & Marez, L. D. (2012). Smart ideas for smart cities: investigating crowdsourcing for generating and selecting ideas for ICT innovation in a city context. *Journal of theoretical and applied electronic commerce research 7* (3), 49–62. doi:10.4067/s0718-18762012000300006

Selada, C. (2017). Smart cities and the quadruple helix innovation systems conceptual framework: the case of Portugal. In *The quadruple innovation helix nexus* (pp. 211–244). doi:10.1057/978-1-137-55577-9_8

Silva, B. N., Khan, M. & Han, K. (2018). Towards sustainable smart cities: a review of trends, architectures, components and open challenges in smart cities. *Sustainable Cities and Society 38*, 697–713. doi:10.1016/j.scs.2018.01.053

Spagnoli, F., van der Graaf, S. & Brynskov, M. (2019). The paradigm shift of living labs in service co-creation for smart cities: SynchroniCity validation. In *Lecture notes in information systems and organisation* (Vol. 27, pp. 135–147). doi:10.1007/978-3-319-90500-6_11

Ståhlbröst, A. (2012). A set of key principles to assess the impact of Living Labs. *International Journal of Product Development 17* (1/2), 60–75. doi:10.1504/IJPD.2012.051154

Ståhlbröst, A. (2013). A living lab as a service: creating value for micro-enterprises through collaboration and innovation. *Technology Innovation Management Review 3* (11), 37–42. doi:10.22215/timreview/744

Ståhlbröst, A. & Holst, M. (2017). Reflecting on actions in living lab research. *Technology Innovation Management Review 7* (2), 27–34. doi:10.22215/timreview/1055

Van Geenhuizen, M. (2016). Living labs as boundary-spanners between triple helix actors. *Journal of Contemporary Eastern Asia 15* (1), 78–97.

Vanmeerbeek, P., Vigneron, L., Delvenne, P., Rosskamp, B. & Antoine, M. (2015). Involvement of end-users in innovation process: towards a user-driven approach of innovation — a qualitative analysis of 20 livings labs. In *Proceedings of the European network of living labs, research day conference, OpenLivingLab days* (pp. 79–86). Retrieved from https://hdl.handle.net/2268/183928

Veeckman, C. & van der Graaf, S. (2015). The city as living laboratory: empowering citizens with the citadel toolkit. *Technology Innovation Management Review 5* (3), 6–17. doi:10.22215/timreview/877

Voytenko, Y., McCormick, K., Evans, J. & Schliwa, G. (2016). Urban living labs for sustainability and low carbon cities in Europe: towards a research agenda. *Journal of Cleaner Production 123*, 45–54. doi:10.1016/j.jclepro.2015.08.053

Westerlund, M. & Leminen, S. (2011). Managing the challenges of becoming an open innovation company: experiences from living labs. *Technology Innovation Management Review 1* (1), 19–25. doi:10.22215/timreview/489

Wilson, J., Patel, H., Pettitt, M. & Saikayasit, R. (2008). Living labs: a new development strategy. In J. Schumacher & V.-P. Niitamo (Eds.), *European living labs — a new approach for human centric regional innovation* (pp. 103–119). Berlin, Germany: Wissenschaftlicher Verlag.

Zuzul, T. W. (2019). "Matter battles": cognitive representations, boundary objects and the failure of collaboration in two smart cities. *Academy of Management Journal 62* (3), 739–764. doi:10.5465/amj.2016.0625

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