Universitat Autònoma de Barcelona

From the Triple to the Quadruple Helix of Innovation: Theory and Practice

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Thesis title: From the Triple to the Quadruple Helix of Innovation: Theory and Practice

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Abstract

This PhD thesis addresses the main concern of policymakers and innovation practitioners on how to spur innovation and socio-economic growth by interacting with different actors. It responds to the call for further research on the Quadruple Helix model, an extension of the Triple Helix. The Triple Helix is regarded as the core innovation model of university-industry-government relations. However, its effectiveness has been increasingly questioned. Some authors argue that the Quadruple Helix potentially offers an improvement by adding the fourth helix representing societal demands in the innovation process.

The Quadruple Helix model emerged as a normative framework and became a policy concept—particularly in Europe—during the 2010s. However, it remains under-researched, preventing it from contributing to innovation theory and practice substantially.

This thesis aims to explore under which conditions and how the Quadruple Helix functions. To this end, it comprises a systematic literature review and three empirical papers in the Spanish and Danish contexts investigating the Quadruple Helix from two main streams: living labs as orchestrators of the Quadruple Helix collaboration and public sector innovation as a potential result of the Quadruple Helix approach. A mixed research method is adopted, predominantly by using an exploratory qualitative approach supplemented by some quantitative elements in the third paper, to shed new light on the under-explored Quadruple Helix model in different settings and under different theoretical lenses. These explorations challenge some simplified assumptions of the existing Quadruple Helix concept and provide evidence for refining innovation policies.

Overall, this thesis provides empirical evidence and mechanisms to offer three conditions for the Quadruple Helix to function: (i) leverage the power positions of citizens in collaborative systems; (ii) manage stakeholder expectations and satisfaction in collaborations; and (iii) organise collaborative practices of (public sector) organisations to benefit from innovation. The thesis concludes that engaging citizens in ways that allow them to provide meaningful contributions to innovation systems is a complex process that involves careful planning at different levels.

The author does not claim that some challenges of the Quadruple Helix model are insurmountable but rather adopts a sceptical stance towards its development and applicability. For the Quadruple Helix to be considered an appropriate framework to analyse innovation processes, at least three main factors need to be considered: power asymmetries between the fourth helix and other Triple Helix actors, stakeholder expectations and satisfaction, and organisational changes. Without considering such factors, the Quadruple Helix model will not be suitable to serve as a foundation or provide plausible explanations for the ways actors interact to generate innovation.

Keywords: Triple Helix; Quadruple Helix; collaboration; innovation systems; governments; university; industry; civil society; citizen engagement; living labs; public sector innovation

Resum en català

Aquesta tesi doctoral aborda la principal preocupació dels responsables polítics i els professionals de la innovació sobre com estimular la innovació i el creixement socioeconòmic mitjançant la interacció amb diferents actors. Respon a la crida a fer més investigacions sobre el model de la Quàdruple Hèlix, una extensió de la Triple Helix. La Triple Hèlix es considera el model d'innovació bàsic en base a les relacions universitat-indústria-govern. Tanmateix, la seva eficàcia ha estat cada cop més qüestionada. Alguns autors argumenten que la Quàdruple Hèlix ofereix potencialment una millora afegint la quarta hèlix, que representa les demandes de la societat en el procés d'innovació.

El model de Quàdruple Hèlix va sorgir com a marc normatiu i es va convertir en un concepte polític—sobretot a Europa—durant la dècada iniciada el 2010. No obstant això, el tema continua poc investigat, cosa que impedeix que contribueixi substancialment a la teoria i la pràctica de la innovació.

Aquesta tesi pretén explorar en quines condicions i com funciona la Quàdruple Hèlix. Amb aquesta finalitat, la tesi inclou una revisió sistemàtica de la literatura i tres articles empírics en els contextos espanyol i danès, on s'investiga la Quàdruple Hèlix des de dos eixos principals: els living labs com a orquestradors de la col·laboració de tipus Quàdruple Hèlix i la innovació del sector públic com a resultat potencial de l'enfocament de la Quàdruple Hèlix. S'adopta un mètode d'investigació mixt, principalment mitjançant l'ús d'un enfocament qualitatiu exploratori complementat amb alguns elements quantitatius al tercer article, per aportar nova llum sobre el model de Quàdruple Hèlix, poc explorat en diferents entorns i sota diferents lents teòriques. Aquestes exploracions desafien alguns dels supòsits existents sobre la Quàdruple Hèlix i proporcionen evidència que pot ser d'utilitat per a millorar les polítiques d'innovació.

En conjunt, aquesta tesi proporciona evidència empírica que assenyala tres condicions per a que la Quàdruple Hèlix funcioni: (i) aprofitar les posicions de poder dels ciutadans en els sistemes col·laboratius; (ii) gestionar les expectatives i la satisfacció dels grups d'interès en les col·laboracions; i (iii) organitzar pràctiques col·laboratives en les organitzacions (del sector públic) per beneficiar-se de la innovació. La tesi conclou que implicar els ciutadans de manera que els permeti aportar contribucions significatives als sistemes d'innovació és un procés complex que implica una planificació acurada a diferents nivells.

L'autora no afirma que alguns reptes del model de Quàdruple Hèlix siguin insuperables, sinó que adopta una posició escèptica respecte al seu desenvolupament i aplicabilitat. Per a que la Quàdruple Hèlix es consideri un marc adequat per analitzar els processos d'innovació, cal tenir en compte almenys tres factors principals: les asimetries de poder entre la quarta hèlix i altres actors de la Triple Hèlix, les expectatives de les parts interessades i la satisfacció, i els canvis organitzatius. Sense tenir en compte aquests factors, el model de la Quàdruple Hèlix no serà adequat per servir com a base ni per proporcionar explicacions plausibles sobre les formes en què els actors interactuen per generar innovació.

Paraules clau: Triple Hèlix; Quàdruple Hèlix; col·laboració; sistemes d'innovació; governs; universitat; indústria; societat civil; participació ciutadana; living labs; innovació del sector públic

Resumen en castellano

Esta tesis doctoral aborda la principal preocupación de los responsables políticos y los profesionales de la innovación sobre cómo estimular la innovación y el crecimiento socioeconómico en base a la interacción entre diferentes actores. Responde a la llamada a más investigación sobre el modelo de la Cuádruple Hélice, una extensión de la Triple Hélice. La Triple Hélice se considera el modelo central de innovación en base a las relaciones universidad-industria-gobierno. Sin embargo, su eficacia ha sido cada vez más cuestionada. Algunos autores argumentan que la Cuádruple Hélice ofrece potencialmente una mejora al agregar la cuarta hélice, que representa las demandas sociales en el proceso de innovación.

El modelo de la Cuádruple Hélice surgió como un marco normativo y se convirtió en un concepto político—particularmente en Europa—durante la década iniciada en 2010. Sin embargo, el tema sigue estando poco investigado, lo que impide que contribuya sustancialmente a la teoría y la práctica de la innovación.

Esta tesis tiene como objetivo explorar en qué condiciones y cómo funciona la Cuádruple Hélice. Para lograr este objetivo, se incluye una revisión sistemática de la literatura y tres artículos empíricos en los contextos español y danés, que investigan la Cuádruple Hélice desde dos ejes principales: living labs como orquestadores de la colaboración Cuádruple Hélice y la innovación del sector público como resultado potencial de la Cuádruple Hélice. Se adopta un método de investigación mixto, predominantemente mediante el uso de un enfoque cualitativo exploratorio complementado con algunos elementos cuantitativos en el tercer artículo, para arrojar nueva luz sobre el modelo de la Cuádruple Hélice, poco explorado en diferentes escenarios y bajo diferentes lentes teóricas. Estas exploraciones desafían algunas suposiciones simplificadas del concepto de la Cuádruple Hélice existente y proporcionan evidencia para refinar las políticas de innovación.

En general, esta tesis proporciona evidencia empírica que señala tres condiciones para que la Cuádruple Hélice funcione: (i) aprovechar las posiciones de poder de los ciudadanos en los sistemas colaborativos; (ii) gestionar las expectativas y la satisfacción de las partes interesadas en las colaboraciones; y (iii) organizar prácticas colaborativas en las organizaciones (del sector público) para beneficiarse de la innovación. La tesis concluye que involucrar a los ciudadanos en formas que les permitan ofrecer contribuciones significativas a los sistemas de innovación es un proceso complejo que implica una planificación cuidadosa en diferentes niveles.

La autora no afirma que algunos desafíos del modelo de la Cuádruple Hélice sean insuperables, sino que adopta una postura escéptica hacia su desarrollo y aplicabilidad. Para que la Cuádruple Hélice se considere un marco apropiado para analizar los procesos de innovación, se deben considerar al menos tres factores principales: las asimetrías de poder entre la cuarta hélice y otros actores de la Triple Hélice, las expectativas y satisfacción de las partes interesadas, y los cambios organizativos. Sin considerar tales factores, el modelo de la Cuádruple Hélice no será adecuado para servir como base o proporcionar explicaciones plausibles sobre las formas en que los actores interactúan para generar innovación.

Palabras claves: Triple Hélice; Cuádruple Hélice; colaboración; sistemas de innovación; gobiernos; universidad; industria; sociedad civil; participación ciudadana; living labs; innovación del sector público

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Abbreviations

AAU	Aalborg University
COI	Centre for Public Innovation (*Center for Offentlig Innovation* in Danish)
COVID-19	2019 Coronavirus disease
ENoLL	European Network of Living Labs
Eurostat	European Statistical Office
ICT	Information and Communication Technology
NIS	National Innovation System
OECD	Organisation for Economic Cooperation and Development
RIS	Regional Innovation System
RIS3	Research and Innovation Strategies for Smart Specialisation
RRI	Responsible Research and Innovation
UAB	Autonomous University of Barcelona (*Universitat Autònoma de Barcelona* in Catalan)

I. Thesis Introduction

Innovation plays an integral role in the attainment of competitiveness and growth in a knowledge-based economy (Asheim et al., 2011; Cooke, 2002). Nowadays, it is also expected that innovation should benefit society at large by addressing interrelated economic, social and environmental problems (Clausen et al., 2020; Krlev et al., 2020). Although the definition of innovation can be broad, its main feature often refers to the new or improved practices that potentially produce socio-economic impacts (De Vries et al., 2016; OECD/Eurostat, 2018).

Particularly for the public sector, at least because of its economic weight, there is growing policy attention on encouraging innovation in the sector (Arundel et al., 2019). This encouragement aims to improve the efficiency of resource usage and the quality of public services, as well as address overall social challenges, such as social and economic inequality, urban overpopulation and environmental contamination (Lewis et al., 2018; Torfing & Ansell, 2017).

Given the widespread recognition of the importance of innovation amongst both policymakers and researchers, there is an apparent interest—if not a pressing necessity—in understanding the conditions under which innovation flourishes (Asheim et al., 2019; Tödtling & Trippl, 2018). Over the last three decades of innovation studies, it has been commonly accepted that innovation is a systemic result of 'non-linear, collaborative and cumulative learning processes' (Isaksen et al., 2018, p. 3).

Nevertheless, precisely identifying the key actors and the ways they interact to generate innovation remains subject to extensive debates (Carlsson et al., 2002; Coenen & Díaz López, 2010). These debates are observed in a wide range of research but are most predominant in two interrelated research trends: the first is related to delineating innovation system boundaries, such as national, regional, sectoral and technological (Carlsson & Stankiewicz, 1991; Cooke et al., 1997; Lundvall, 2010; Malerba, 2002); the second, which emerged later, is concerned with providing explanatory models of innovation intensity within innovation systems, such as the Triple Helix and Quadruple Helix (Etzkowitz & Leydesdorff, 2000; Leydesdorff, 2012).

This PhD thesis explores the key actors and their interactions for innovation and regional development by combining both aforementioned areas of research on innovation systems. It is particularly concerned with public sector innovation, which aims to promote not only economic benefits but also broader public and social values.[1] The thesis uses the Triple Helix model as the starting point and critically examines its extension, which is the Quadruple Helix.

1. Background

1.1 What are the helix models?

The Triple Helix model of innovation, as a metaphor for three types of partners working together (i.e. university-industry-government), was introduced in the mid-1990s by Etzkowitz and Leydesdorff (1995; 1996). The model suggests that the increasingly pivotal role of the university and the hybridisation of interactions among university, industry and government account for the production of knowledge and innovation, particularly in the science and technology domains (Etzkowitz & Leydesdorff, 2000; Ranga & Etzkowitz, 2013). This means that innovation is potentially generated when these three types of partners, in addition to their traditional roles, 'take on new tasks' (e.g. university takes the 'third mission' to contribute to entrepreneurship and innovation activities, besides education and research) or 'take the role of the other' (Etzkowitz, 2008, p. 9). One of the key arguments for the trilateral relationship is that a third actor will help mediate the tensions between the other two actors (Etzkowitz, 2008). By understanding the Triple Helix, one could explain the complex dynamics of innovation and the formation of innovation systems based on the actors' expectations (Leydesdorff & Etzkowitz, 1998; Leydesdorff & Strand, 2013).

The Triple Helix model has become very popular since its introduction, with a considerable number of research and policy discourses discussing it (Benneworth et al., 2015; Galvao et al., 2019; Trousset, 2014). The model has also been questioned about its effectiveness in generating innovation in different contexts. In this discussion, some authors

[1] 'The public sector includes general government and public corporations' (European Commission et al., 2009, p. 437). This thesis uses the term 'public sector' to refer to general government entities, such as public administration organisations at the local and regional levels.

have observed that actors other than those representing university, industry and government might play important roles and should be considered to strengthen innovation generation (Bunders et al., 1999; Jensen & Trägårdh, 2004).

In this vein, the Quadruple Helix model proposes that a *fourth helix* is relevant in the knowledge production and innovation processes, in addition to the core Triple Helix actors (Afonso et al., 2012; Carayannis & Campbell, 2009; MacGregor et al., 2010). Academic opinions are divided about which specific actors this fourth helix refers to. However, the additional helix is often seen to represent the social demands raised by the public, civil society, citizens or users. It is expected that with a wider set of participants representing social demands, the Quadruple Helix model offers the following two main improvements on the original Triple Helix: (i) enhancing democracy of knowledge, presuming that the processes of advancing democracy co-evolve with the processes of advancing knowledge (e.g. Carayannis & Campbell, 2009) and (ii) producing diverse innovation types and outcomes rather than mainly technology-driven ones (e.g. Arnkil et al., 2010; Nordberg, 2015).

1.2 Potentials and challenges of the Quadruple Helix approach

Investigating key actors and their interactions to spur innovation and regional development is pertinent in the contemporary policy contexts. Among those, the issues of engaging social actors and incorporating them into innovation systems appear to be of interest in Europe, given the continent's strong ambition to pursue 'smart, sustainable and inclusive growth' (Foray et al., 2012, p. 7). The European Commission dedicated several innovation and regional development policies for the 2014–2020 period to work towards this smart, sustainable and inclusive goal (European Commission, 2017). Although these policies were associated with different norms, theories and practices, they often shared the same argument for an extensive actor involvement (Fitjar et al., 2019).

For instance, the agenda of Responsible Research and Innovation (RRI), positioned within the Horizon 2020 research and innovation funding programme, aims to better align research and innovation outcomes with the needs and expectations of society (European Commission, 2014). To this end, including social actors is perceived essential. Likewise, constituting an

integral part of the reformed Cohesion Policy, the Research and Innovation Strategies for Smart Specialisation (RIS3) seeks to shape the competitive advantages of regions in all European Union member states via their own strengths (Foray et al., 2012). As the strengths of each region are different and not always technology-based, the design of RIS3 has been interpreted as an open and user-oriented process involving diverse actors (Foray et al., 2012). In this sense, it is assumed that participation among conventional innovation actors (e.g. Triple Helix) is no longer sufficient. The governance should include other types of actors with new participation forms (e.g. additional participation of civil society and users in the Quadruple Helix on experimental platforms) (Foray et al., 2012).

The 2010s have seen several platforms and local initiatives established or re-oriented to facilitate multi-actor engagement, perhaps under the influence of innovation policies, particularly in Europe. Among those, living labs are becoming widespread instruments in promoting and orchestrating regional citizen-centred innovation ecosystems, often supposedly in Quadruple Helix relations/partnerships/contexts (Bifulco et al., 2017; Engels et al., 2019; Hyysalo & Hakkarainen, 2014). Living labs are characterised by three main elements: involving users early in the innovation process, co-creating with multi-actors and experimenting in or stimulating a real-life context (e.g. Eriksson et al., 2005; Hossain et al., 2019). Interestingly, there have been extended expectations that living labs produce not only technological and commercial benefits for the private sector but also public and social value for the public and civic sectors (Nguyen & Marques, 2021).[2] These initiatives provide good opportunities to investigate the engagement of social actors and their interactions in innovation systems, which should not be assumed to exist.

In general, the Quadruple Helix model is far from a well-established concept (Arnkil et al., 2010; Cavallini et al., 2016), although there is a concurrence in the guide for RIS3 and practice adoption intended by a large number of living labs. The Quadruple Helix model has been mainly a ‘vision’, and it substantively lacks a conceptual framework and empirical evidence on its operation and efficiency. Therefore, there is a necessity to critically examine

[2] Paper 2 in this thesis.

the ways in which the Quadruple Helix model is developed and articulated within innovation theory and practice.

2. Purpose of the Thesis and Research Questions

The primary purpose of this thesis is to critically examine and contribute to the development of the Quadruple Helix model of innovation as an explanatory model in innovation theory and practice. In embarking on this journey, it is crucial to consider two main interconnected points concerning the ambiguity of the term and the under-theorisation of the Quadruple Helix model.

First and foremost, the 'Quadruple Helix' term is ambiguous. The Quadruple Helix model emerged as *a normative framework* premised on the assumption that the 'pluralism of knowledge modes should be regarded as essential for advanced knowledge-based societies and economies' (Carayannis & Campbell, 2009, p. 206). Therefore, the 'media-based and culture-based public' should be involved in the innovation process—probably like its involvement in political democracy processes—to shape public reality and ultimately influence innovation systems. The model then became *a policy guide* to promote open and user-centred innovation systems (Foray et al., 2012) whilst being newly established as *an academic concept* to explain innovation production (Leydesdorff, 2012) and *a practice tool* to mobilise key actors in innovation networks (ENoLL, 2019; Malmberg et al., 2017). When it comes to research, minding the boundaries among these labels is essential because of the likely disparity between the normativity of what should be and the practice of what it is (Foray, 2020; P. Marques et al., 2018; Osborne, 2010). The Quadruple Helix remains predominantly a normative framework (Vallance, 2017) envisioned by researchers and policymakers to include actors and encourage interactions for innovation. In this sense, the model often emphasises the desired outcomes yet lacks sufficient observations to gain the explanatory power and scientific rigour that are useful for innovation theory and practice.

Second, much work is still needed to develop the Quadruple Helix model as an academic concept and differentiate it from other existing concepts. A useful social science field of research must have 'a conceptual framework that explains and predicts a set of empirical phenomena not explained or predicted by conceptual frameworks already in existence in

other fields' (Shane & Venkataraman, 2000, p. 217). Such a conceptual framework is not yet available for the Quadruple Helix. For instance, the discussion on which *fourth helix* should be added to the Triple Helix is a core part of Quadruple Helix literature, yet it is somewhat confusing, with different types of actors proposed (Björk, 2014; Nordberg, 2015). Some authors have suggested including 'users' as the additional helix (Arnkil et al., 2010). However, users and their relations with producers have long been the focus of innovation studies (e.g. Von Hippel, 2005). Hence, defining the Quadruple Helix as merely an open and user-oriented process is not novel (Vallance, 2017). Conversely, 'civil society' as the fourth helix seems interesting for innovation studies, but civil society includes a broad range of actors among which citizens have been the centre of public management since the 1960s (Siebers & Torfing, 2018; Strokosch & Osborne, 2020). In this regard, it has been mentioned that the active involvement of civil society is what differentiates the Quadruple from the Triple Helix (Borkowska & Osborne, 2018). However, it remains unclear who exactly civil society is, which roles it plays and to what extent it should be included (Engelbert et al., 2019; Siebers & Torfing, 2018).

As an area of research, it is necessary to define the concept clearly to identify the scope where the processes are positioned and, finally, to analyse the results through conceptual reasoning and empirical observations instead of relying on what different agents (even researchers) envisioned from their own values (Benneworth et al., 2015; P. Marques et al., 2018; Vallance, 2017). To date, the Quadruple Helix model has lacked such elements.

This thesis seeks to contribute to a deeper understanding of the Quadruple Helix concept by examining the ways in which the model functions theoretically and empirically. The overarching questions guiding the research are as follows: *Under which conditions and how does the Quadruple Helix model function?*

The thesis positions the Quadruple Helix into the widely established innovation system theory (e.g. Carlsson et al., 2002), claiming that exploring elements (what/who) should be further associated with the relations (how) and the functions (why) of the systems. At the same time, in the third paper, public administration literature has been applied to understand the debates on social actor participation and public sector innovation. Following Section 3, which provides theoretical considerations, Section 4 presents a systematic literature review

that discusses the contemporary arguments on what the fourth helix in the Quadruple Helix model is and why it is included. The systematic literature review also identifies the knowledge gaps in conducting empirical research to provide a more comprehensive understanding of Quadruple Helix. The thesis comprises three empirical papers based on the contexts of Spain and Denmark. They seek to address three important knowledge gaps related to the factors at different levels and the ways by which the Quadruple Helix may function including: (i) power relations in innovation systems; (ii) stakeholder expectations and satisfaction in innovation networks; and (iii) organisational arrangements of public organisations for collaborative public sector innovation. These knowledge gaps will be elaborated on in Section 4, which presents the systematic literature review.

3. Theoretical Considerations

3.1 Innovation

Innovation can be traced back to innovative individuals, the so-called 'entrepreneurs', in Schumpeter's major piece of work entitled 'The theory of economic development' published in German in 1912 and first translated into English in 1934 (Fagerberg & Verspagen, 2009; Schumpeter, 1983). The field of innovation studies was established later in the late 1950s (Fagerberg & Verspagen, 2009; Martin, 2012). Since then, the field has constantly grown and diversified, with a wide range of interdisciplinary research (Martin, 2016). These days, the definition of innovation often aligns with what Schumpeter underlined about novelty, yet the types of innovation are varied, and the importance of innovation goes beyond its conventional economic value (Cajaiba-Santana, 2014; De Vries et al., 2016).

The shift in the perception of innovation is also reflected, though only recently, in the definitions provided by multilateral organisations, such as the Organisation for Economic Cooperation and Development (OECD) and the European Commission. Since 1992, the 'Oslo Manual' by the OECD and European Statistical Office (Eurostat) has provided the guidelines for collecting data on innovation. Innovation surveys based on the guidelines, such as the Community Innovation Survey utilised by an increasing number of academic papers, were initially intended for firms (Arundel et al., 2019; OECD/Eurostat, 2018). Although the third edition of the Oslo Manual (2005) has been adapted to conduct some surveys in the

public sector, it was only in the fourth edition in 2018 that the definition of innovation was changed to encompass all sectors beyond the business sectors:

> An **innovation** is a new or improved product or process (or combination thereof) that differs significantly from the unit's previous products or processes and that has been made available to potential users (product) or brought into use by the unit (process) (OECD/Eurostat, 2018, p. 20, emphasis in the original).

'Unit' here refers to the actor—either individuals or organisations—responsible for innovation in any institutional sector. The types of innovation are not only products and processes but also services and ways of communication, among others (Arundel et al., 2019; Thøgersen et al., 2020). Innovations 'may be brand new but are more often new combinations of existing elements' (Edquist, 2005, p. 1).

Whilst the economic value of innovation has been widely established, studies on the role of innovation in driving social transformation have appeared only since the late 1990s and early 2000s (Cunha & Benneworth, 2020; Edwards-Schachter & Wallace, 2017; Hartley, 2005). Innovations have been long considered as processes to make inventions that 'work technically and commercially' (Tidd et al., 2005, p. 65), thereby contributing to economic development. Nevertheless, at a time when the world is coping with complex challenges, such as climate change and the Coronavirus disease 2019 (COVID-19) pandemic, innovation is eliciting increasing attention from public organisations to explore its potential in providing solutions to these problems (Bekkers & Tummers, 2018; Cinar, 2019; Göransson et al., 2021; Vickers et al., 2017). The latter trend often involves literature on two overlapping yet dissimilar concepts: public sector innovation and social innovation. However, this is not to claim that these two concepts are limited to social aspects, as their concerns on economic aspects are evident (e.g. Arundel et al., 2019; Domanski et al., 2020).

Overall, although there has been a consensus that innovation is no longer 'as we know it', great effort is still needed to systematically understand in which ways innovation benefits society at large (Clausen et al., 2020; Foroudi et al., 2020; Krlev et al., 2020). In this thesis, innovation is referred to as the implementation of 'new or improved' ideas that potentially generate socio-economic impacts. Accordingly, public sector innovation is particularly of

interest. The innovation could be in the form of types of, but not limited to, processes, products and services, either initiated by individuals or adopted by organisations. Given the nature of the research topic relating to a wide range of actors, this broad approach allows the exploration of the landscape of emerging innovation theories and practices.

3.2 Innovation system perspective

The innovation system concept that emerged during the 1980s (Lundvall, 2007) presents a profound transformation in innovation studies. The tenet of the concept is that the dynamics of innovation have shifted *from* a linear process of 'science push' or 'market pull' *to* a non-linear process of learning (Martin, 2012; Mytelka & Smith, 2002). The linear innovation development, which aligns with Mode 1 of knowledge production, specifically means 'science leads to technology and technology satisfies market needs' (Gibbons et al., 1994, p. 51). This linearity has been considered simplistic and unrealistic, primarily because it lacks vital feedback loops and trials to stimulate innovation (Edquist & Hommen, 1999; Gibbons et al., 1994; Kline & Rosenberg, 1986). From the systemic perspective, innovation does not occur in isolation. Rather, innovation depends on the interactions among a spectrum of actors that take part in and play various roles in the learning process (Bloch & Bugge, 2013; Edquist & Hommen, 1999; Porto-Gomez et al., 2019).

'Systems are made up of components, relationships, and attributes' (Carlsson et al., 2002, p. 234, emphasis in the original). Likewise, innovation systems often involve actors, the relations among actors and the functions of systems (Leydesdorff, 2012; Lundvall, 2010; Ranga & Etzkowitz, 2013). The three key challenges of the innovation system approach are to identify the level of analysis, the population of analysis and the measurement method of system performance (Carlsson et al., 2002). Accordingly, innovation systems comprise different variants that seek to delineate system boundaries (Coenen & Díaz López, 2010; Edquist, 2005). Among those, national innovation systems (NISs) (e.g. Freeman, 2002; Lundvall et al., 2002) and regional innovation systems (RISs) (e.g. Asheim & Isaksen, 1997; Cooke et al., 1997) are two burgeoning lines of research that deal with the geographical dimension of innovation systems (Coenen, 2007).

The main purpose of this doctoral thesis is not to discuss the strengths and weaknesses of these innovation system variants. Rather, I adopt the generally accepted innovation system approach as the foundation for understanding innovation dynamics in certain institutional contexts and spatial scales (Isaksen et al., 2018). Following the approach of Leydesdorff and Porto-Gomez (2019), innovation systems enable raising empirical questions and analysing specific case studies. Hence, the 'regional' aspect is particularly selected in this thesis to guide empirical examination. Regions simply refer to the administrative regions categorised under Eurostat's Nomenclature of Territorial Units for Statistics (NTUS2).

On the one hand, the increasing globalisation has raised the question of whether the territorial innovation systems are still valid because system boundaries have become porous (Binz & Truffer, 2017). On the other hand, it is precisely this globalising tendency that greatly explains the renewed concerns on competitiveness and growth among regions (Asheim et al., 2019; Mackinnon et al., 2002). RISs have proven to have the potential to enhance innovation performance by concentrating on territorially embedded knowledge networks and agglomerations, thereby influencing policy formulation (Benneworth et al., 2009; Coenen, 2007; Tödtling & Trippl, 2018). This acknowledgement justifies the choice of using RISs as an underlying frame of reference.

3.3 The Triple Helix model

The Triple Helix model suggests that the interactions among university-industry-government are 'the key to improving the conditions for innovation' (Etzkowitz, 2003, p. 295; Etzkowitz & Leydesdorff, 1995, 2000). Helices constitute the biological metaphor for interwoven and interconnected sectors (Etzkowitz & Leydesdorff, 2000), which present multiple reciprocal linkages (Etzkowitz & Leydesdorff, 1995). The model of three helices argues for a third mediating component to 'solve problems and meet new needs' due to the conflictual tendency of bilateral relations (Etzkowitz, 2008, p. 10). Initially, these organisations work together to boost their performance, which can be done through innovation-related institutional domains in accordance with their traditional roles (that is, the university is a source of knowledge, the industry focuses on production and the government provides regulatory rules). In the next step, they may take new roles (e.g. the popular discussion on the 'third mission' of university)

or ‘take the role of the other’ (Etzkowitz, 2003, 2008). Thus, this progress enables potential sources of innovation and supports the formulation of creative ideas from all partners.

The Triple Helix model is based on the ideally equivalent institutional spheres in the network (Leydesdorff & Etzkowitz, 1996). Put differently, university, industry and government are three ‘relatively equal partners’ (Etzkowitz, 2003, p. 308) as opposed to the perception of governments controlling the remaining actors following a statist model or all partners being perceived as operating separately from each other with strong boundaries following a laissez-faire model (Etzkowitz, 2003; Etzkowitz & Leydesdorff, 2000). Figure 1 presents these three models.

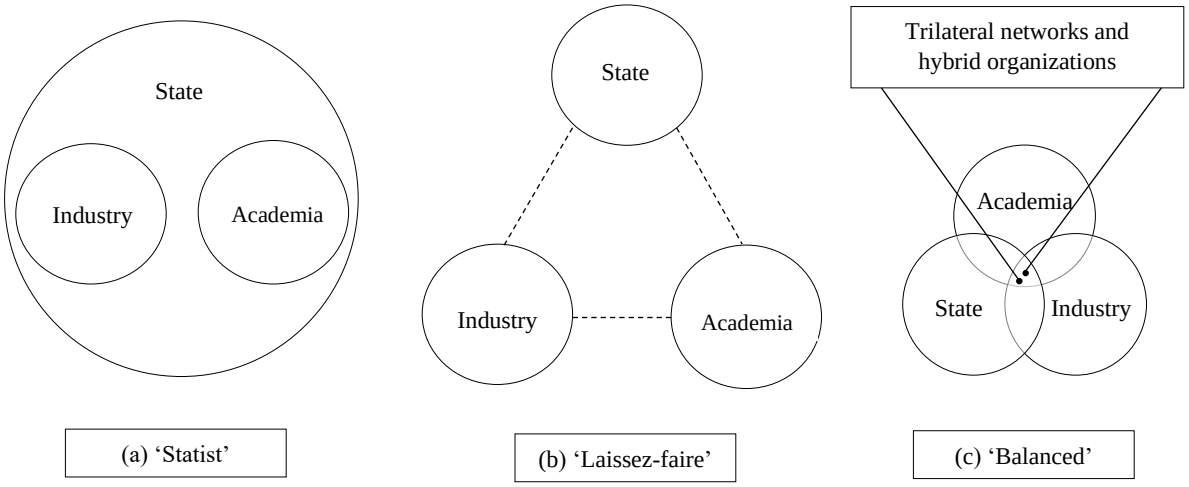

Figure 1. Triple Helix configurations.

Source: Redesigned by Ranga and Etzkowitz (2013, p. 239) after Etzkowitz and Leydesdorff (2000).

Since the 2000s, the development of the Triple Helix model has seen two approaches to enhance the model’s theoretical foundations (Leydesdorff, 2012; Ranga & Etzkowitz, 2013): the neo-institutional (e.g. Etzkowitz et al., 2000) and the neo-evolutionary (e.g. Leydesdorff, 2000) perspectives. The neo-institutional perspective focuses on institutions and institutional arrangements, predominantly examining the enhanced roles of the university through case studies (Etzkowitz, 2004). Instead of focusing on institutions as carriers of certain functions, the evolutionary perspective aims to analyse the functions and their outputs in selection environments (Leydesdorff & Zawdie, 2010). In the Triple Helix, these selection environments are novelty production (academia), wealth generation (industry) and normative

control (government). According to Ranga and Etzkowitz (2013), both perspectives implicitly underline the systemic aspect of Triple Helix interactions rather than explicitly connecting the Triple Helix model to the innovation system literature. Ranga and Etzkowitz specified the Triple Helix into the components (three actors), relationships (e.g. networking, collaborative leadership) and functions (e.g. generation and diffusion of knowledge and innovation) aligning with the innovation system concept.

This thesis adopts the systemic perspectives towards the Triple Helix and its extensions while simultaneously considering the potential of the model in formulating innovation systems. The thesis does not only focus on a macro innovation system level but also meso and micro levels of organisations, innovation collaboration (e.g. networks) and innovation processes. This approach aligns with the arguments for the need to research the ways that different micro interactions and organisational arrangements embed themselves into the regional innovation system (or regional DNA, just like the metaphor of the Triple Helix) to create a longer-lasting effect of change (Benneworth et al., 2015; Popa et al., 2020).

I understand that the Triple Helix may not be rooted in innovation systems or be equated to innovation systems, as cautioned by Cai and Lattu (2021). However, over time, the discussions on the Triple Helix and (regional) innovation systems provide valid rationales to combine these relevant fields.

From the Triple Helix discourse, the main purpose of the model is to provide a heuristic or ‘a framework for investigating empirical questions at a level of “systemness”, defined in terms of regimes and trajectories’ (Leydesdorff & Zawdie, 2010, p. 790). At the same time, the model aims to turn innovation studies from ‘a narrow focus on path-dependent national and regional systems [micro-processes] to a more open-ended approach [relations among institutional spheres]’ (Etzkowitz, 2003, p. 333). In this sense, the model is applicable to various innovation system scales and does not require a geographical delineation like NISs or RISs (Leydesdorff & Zawdie, 2010). Nevertheless, the Triple Helix initiatives have admittedly been observed more at the regional level, and increasing research have embedded the model in regional scales (Etzkowitz, 2003; Ranga & Etzkowitz, 2013; Smith & Bagchi-Sen, 2010).

From the innovation system side, how to organise empirical studies has been one of the main concerns (Lundvall, 2007). The Triple Helix proposal has faced critical comments regarding the lack of consideration of asymmetric knowledge, weak generalisation and insufficient contextualisation (Cooke, 2005; Gunasekara, 2006). The abstract consideration of each partner in the model is also a concern. Although the roles of universities towards regional development have been acknowledged (Charles, 2003), 'there is no […] typical university, and there is no typical way to be or become an entrepreneurial university' (Martinelli et al., 2008, p. 260).[3] However, the Triple Helix interactions can indeed be integrated into RISs, for instance, to examine inter-organisation and inter-cluster synergies of knowledge flows (Benneworth et al., 2015; Cooke, 2010). The contemporary literature on RISs has seen widespread interest in the Triple Helix, although the application needs to be cautious as there is no common recipe towards successful regional development, among other reasons (Fernandes et al., 2020; Tödtling & Trippl, 2005).

3.4 Extensions of the Triple Helix model

Although the Triple Helix may encourage concerted efforts towards innovation, several scholars have been concerned that the model overlooks the roles of different actors who might be the driving forces in innovation systems, such as civil society, entrepreneurs and innovation users (Brännback et al., 2008; Bunders et al., 1999; Jensen & Trägårdh, 2004; Kolehmainen et al., 2016; Lindberg et al., 2014; Pugh, 2017). This concern was raised soon after the Triple Helix's emergence, briefly mentioned in the report of the second international conference on the Triple Helix (Leydesdorff & Etzkowitz, 1998). Later, the report of the fourth conference officially established and summarised the discussion on whether 'the public' could be the fourth helix (Leydesdorff & Etzkowitz, 2003). The two initiators of the Triple Helix initially argued that the specialised and coded functional helices in the Triple Helix emerge from and within civil society. Hence, civil society or the public serves as the

[3] Entrepreneurial university is often at the heart of the Triple Helix model (Etzkowitz et al., 2008). It is a type of university that, in addition to teaching and research missions, enables the university community to engage in entrepreneurial activities; therefore, the entrepreneurial university potentially contributes to economic and social development (Guerrero et al., 2016).

foundation of innovation and the basis of a Triple Helix initiative rather than an independent helix in the model (Etzkowitz, 2003; Leydesdorff & Etzkowitz, 2003).

Change and development are continuous in the nature of the Triple Helix (Etzkowitz, 2003); therefore, the model can be extended if it bolsters explanatory power (Leydesdorff, 2012). Empirically, some research has indicated the significant roles of civil society (Bunders et al., 1999; Jensen & Trägårdh, 2004). Theoretically, the Quadruple Helix has emerged as a supposedly more inclusive model by adding a *fourth helix* into the Triple Helix, suggested as 'media-based and culture-based public' (Carayannis & Campbell, 2009) and, later, 'civil society' (Carayannis & Campbell, 2012). These authors speculated that culture and the communication of media on public reality shape an innovation system and further emphasise the importance of knowledge democracy. A growing body of literature has embarked on unveiling this fourth helix with a number of definitions, including factors such as creative knowledge environment (Nordberg, 2015) and international connection (Lew et al., 2018) *or* specific actors, such as citizens (Campanella et al., 2017).

The Quintuple Helix has also been proposed to incorporate the 'natural environment' into the Quadruple Helix system (Carayannis et al., 2012). Leydesdorff (2012) labelled such extensions as the 'N-tuple helix'. This thesis is particularly concerned with examining the Quadruple Helix, theoretically and practically, given that any extension should be carefully considered. This caution is against the risk of providing 'broad (and untestable) stylised statements [… or] high-level theory discussions that remain uncoupled to real-world experience' (Cooke, 2005, p. 1133). Additional dimensions would ask for substantive specification, empirical data operationalisation and, sometimes, relevant indicator development (Leydesdorff, 2012). Thus, critically exploring the Quadruple Helix functions would be imperative before moving to another model.

4. The Quadruple Helix Model: A Systematic Literature Review

A systematic literature review is 'a method of making sense of large bodies of information' and a way of pointing out the uncertainty that calls for further research (Petticrew & Roberts, 2006, p. 2). A systematic literature review was conducted to identify the main characteristics

of the Quadruple Helix literature. Furthermore, the review served as the basis for identifying the research gaps in the individual papers.

This literature review was continuously updated throughout the project, with the last update made in early 2022 for the review period up to 2021. To facilitate this update, the literature selection was performed in a stepwise manner to ensure replication.

4.1 Systematic literature selection

The literature review aimed to answer the following questions: 'What is the fourth helix in the Quadruple Helix model? Why is this fourth helix included?' A well-defined fourth helix is critical to developing the Quadruple Helix model as an academic concept because it allows distinguishing the Quadruple Helix model from other concepts. For this reason, conceptually exploring these research questions (what/who and why) should be the first step before empirically investigating the conditions and the ways (how) the model functions.

The literature were selected by adopting the steps suggested by Fink (2014), collating a total of 138 papers at the end (Table 1). The bibliographic sources were the Web of Science (WoS) and Scopus, the two largest databases of peer-reviewed articles. Using the Boolean search technique, the search terms were: 'Quadruple Helix' OR 'Fourth Helix'. The search terms should appear in the title, abstract or keywords of English documents published up to the year 2021.

Only publications in peer-reviewed journals were considered; book chapters and conference proceeding papers were excluded. One of the challenges in reviewing the Quadruple Helix is the interdisciplinary nature of the topic and its outlets. Hence, the subject areas were mostly selected manually, except for the elimination of some obvious natural science topics (e.g. biochemistry, genetics and molecular biology). In the screening of article abstracts, the articles were selected if the Quadruple Helix topic referred to a discussion related to university, government, industry and the fourth helix. Next, duplicate literature appearing in both databases and downloaded full texts were removed.

After this step, I reviewed the full texts to select the appropriate studies. I excluded editorial papers (although I read them to have an overview and identify potential papers) and

literature reviews (to avoid repetition). Studies were also excluded if the papers were noticeably off-topic and the research design appeared to have major problems, such as unclear purposes, research design and data sources. This individual assessment step was time-consuming, although it was intended to serve as a double-check rather than a critical step, given that the articles were peer-reviewed. I did not select publications based on journal ranking. Although paper quality, to a substantial extent, can be based on the quality of publishing journals (e.g. journal ranking), individual assessment is often encouraged since the paper quality differs within journal ranks and even within the same journal (e.g. Vogel et al., 2017). During the review, it seemed that articles published in well-established journals tended to be included more.

Table 1. Systematic literature selection.

	Scopus	**WoS**
*'Quadruple Helix' OR 'Fourth Helix', covering the end of 2021**	*443*	*333*
Limited to English	434	323
Limited to journals or articles	329	258
After excluding irrelevant topics (e.g. natural sciences)	198	188
Abstract reviews	*198*	*188*
Limited to English	195	188
After excluding irrelevant topics (e.g. natural sciences)	189	157
After removing replication	224	
Full text downloads and reviews	***220***	
After excluding editorials, literature reviews, irrelevant topics and weak research design	138	
Final studies included in review	***138***	

*The results from the WoS were covered up to June 2021 only due to system inaccessibility in 2022.

4.2 Key literature characteristics

Figure 2 shows the frequency of published papers on the Quadruple Helix or the fourth helix every year, with a total of 121 empirical papers and 17 conceptual papers. The first paper was published by Jensen and Trägårdh (2004), where they posited the important roles of the 'fourth helix' based on a case study of 'weak' regions.

The number of papers has increased more steadily since 2013. One possible explanation for the increasing research interest could be the shift from the Triple to the Quadruple Helix in European innovation policy discourse. Among 138 articles, 24 articles (17%) received funding from the European Union, whilst 12 articles (9%) were funded by the European member states.

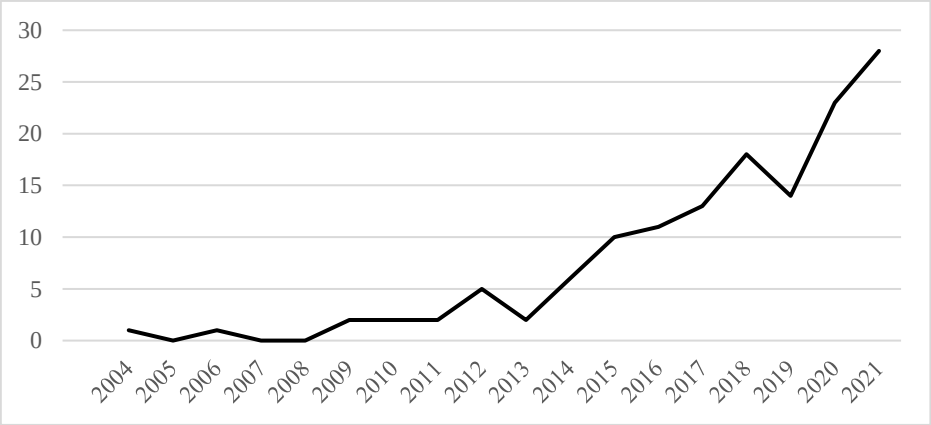

Figure 2. Number of publications on the 'Quadruple Helix' or 'Fourth Helix'.

Table 2 provides the list of 15 journals that published more than two papers on the topic (accounting for 53% of the total publications).

Table 2. Top 15 publishing journals.

No.	Journals	No. of Papers
1	Journal of Knowledge Economy	26
2	Sustainability	12
3	R&D Management	7
4	Technological Forecasting and Social Change	4
5	International Journal of Innovation Management Science and Public Policy	3/journal
6	Economies European Planning Studies European Urban and Regional Studies Journal of Innovation and Entrepreneurship Journal of Technology Transfer Local Economy Minerva Studies in Agricultural Economics Technology Innovation Management Review	2/journal

4.3 The fourth helix: Who and why?

This section presents the results from an iterative process of content analysis based on a summary of each selected paper.

4.3.1 Conceptual papers

There is a lack of consistency in the way the fourth helix is conceptualised, even by E. G. Carayannis and D. F. J. Campbell, two of the supposed first proponents of the Quadruple Helix model. Carayannis and co-authors contributed the greatest number of papers (five out of 17 published conceptual papers). In the five papers, efforts have been made to position the concept into established theories (e.g. innovation (eco)systems) and further connect it to the emergent concepts (e.g. RIS3). The conceptualisation of the fourth helix is reiterated across publications, and it remains confusing. The fourth helix includes an increasing number of types of actors based on two key assumptions: (i) the democracy of knowledge requires the pluralism of actors as per the democracy of politics,[4] and (ii) society, as the end-user of innovation, is a key actor in the innovation process, along with other actors. Table 3 gives an overview of the types of actors proposed to be included as the fourth helix and the arguments by Carayannis and co-authors.

The remaining 12 papers considered the fourth helix as predominantly civil society, while a few papers included the fourth helix as the public, media, end-users and consumers. They adopted the Quadruple Helix as a means to discuss other concepts, such as agricultural innovation systems, green economy, social innovation, RRI, universities' third mission and the roles of principal investigators. The arguments are, for instance, (i) to '[capture] the notion that the whole society is involved in innovation' (Afonso et al., 2012, p. 850); (ii) to '[consider] the shift of the focus from economic to inclusive growth, or rather from pure technological to social innovation' (Carl, 2020, p. 741); (iii) for firms 'to incorporate broader deliberation processes associated with responsible research and innovation involving [different actors]' (Paredes-Frigolett, 2016, p. 126); and (iv) for universities to 'contribute to

[4] According to Carayannis and Campbell (2011, p. 342), 'The democracy of knowledge, as a concept and metaphor, highlights and underscores parallel processes between political pluralism in advanced democracy, and knowledge and innovation heterogeneity and diversity in advanced economy and society'.

the socio-economic-cultural development of society' (Cooper, 2017, p. 146) and to produce 'not only commercial benefit and industrial application […] but also get involved in the social value-creating process' (Prónay & Buzás, 2015, p. 503).

Table 3. Examples of the conceptualised fourth helix.

Who	Why
Media-based and culture-based public *(Carayannis & Campbell, 2009, p. 206):* 'This fourth helix [media-based and culture-based public] associates with "media", "creative industries", "culture", "values", "life styles", "art", and perhaps also the notion of the "creative class" […]'	Assumed that media-based and culture-based public influence innovation systems by communicating and constructing public reality. *(Carayannis & Campbell, 2009)* Assumed important roles of the public and culture in creating and producing new knowledge and innovation *(Carayannis & Campbell, 2011)* 'The quadruple helix contextualizes the triple helix' *(Carayannis & Campbell, 2011, p. 342)* Assumed important roles of art-based research and innovation *(Carayannis & Campbell, 2014)*
Media-based and culture-based public; civil society *(Carayannis & Campbell, 2011)*	
(Carayannis & Campbell, 2014, p. 3): '[…] Media-based and culture-based public, the civil society, and arts, artistic research, and arts-based innovation. This fourth helix also could be paraphrased as the dimension of democracy (knowledge democracy) or the dimension of knowledge society in the context of democracy.'	
(Carayannis & Grigoroudis, 2016, p. 35): 'Civil Society — media based-culture integrates and combines two forms of capital: culture-based public — tradition, values etc. (social capital) and media-based public — television, internet, newspapers (capital of information)'	*(Carayannis & Grigoroudis, 2016, p. 31):* 'Society is a key actor in innovation processes along with academia, industry, and government. The society is frequently the end user of innovation and thus has a strong influence on the generation of knowledge and technologies via its demand and user function.'
(Carayannis et al., 2018): Mostly cited the previous articles	Unclear.

4.3.2 Empirical papers

Given the broad range of actors proposed conceptually, it is not surprising that the fourth helix considered/observed also varies in empirical papers. Most authors conceptualised the fourth helix as independent actors rather than factors (e.g. international connection) or an

intermediary of the Triple Helix. Table 4 provides a summary of the fourth helix proposed. This summary is simplified as many categories crosscut each other. For example, civil society includes citizens and non-profit organisations/non-governmental organisations (NGOs). Civil society embodies the demand of society and could also be considered the users of research and innovation.

Table 4. Simplified summary of the fourth helix in empirical papers.

Fourth helix	Examples	No. of Papers
Civil society	Senior citizens, students, volunteers, civil society organisations, NGOs	46
(End) users	Patients, ferry users, research users, customers of the private sector	14
Citizens	Residents who are digitally excluded	13
Community	Communities of practices, communities of local civil society	12
Society/Societal stakeholders	NGOs, farmers	10
Unclear selection		8
Public	Immigrants	7
Intermediary organisations	Community leadership, NGOs, university-industry research centres	3
Journalism, media		3
Entrepreneurs		2
Creative class		1
International connection		1
Knowledge and creative economy		1
Total no. of empirical articles		**121**

Regarding the reasons why the fourth helix is included, a large number of papers adopted the approach under the influence of academic and policy discourses (e.g. human-centred smart city, RIS3), while some other papers proposed actors based on their important roles in the given research context. Some papers also used the Quadruple Helix and the fourth helix to mobilise stakeholders for innovation networks or identify stakeholders for research purposes. Table 5 provides an overview of the reasons for including the fourth helix.

Table 5. Reasons for including the fourth helix.

Why	Examples of Reasons	Examples of Papers
To address sustainability issues	To improve decision-making in the energy sectors: e.g. renewable energy, biogas	García-Terán & Skoglund, 2018
	To deal with sustainability challenges and climate change	Fagiewicz et al., 2021; Skarzauskiene & Mačiulienė, 2021; Yang et al., 2012
To promote entrepreneurial and innovation systems	To generate social innovation and create an entrepreneurial and innovation environment in the rural context	Bótáné Horváth et al., 2015; Nordberg et al., 2020
	To promote entrepreneurial and innovation systems in different sectors: cultural and creative industry, tourism	Björk, 2014; Lindberg et al., 2012
To enhance the performance of organisations in the Triple Helix	To improve public services	Nguyen & Marques, 2021
	To advance the relevance of research and technology transfer from universities	Kronberga et al., 2010; C. Marques et al., 2021; McAdam et al., 2018
	To improve firms' performance	Campanella et al., 2017
To improve the performance of places and innovation processes	To build (smart) cities: align with citizens' needs, create public value and address demographic, environmental and socio-economic urban challenges	Indrawati et al., 2019; Paskaleva et al., 2021; Porto & Oliveira, 2020; Vallance et al., 2020
	To create social value	Popa et al., 2020

4.4 Concluding remarks and introduction to the sub-research questions explored in the three empirical papers

It is evident that the fourth helix proposed in the Quadruple Helix is diverse. Cai and Lattu (2021, p. 18) regarded this flexibility as a strength of the Quadruple Helix model: 'The model's freely defined fourth helix helps to include new elements [civil society, users, stakeholders] in (sustainable) innovation process', though it is admittedly challenging to apply it into the empirical analysis. I concur with some authors that this lack of clarity impedes the development of the model as a useful explanatory framework for both research and practice (Benneworth et al., 2015; P. Marques et al., 2018). This is because it is unclear

under which conditions and in which ways the additional participation of such actors, as well as the Quadruple Helix, may function and benefit.

The systematic literature review provided an overview of who is proposed as the fourth helix and why it is included. Although civil society appears to be the most popular type of actor to be included, this sector is dispersed and heterogeneous (Hartley, 2005; Siebers & Torfing, 2018). The systematic literature review reveals that only a few papers considered this heterogeneity aspect. There is a need to clarify specifically who the civil society or users exactly are and their interests (Schütz et al., 2019; Vallance et al., 2020) to better facilitate their engagement. In addition, it is necessary to understand the way the fourth helix gets involved to meaningfully influence innovation processes. This thesis comprises three empirical papers to provide insights into the aforementioned issues and specifically address three main research gaps, as explained in the following sections.

4.4.1 Power relations in innovation systems

The issue of power relations has long been a concern in knowledge and innovation systems (Howells, 2002; Lundvall et al., 2002) and is equally relevant in the Quadruple Helix setting (Aranguren et al., 2018; Miller et al., 2016). An active involvement of civic actors is what differentiates the Quadruple from the Triple Helix (Borkowska & Osborne, 2018). In this sense, a meaningful influence of the fourth helix on the decision-making process to improve outcomes is a critical condition for the Quadruple Helix model to function. Nevertheless, unlike the Triple Helix of 'relatively equal partners' (Etzkowitz, 2003), social representatives have diverse interests and often lack the resources to present them effectively (Borkowska & Osborne, 2018; Engelbert et al., 2019; Huxham & Vangen, 2005). Scholars have thus called for the exploration of mechanisms to enable the equitable participation of all actors, particularly citizens, in the knowledge and innovation generation process (Kronsell & Mukhtar-Landgren, 2018; Ott & Kiteme, 2016).

Several authors have suggested that intermediaries have decisive roles in addressing the power challenge (Björk, 2014; Miller et al., 2016). Among them, living labs are receiving increasing attention, especially in urban areas of Europe, as a user-centred instrument to stimulate inclusive and collaborative systems (Bifulco et al., 2017; Scholl & Kemp, 2016).

However, there is a paucity of understanding of the ways living labs accomplish this challenging task, i.e. to share power in designing smart cities (Compagnucci et al., 2021; Engels et al., 2019).

The first empirical paper entitled ‘Living labs: Challenging and Changing the Smart City Power Relations?’ explores the following research question: *Whether and how living labs include citizens in ways that change power relations with other organisational participants in smart city collaborative systems*? Paper 1 addresses this research question by applying the theory of power and exploring the cases of seven urban living labs in the region of Catalonia.

4.4.2 Stakeholder expectations and satisfaction in innovation networks

Collaboration among Quadruple Helix actors should not be taken for granted (Vallance et al., 2020). Research has revealed that there has often been a huge gap between expectations and actual collaborations among Quadruple Helix actors that undermine the potential of such collaborations (Vilkė et al., 2020). Appropriate measures and incentives are necessary to promote the engagement of different actors (Aranguren et al., 2018). In this case, exploring stakeholder expectations and satisfaction is an important condition for stakeholder engagement and, ultimately, for the Quadruple Helix model to function. Nevertheless, the topic remains under-investigated (Puerari et al., 2018; Von Wirth et al., 2019).

The second empirical paper entitled ‘The Promise of Living Labs to the Quadruple Helix Stakeholders: Exploring the Sources of (Dis)satisfaction’ explores the following research question: *How do expectations and perceived performance influence stakeholders’ engagement in the Quadruple Helix collaboration, such as living labs?* Paper 2 addresses this research question by applying the expectancy disconfirmation theory and exploring an in-depth case of a living lab in the region of Catalonia. The case study reflects the perspectives of all actors representing the Quadruple Helix, which is particularly valuable in understanding the collaboration dynamics (Bellandi et al., 2021; Gascó, 2017).

4.4.3 Organisational arrangements of public organisations for collaborative public sector innovation

The Quadruple Helix model, like the original Triple Helix (Etzkowitz & Leydesdorff, 1995), functions based on reciprocal relationships among participants. The participation of social actors appears most relevant to governments that are supposed to serve their citizenship (Aranguren et al., 2018). However, it is not yet known to what extent the Quadruple Helix model is applicable to generate public sector innovation. This issue is reflected in two main debates.

First, some authors have been concerned with the lack of understanding of the process and the relations of actors in the helix models and proposed a process-analytical perspective of the Quadruple Helix model (García-Terán & Skoglund, 2018; Popa et al., 2020). In this case, 'helixes can be conceptualised as processes of *value co-creation* in which participants—regardless of their title and identity—collaborate and compete for the production of different types of value' (Popa et al., 2020, p. 5, emphasis in the original). Although actors are rarely present at the same time, all helices are found to engage in different stages of innovation (Björk, 2014). Overall, the ways by which the Quadruple Helix actors and interactions contribute to public sector innovation processes remain unclear. Accordingly, the third empirical paper entitled 'Collaborative Public Sector Innovation as a Quadruple Helix Model? Insights from Denmark' addresses the following research sub-question: *With whom and in which helix models do public organisations interact in the innovation process?*

Second, although governments have paid increasing attention to the issue of citizen engagement in innovation processes, for example, to improve public services, the ways to organise such engagement activities remain challenging and unclear (Borghys et al., 2020). New innovation sources and/or their new combinations require adaptable working mechanisms and organisational arrangements (von Hippel, 1988; Waardenburg et al., 2020), which is likely the case for the Quadruple Helix in general and for the citizen engagement in particular. Accordingly, the third empirical paper also explores a second research sub-question: *How do public organisations organise citizen engagement in their innovation activities?*

Paper 3 addresses these research questions by combining innovation systems and the public administration theory, particularly collaborative public sector innovation and the public administration paradigms. Local governments are the main research units. The paper adopts mixed methods using the 2015–2016 public sector innovation survey in Denmark, namely, the Innovation Barometer, and interviews from an in-depth case study of a Danish municipality.

5. Research Context and Methodology

5.1 Research context

This research is a part of the Role of Universities in Innovation and Regional Development (RUNIN) project, an innovative training network for early-stage researchers in the field of innovation and regional studies.[5] The main purpose of the RUNIN project is to advance the body of knowledge on how universities contribute to innovation and develop in their regions by identifying the policies and practices that universities and other regional stakeholders have adopted to improve innovation. The project is organised under four themes: People and Networks, Policies and Interventions, Places and Territories, and Practices and Governance.

This thesis is categorised under the 'Practices and Governance' work package. By investigating the Quadruple Helix model, it seeks to provide insights on actors and interactions for innovation and regional development purposes. The role of universities is examined in broader networks with the additional participation of representatives of societal demands. Although universities are not the main analysis units in this research, all papers have obtained insights from university actors. The results have important implications for the practices and governance of innovation systems among universities and relevant partners.

The thesis mostly investigates the Quadruple Helix topic under the regional context of the Universitat Autònoma de Barcelona (UAB) and Aalborg University (AAU). The detailed reasons for selecting these cases are presented in each included paper. While these two universities share common characteristics, namely, being members of the European

[5] Web page: https://runinproject.eu/

Consortium of Innovative Universities, young, multidisciplinary and proactively engaged, their territories at both national and regional levels are different (e.g. Spain as a moderate-innovation country vs Denmark as a leader; Catalonia as one of Spain's biggest autonomous communities with metropolitan characteristics vs North Denmark Region as Denmark's smallest region with more peripheral features). This case selection brings a diverse picture of the issues involved in engaging citizens and incorporating them into innovation systems in different contexts that are shaped under the same (European) innovation policies.

To facilitate comparisons, I have also chosen sub-systems of regions located in urban areas with some common characteristics (e.g. smart city-oriented goal, quite high social cohesion, sufficient operating funding and strong presence of universities in the territory). The research seeks to address theoretical interests in improving innovation conditions at the city/local level. Although city or urban areas are often considered 'innovation machines' (Florida et al., 2017), their roles should not be taken for granted (Fitjar & Rodríguez-Pose, 2020). Brief information on these two universities and their regions is presented in the subsections below.

5.1.1 Universitat Autònoma de Barcelona (UAB), Catalonia[6]

The UAB was established in June 1968. Since its establishment, the university has oriented itself as an autonomous, democratic and socially responsible university, reflecting these attributes in all aspects of education, research and innovation. It is the second largest public university (with a traditional campus) in Catalonia based on the number of students, with 26,467 undergraduates and 7,995 postgraduates (ACUP, 2016). The university holds leading positions in the most prestigious worldwide rankings due to its profound efforts in fostering teaching excellence, promoting research impacts and attracting international talent.[7] In 2019, the QS World University Ranking placed the university in the second position in Spain, 82nd in Europe and 188th worldwide out of the 500 best universities in the world.

[6] Part of this section was published as 'Manrique, S., & Nguyen, H. T. (2021). Balancing Regional Engagement and Internationalisation: The Case of Autonomous University of Barcelona. In D. Charles, R. Ahoba-Sam, & S. Manrique (Eds.), *Entrepreneurial Universities in Regional Innovation* (pp. 95–130). UK Book Publishing'. (The two authors contributed equally; the authorship is in alphabetical order.)

[7] https://www.uab.cat/web/about-the-uab-1345666325480.html

The main campus of the UAB belongs to the metropolitan region of Barcelona Province in Catalonia, one of the 17 autonomous communities in Spain. Its home region, Catalonia, is considered one of the driving economic forces in Spain that makes up an average of about 20% of the gross domestic product from 2003 to 2020 (Romero, 2022). Innovation has an important role in fostering regional economy, involving a wide range of actors, including citizens, in its official system (Government of Catalonia, 2010). At the local level, the university has a strong connection with many surrounding municipalities, originally with Barcelona city; its ties are not limited to Cerdanyola del Vallès, where its main campus is located. This stems from historical, social and economic reasons but also the active participation of the university in regional initiatives (Manrique & Nguyen, 2017). One of its close-tie cities studied in this PhD thesis is Sant Cugat del Vallès, a member of the Catalonian Innovation Triangle.

5.1.2 Aalborg University (AAU), North Denmark

The AAU was originally established in 1974 to meet the needs of the North Denmark region to increase the proportion of tertiary education among young people and support the transition of the regional industry structure from declining manufacturing sectors to new growth areas (Gregersen et al., 2009). It is the only university in the region and the fifth largest university in the country. From 1,600 students at the outset, the enrolees reached 20,211 regular students and 850 PhD students in 2018.[8] Its core value is the problem-based learning model, which is believed to lead to new insights and new solutions to social challenges (Aalborg University, 2016). In recent years, the AAU has been listed in most international ranking lists. In 2020, the university was number 324 in the world according to the QS World University Ranking.

Nowadays, the AAU is present in three Danish cities, with the main campus in Aalborg of North Denmark region. Aalborg is the main city in North Denmark, the least populous region among the five Danish ones. With 217,075 inhabitants as of 2020, Aalborg Municipality accounts for more than one-third of the population in its region and is among

[8] https://www.en.aau.dk/about-aau/figures-facts/

the three largest municipalities in Denmark (Statistics Denmark, n.d.). More than half of the municipality's population lives in the city of Aalborg.

5.2 Methodological considerations

The choice of research method depends on (i) the types of research questions and research objectives; (ii) the extent of existing knowledge; and (iii) the amount of time and available resources (Catterall, 2000; Saunders et al., 2016). This research is designed as mixed-method research, predominantly by exploratory qualitative methodology. With a majority of 'how' research questions, using the qualitative research method would foster a better understanding of the decision-making and behaviours of actors in relationships. The Quadruple Helix model is a nascent area of research with one decade of development. Exploratory research would allow addressing the under-explored research questions and developing new insights into the complex picture of the actor interactions. Finally, for the third and last paper, elements of a quantitative method have been included to quantify the Quadruple Helix interactions, given that understanding of this topic has improved.

There are two main reasons for using a case study as the preferred strategy (Eisenhardt, 1989; Yin, 2003). A case study is useful in investigating the dynamics in single settings or examining complicated phenomena that evolve over time. Furthermore, case-based strategy is best suited for understanding behaviours in inter-sectional relationships. Both multiple and single case studies have been used.

In the two first papers, living labs, which (cl)aim to be user-centred, are used as units of analysis to better understand citizen engagement and, thus, examine the emergence of the Quadruple Helix in specific initiatives. Living labs were selected on the understanding that the performance of innovation intermediaries is critical to increasing stakeholders' engagement in collaborations (Simon & Marques, 2021). Purposive sampling is the main sampling technique. Living labs that are active members of the European Network of Living Labs (ENoLL) and the regional lab network (CatLabs) are the most suitable sample for answering the research questions because this population has the characteristic of empowering users and citizens in work processes. Catalonia is the home of about one-third

of ENoLL members in Spain. The region also embeds the living lab approach in their regional innovation strategies. Therefore, Catalonia is an outstanding region to study.

In the third paper, public administration organisations, particularly local governments, are the main analysis units. This selection draws upon observations from living lab cases that governments are active actors in initiating and maintaining Quadruple Helix interactions. Ideally, further investigations should be conducted for the case studies in Catalonia to obtain a full picture of the said region. However, the political crisis in the region at the end of 2017 led to constraints in collecting data. Meanwhile, Denmark provides useful insights for Quadruple Helix research from public sector standpoints due to the robust innovation spirit of public organisations and strong presence of civil society in the country. However, some studies show that Denmark mainly performs government-led innovation (Lee et al., 2012). There is a necessity to study how local Danish governments encourage external sources, including citizens and civil society organisations, to engage in innovation activities.

5.3 Data collection and analysis techniques

The primary data of the research comprised semi-structured interviews with different stakeholders such as living lab coordinators, public authorities, academics, innovation managers and residents, given the exploratory nature of the research questions. The secondary qualitative data included web pages and other provided documents about the case studies. The author actively observed and participated in living lab activities during the data collection. Furthermore, during the secondment at AAU, my co-supervisor facilitated my partial access to the secondary quantitative data of a public sector innovation survey (2015–2016), namely, the Innovation Barometer, in Denmark, which comprised cross-sectional data collected by Statistics Denmark and The National Centre for Public Innovation (*Center for Offentlig Innovation* – COI).[9]

Interviews were recorded where permitted and later transcribed for analysis. The qualitative data were organised and analysed by adapting a thematic (content) analysis

[9] Since 2022, COI has been called The National Centre for Public-Private Innovation (*Center for Offentlig-Privat Innovation* – CO-PI).

technique (Braun & Clarke, 2006). This technique was used due to its flexibility in organising and interpreting the data. For the quantitative data, I mainly explored the descriptive results to set the scene for research rather than inferential statistics. Considering the exploratory nature of this thesis and the young stage of Quadruple Helix research, descriptive statistics should be efficient to provide implications for further qualitative research and hypothesis testing.

6 Summary of Papers

The papers included in this thesis are summarised in Table 6.

Table 6. Summary of included papers.

I. Living Labs: Challenging and Changing the Smart City Power Relations? Nguyen, H. T., Marques, P. & Benneworth, P.	
Research questions	Whether and how do LLs include citizens in ways that change power relations with other organisational participants in smart city collaborative systems?
Research design and data sources	Qualitative - Multiple case studies (Macro level of regional innovation system) Semi-structured interviews & Content analysis
Status	Under peer-review process. Revised and resubmitted.
II. The Promise of Living Labs to the Quadruple Helix Stakeholders: Exploring the Sources of (Dis)satisfaction (Nguyen, H. T. & Marques, P.)	
Research questions	How do expectations and perceived performance influence stakeholders' engagement in the Quadruple Helix collaboration, such as living labs?
Research design and data sources	Qualitative – In depth single case study (Micro level of one collaboration) Semi-structured interviews & Content analysis
Status	Published in *European Planning Studies* (2021)
III. Collaborative Public Sector Innovation as a Quadruple Helix Model? Insights from Denmark (Nguyen, H. T.)	
Research questions	To what extent is the Quadruple Helix model applicable to public sector innovation?' This question is approached in two parts: • With whom and in which helix models do public organisations interact in innovation process? • How do public organisations organise citizen engagement in their innovation activities?
Research design and data sources	Mixed method - Micro level of innovation processes and meso level of organisations Cross-sectoral survey and semi-structured interviews Descriptive statistics & Content analysis
Status	Working paper

7 Conclusions

This PhD thesis critically examines the development of the Quadruple Helix model as an academic concept and its practical implications. It aims to explain the ways in which the Quadruple Helix may function, considering the extent the Quadruple Helix model is actually functional and under which conditions. The thesis presents a systematic literature review in this Introduction and three papers based on empirical studies that aim to contribute to multi-level understanding of the Quadruple Helix concept.

In general, the Quadruple Helix model is concerned with including a *fourth helix* that presents social demands in innovation processes along with the Triple Helix of government, academia and industry. However, the systematic literature review has underscored the lack of consensus on how the fourth helix is proposed conceptually and empirically.

Embracing a Quadruple Helix approach influences different levels of innovation practices and governance, including the macro level of (regional) innovation systems, the meso level of specific organisations and, finally, the micro level of related collaborations and processes. These three levels are interrelated: the changes at one level lead to the changes at other levels or in the whole innovation landscape. For example, a (macro) regional innovation system that appreciates citizens' value may potentially change the norms at the (meso) organisational scale and subsequently lead to organisation participation in (micro) innovation collaboration and processes.

7.1 Research findings and theoretical contributions

Figure 3 below presents the main findings from the three papers underlying the antecedents for a multi-level Quadruple Helix conception.

Overall, obtaining collective perspectives and resources from citizens and societal demands is beneficial for each stakeholder. However, it is evident that adopting a Quadruple Helix approach in research and innovation strategies is complex if the imperative is to engage citizens actively and meaningfully in the systems to improve outcomes.

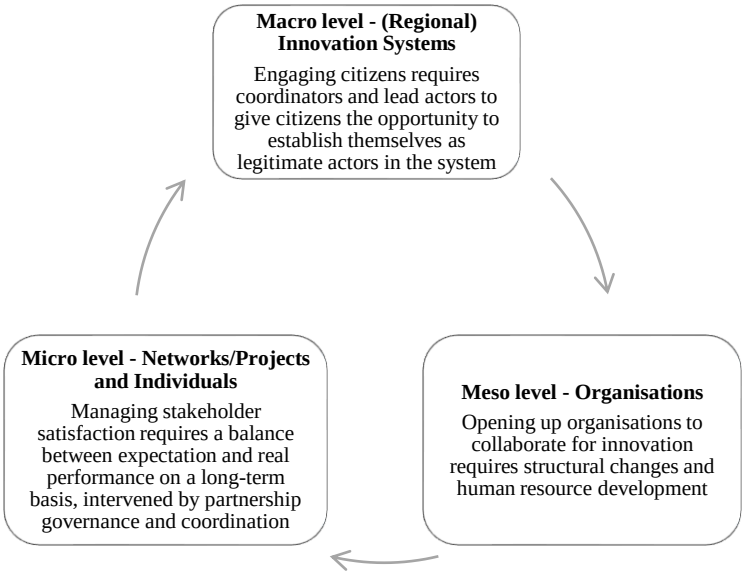

Figure 3. Antecedents for a multi-level understanding of the Quadruple Helix model.

Putting the Quadruple Helix into practice is more challenging than what policy and theory discourses have expressed that everyone is motivated to collaborate and obtains benefits from such per se. This study has offered insights from two different European areas, where living labs are typical intermediaries in one case (Papers 1 and 2) and, in the other, public organisations have been restructured, including assigning in-charge agents and units for citizen engagement (Paper 3). In both regional settings, some benefits and challenges could be identified, but it was difficult to find the 'ideal' governance arrangements with the Quadruple Helix model. This thesis calls for further attention to organising and managing innovation practices at multiple levels to possibly experience its advantages.

Under which conditions and how does the Quadruple Helix model function?

By leveraging the three papers, the thesis proposes three conditions that allow the Quadruple Helix model to operate: (i) leverage the power positions of citizens in collaborative systems; (ii) manage stakeholder expectations and satisfaction in collaboration; and (iii) organise the collaborative practices of (public sector) organisations to promote innovation. It mainly contributes to innovation studies whilst connecting and being foregrounded in the theory of power, expectancy disconfirmation theory and public administration literature. The empirical evidence offers broad studies from multiple cases of living labs and local governments in Spanish and Danish contexts.

Paper 1 applies the power theory—the only paper in Quadruple Helix research to do so—to critically investigate the likely power asymmetries between citizens and other organisational participants in collaborative systems and determine how to challenge and change such power relations. The paper proposes a self-reinforcing mechanism that agencies exert through 'power bankers', coupled with factors such as political support and incentives, which endow citizens with temporary positions of power to deploy means to achieve their goals. The identified mechanism appears to be strongly reliant on publicly funded coordinators, who are unlikely to be present in all contexts. The considerable efforts required to engage citizens at the basic level in a socially active region suggest that, in less social regions, it could be even harder to mobilise citizens to build smart cities. These findings suggest the need for a sceptical attitude towards the Quadruple Helix model.

Paper 2 presents the first study that adopts the expectancy disconfirmation theory to examine stakeholder satisfaction towards interactive innovation collaborations instead of products/services.[10] It proposes a cognitive and decision-making model in terms of a figure (Figure 4) that can have an analytic use for theory and can also be informative for the practice of collaborative innovation management. The model extends the expectancy disconfirmation framework (Oliver, 1980; Van Ryzin, 2004) with an emphasis on the intervention of partnership governance and management, which communicates and bridges the stakeholder expectation gap to sustain the collaboration. The access to final users or citizens appears to be attractive for all the other stakeholders: firms can capture the value of their proximity to users, the public sector is requested to be closer to citizens to improve public services and universities are increasingly prompted to directly impact a wider public. However, the alignment among these stakeholders is complex as the interactions involve conflicting logics and priority and, thus, require a likely trade-off or compromise of value. It suggests that collaborations in the form of a Quadruple Helix model do not function seamlessly.

[10] The expectancy disconfirmation theory suggests that the satisfaction of customers/users is related to their expectations, the quality of products/services and the discrepancy between the first two factors (Oliver, 1980; Van Ryzin, 2004). The expectancy disconfirmation theory was initially applied to evaluate customer satisfaction in marketing studies and gradually expanded to evaluate citizen satisfaction in public management.

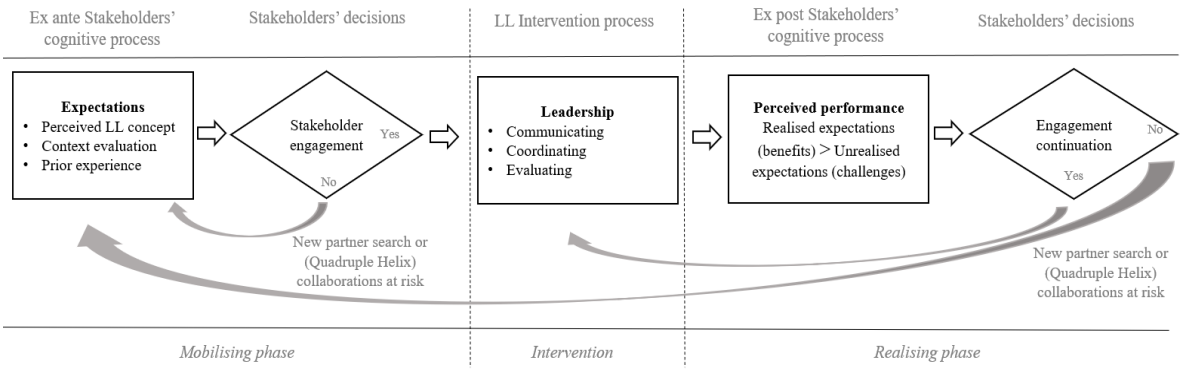

Figure 4. A model of stakeholders' decision processes for engagement.

Source: Nguyen & Marques (2021, p. 13)

Paper 3 presents the first study that connects and examines the applicability of the emergent Quadruple Helix model to public sector innovation. The research proposes several influential factors when local governments select actors to work with during an innovation process. The complexity of the different levels in an innovation system emphasises the over-simplification of the Quadruple Helix model, where the four types of actors are supposed to be present and interact in intermittent ways. According to the survey, the Quadruple Helix actors were present in local public sector innovation processes, with civil society being the most frequent interacting actor and factor. However, regarding actor interactions, the results show that the proportion of municipal workplaces that organised the innovation process into a Triple Helix or Quadruple Helix model was rather small. All types of helix actors are not necessarily engaged either at the same stage of innovation or in the same individual project. The in-depth case study points out that the choice of partners and the organisation of collaboration differ, even among internal communities in the same municipality, in terms of their own interests and challenges.

In general, the author does not claim that some challenges of the Quadruple Helix are insurmountable but rather raises a sceptical attitude on the development and applicability of the model. Three main factors will need to be considered for the Quadruple Helix to function in practice: power asymmetries, stakeholder expectations and satisfaction, and organisational arrangements. Without considering these aspects, the Quadruple Helix model will be impotent in providing a plausible explanation of the ways actors interact to generate innovation.

7.2 Contributions to the theory of helix models, particularly the Quadruple Helix

This research offers valuable insights into the development of the Quadruple Helix model as a potential academic concept to explain innovation generation. It challenges some underlying assumptions about the Quadruple Helix model and, perhaps, also about the original Triple Helix.

First, the metaphor of 'helix' obscures the fact that each sector and each organisation is complex and far from being homogeneous. For instance, there are different types of universities (Charles, 2006; Charles et al., 2014) and firms (MacGregor et al., 2010). Paper 3 in this thesis has pointed out that there are different departments or units with varying interests in the same governmental organisation, particularly in a municipality. In the case of the Quadruple Helix, it is not enough to clarify 'the fourth helix' as a type of actors but clarify exactly who they are and their interests, which are often neglected by scholars (Engelbert et al., 2019). All papers in this thesis have critically considered this issue and provided specific types of participating citizens and their interests or motivations; it is discussed more explicitly in Paper 1. The issue of clarifying participants of other helices should also be critically considered.

Second, it is difficult to differentiate between different helices, particularly the fourth helix, with the other helices. For example, should entrepreneurs constitute the fourth helix (Schoonmaker & Carayannis, 2013) or be included in the industry helix (Björk, 2014)? Is student the fourth helix (Pirlone & Spadaro, 2020) or the academia helix? There is also an observation that the government, industry and university helices can be part of the fourth helix (Höglund & Linton, 2018). Paper 2 of this thesis has revealed that the participating residents are mainly employees of companies in the investigated area; some participating academics also reside there. In this case, we categorised participating employees of companies as the fourth helix since their involvement was outside of working hours and derived from the rights of citizenship. Conversely, we considered participating academics in the academia helix because their participation accounted for part one of the institutional tasks. However, this boundary distinction can be challenging, as each of us is a citizen.

Third, several fundamental steps of forming helix models, particularly the Quadruple Helix model, to generate innovation need to be challenged. This refers to at least the two steps when helix actors 'take on new tasks' and 'take the role of the other', if the first neccesary step is not mentioned, namely, when all helices with different interests and dynamics come to work together (Etzkowitz, 2008). Regarding the step 'take on new tasks', the question for researchers is theoretically how active the civil society needs to be to make them the fourth helix. It is necessary to consider this point when developing the Quadruple Helix as an explanatory model of innovation production. In most research, the new roles of civil society (e.g. as the driver of the innovation process) and their relationships with other helices (e.g. as an equal partner) are not clearly observed (Höglund & Linton, 2018; Kriz et al., 2018). There has been little evidence of involving civil society actors in a truly bottom-up approach, which distinguishes the Quadruple Helix from the Triple Helix (Borkowska & Osborne, 2018). In line with this point, a recent analysis by Borghys et al. (2020, p. 4) indicated:

> Whereas the [Quadruple Helix] concept is seen in the literature as a way to innovate together […], in its execution, it often boils down to several recurring meetings with representatives from the four "helices" in the local ecosystem, with the goal of coming up with new project ideas, or as a forum to share challenges and concerns. In this light, the "quadruple helix" approach is mostly reduced to a means of gathering new project ideas […].

All papers in this thesis revealed that the participation of citizens, to some extent, has been active compared with their traditional roles (e.g. users, buyers, voters, taxpayers), as a result of the encouragement of relevant agents (e.g. coordinators, public officers). Supposing that 'take on new tasks' appears to be fulfilled to some extent in a given time, 'taking the role of the other' is another level that is simplistic and not realistic, as learnt from the view of public administration theories. Indeed, citizen participation, as well as the participation of social actors, can be alluring as it used to be perceived: 'no one is against [citizen participation] in principle because it is good' (Arnstein, 1969, p. 216). Although different levels were proposed in the citizen participation ladder by Arnstein (1969), the question posed remains: What extent of participation and power should cititzens hold (Sønderskov, 2020)? From the citizen capacity side, the situation when citizens engage in final decision-making is not feasible in a fragmented society (Skelcher & Torfing, 2010). From the government side, some

scholars have warned of the risks wherein participation is not a means for the government to fix democracy deficits or a strategy to improve the efficiency of governance (Hertting & Kugelberg, 2018). Instead, participation can be an excuse to avoid, or at least to share, responsibilities in a complex political situation (Hertting & Kugelberg, 2018). This issue has to be seriously taken into account by scholars who investigate helix models of innovation.

7.3 Implications for policy and practice

Considering the inter-sectoral nature of the Quadruple Helix topic, the results from this thesis have several implications for different stakeholders as innovation practitioners and managers. The thesis also generates relevant messages to (local and regional) policymakers since the Quadruple Helix has been embedded with current European regional research and innovation policies. Well-designed policies could fail without considering the limitations of organisations and management (Bozeman, 2013). This thesis, with its focus on different levels of systems, organisations, networks and processes, could offer benefits in this sense.

7.3.1 Living labs and other intermediaries of collaboration

Financial sustainability is one of the main concerns of living lab managers. These organisations should probably identify clearly the main utilisers and users to provide appropriate 'services' based on their existing advantages. Co-creation and experimentation have been a trend in regional innovation systems to generate collective ideas. Mastering in facilitating co-creation and generating systematic results from these sessions would be some of the competitive advantages of living labs compared with other intermediaries. Clear communication among stakeholders to set their expectations is the key to collaboration satisfaction and sustainability.

7.3.2 Local and regional authorities

Governmental organisations are the most active actors in all case studies considering their characteristic of being close to citizens and NGOs. However, engaging citizens actively in working processes is not straightforward. Instead of calling for 'collaborative leadership' among Quadruple Helix actors to improve governance and decision-making, as indicated in RIS3 (Foray et al., 2012), it is important to focus more closely on the mechanisms by which

civic actors can reinforce their power sources and positions to exercise their agency in (regional) innovation systems.

7.3.3 Universities

Universities play an important role in all studied cases, both formally as enablers of collaboration and informally as the one-off participation of academics in training and public debates. University managers can motivate and effectively facilitate academics' engagement with civil society through the following: (i) assigning coordinators who are in charge of administrative work to support academics' participation; (ii) considering research dissemination activities as a part of academic staff evaluation (with cautious indicators); and (iii) better communicating with academics to align their research interests with the emerging opportunities in approaching the general public and obtaining funding.

7.3.4 Businesses

Companies are one of the highly sought actors in Quadruple Helix-based initiatives. However, their involvement has been occasional, especially in the case of big companies. Innovation collaboration and corporate social responsibilities appear to be interrelated. Hence, managers in these two departments should communicate to search for development opportunities in the changing business environment. Small and medium-sized enterprises and spin-offs should take advantage of this trend and the goodwill from universities and governments to experiment and develop their products and services.

7.3.5 Citizens and other civil society actors

On the one hand, the implementation of policies on the Quadruple Helix has endowed civic actors with opportunities for influencing innovation practices. Citizens and entrepreneurs should utilise this chance to make their voices heard and create critical resources that would allow them to obtain formal positions in governance arrangements. On the other hand, the higher expectations from different regional actors have challenged the roles of citizens and NGOs, not only in identifying social problems but also in co-creating solutions and public value. The results of this thesis emphasise the need for a change in citizens' behaviour (from passive to active) and for NGOs to improve their competency, especially their

communication and coordination capabilities, to collect citizens' ideas and support their activities.

7.4 Limitations and future research directions

This study suggested mechanisms for citizen empowerment and interaction management towards Quadruple Helix collaborations by living labs and public organisations. Further studies are warranted to explore whether such mechanisms would be applicable to cases in other places with different dynamics, such as living labs with a strong presence of industry (e.g. Flemish model in Belgium). This thesis examined living labs as a potential instrument for citizen inclusion to expand the problem-solving capacity. The effect of intermediaries in general, and citizen participation in particular, on democracy should be subjected to a deeper examination.

Living labs are likely not the only instrument that attempts to orchestrate inclusive innovation systems. Future research could investigate the alternative mechanisms used by regional organisations and examine how other traditional intermediaries (such as research and technology organisations and technology transfer offices) are adapting to this trend.

In this study, a subjective measure of expectancy disconfirmation (e.g. Van Ryzin, 2004) was applied by directly asking actors how satisfied they were with the collaboration performance compared with their initial expectation. This subjective approach allowed the identification of satisfaction based on the gap between expectation and performance, but not the direct influence of expectation on satisfaction. Future research can adopt a subtractive method with separate quantitative indicators (Petrovsky et al., 2017; Van Ryzin, 2004) to measure the latter issue. In addition, the findings suggested that in collaborations, stakeholder satisfaction was influenced more by the intervention of partnership governance and coordination, instead of merely the gap between expectation and implementation performance, as suggested by the expectancy disconfirmation theory. Further research on a larger scale will be valuable to confirm this point.

The data for the three empirical papers in this thesis were collected before the COVID-19 pandemic. It would be valuable to understand how the COVID-19 context has shaped and

been shaped by citizen inclusion and other collaborative strategies of (public and private) organisations to respond to the crisis and to further innovate. Collaborations, especially cross-sector, are more likely to form in turbulent settings (Bryson et al., 2006). Notably, one case under this study revealed that the 2009 financial crisis had been the catalyst for active civic participation.

Access to citizen interviewees was relatively limited in some cases. Future interviews could uncover more nuances in citizen perceptions. Further research that offers broader citizen insights would be beneficial, although this issue may be difficult to overcome due to the dispersion of citizens.

The findings underscored the current disconnect between the interests of the industry in citizen-driven collaborations. Further research is needed to explore whether the change in collaboration discourse and the practice of governments and universities, with an emphasis on citizen inclusion, will create a 'domino effect' in the perception of companies, especially in smart city development areas. The findings also indicated that increasing expectations in the roles of universities in collaborative systems might give rise to both opportunities and challenges (e.g. impact reinforcement vs mission overload). It would be important to investigate how universities perceive and deal with this issue at the management and academic levels.

Lastly, the tendency of multi-actor collaborations consisting of different backgrounds and interests has placed coordinators, boundary spanners (who possess inter-sectoral experience and expertise) and, speaking broadly, individuals, at the heart of innovation practices. Exploring such individual roles could be a promising area of research.

References

Aalborg University. (2016). How Aalborg University creates knowledge for the world. Aalborg.

ACUP. (2016). *Universities of Catalonia: The area of university excellence in Southern Europe*.

Afonso, O., Monteiro, S., & Thompson, M. (2012). A growth model for the quadruple helix. *Journal of Business Economics and Management, 13*(5), 849–865. https://doi.org/10.3846/16111699.2011.626438

Aranguren, M. J., Magro, E., Navarro, M., & Wilson, J. R. (2018). Governance of the territorial entrepreneurial discovery process: looking under the bonnet of RIS3. *Regional Studies,* 1–11.

https://doi.org/10.1080/00343404.2018.1462484

Arnkil, R., Järvensivu, A., Koski, P., & Piirainen, T. (2010). *Exploring Quadruple Helix: Outlining user-oriented innovation models* (University of Tampere: No. 85/2010).

Arnstein, S. R. (1969). A Ladder Of Citizen Participation. *Journal of the American Planning Association*, *35*(4), 216–224. https://doi.org/10.1080/01944366908977225

Arundel, A., Bloch, C., & Ferguson, B. (2019). Advancing innovation in the public sector: Aligning innovation measurement with policy goals. *Research Policy*, *48*(3), 789–798. https://doi.org/10.1016/j.respol.2018.12.001

Asheim, B. T., & Isaksen, A. (1997). Location, agglomeration and innovation: Towards regional innovation systems in Norway? *European Planning Studies*, *5*(3), 299–330. https://doi.org/10.1080/09654319708720402

Asheim, B. T., Isaksen, A., & Trippl, M. (2019). *Advanced Introduction to Regional Innovation Systems*. *Elgar Advanced Introductions series*. Edward Elgar Publishing Limited.

Asheim, B. T., Moodysson, J., & Tödtling, F. (2011). Constructing regional advantage: Towards state-of-the-art regional innovation system policies in Europe? *European Planning Studies*, *19*(7), 1133–1139. https://doi.org/10.1080/09654313.2011.573127

Bekkers, V., & Tummers, L. (2018). Innovation in the public sector: Towards an open and collaborative approach. *International Review of Administrative Sciences*, *84*(2), 209–213. https://doi.org/10.1177/0020852318761797

Bellandi, M., Donati, L., & Cataneo, A. (2021). Social innovation governance and the role of universities: Cases of quadruple helix partnerships in Italy. *Technological Forecasting and Social Change*, *164*, 120518. https://doi.org/10.1016/j.techfore.2020.120518

Benneworth, P., Coenen, L., Moodysson, J., & Asheim, B. (2009). Exploring the multiple roles of Lund University in strengthening Scania's regional innovation system: Towards institutional learning? *European Planning Studies*, *17*(11), 1645–1664. https://doi.org/10.1080/09654310903230582

Benneworth, P., Smith, H. L., & Bagchi-Sen, S. (2015). Special Issue: Building Inter-Organizational Synergies in the Regional Triple Helix. *Industry and Higher Education*, *29*(1), 5–10. https://doi.org/10.5367/ihe.2015.0242

Bifulco, F., Tregua, M., & Amitrano, C. C. (2017). Co-governing smart cities through living labs. Top evidences from EU. *Transylvanian Review of Administrative Sciences*, (50E), 21–37. https://doi.org/10.24193/tras.2017.0002

Binz, C., & Truffer, B. (2017). Global Innovation Systems—A conceptual framework for innovation dynamics in transnational contexts. *Research Policy*, *46*(7), 1284–1298. https://doi.org/10.1016/j.respol.2017.05.012

Björk, P. (2014). The DNA of Tourism Service Innovation: A Quadruple Helix Approach. *Journal of the Knowledge Economy*, *5*(1), 181–202. https://doi.org/10.1007/s13132-014-0183-x

Bloch, C., & Bugge, M. M. (2013). Public sector innovation - From theory to measurement. *Structural Change and Economic Dynamics*, *27*, 133–145. https://doi.org/10.1016/j.strueco.2013.06.008

Borghys, K., van der Graaf, S., Walravens, N., & Van Compernolle, M. (2020). Multi-Stakeholder Innovation in Smart City Discourse: Quadruple Helix Thinking in the Age of "Platforms." *Frontiers in Sustainable Cities*, *2*(5). https://doi.org/10.3389/frsc.2020.00005

Borkowska, K., & Osborne, M. (2018). Locating the fourth helix: Rethinking the role of civil society in developing smart learning cities. *International Review of Education*, *64*, 1–18. https://doi.org/10.1007/s11159-018-9723-0

Bótáné Horváth, N., Katonáné Kovács, J., & Szőke, S. (2015). Building an entrepreneurial environment in rural regions: a possible way to develop human and social capital. *Studies in Agricultural Economics*, *117*(1), 20–26. https://doi.org/10.7896/j.1428

Bozeman, B. (2013). What Organization Theorists and Public Policy Researchers Can Learn from One Another: Publicness Theory as a Case-in-Point. *Organization Studies*, *34*(2), 169–188. https://doi.org/10.1177/0170840612473549

Brännback, M., Carsrud, A., Krueger, N., & Elfving, J. (2008). Challenging the triple helix model of regional innovation systems: A venture-centric model. *International Journal of Technoentrepreneurship*, *1*(3), 257–277. https://doi.org/10.1504/IJTE.2008.020539

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Bryson, J. M., Crosby, B. C., & Stone, M. M. (2006). The design and implementation of cross-sector collaborations: Propositions from the literature. *Public Administration Review*, *66*(SUPPL. 1), 44–55. https://doi.org/10.1111/j.1540-6210.2006.00665.x

Bunders, J. F. G., Broerse, J. E. W., & Zweekhorst, M. B. M. (1999). The Triple helix enriched with the user perspective: A view from Bangladesh. *Journal of Technology Transfer*, *24*(2–3), 235–246. https://doi.org/10.1023/A:1007811607384

Cai, Y., & Lattu, A. (2021). Triple Helix or Quadruple Helix: Which Model of Innovation to Choose for Empirical Studies? *Minerva*. https://doi.org/10.1007/s11024-021-09453-6

Cajaiba-Santana, G. (2014). Social innovation: Moving the field forward. A conceptual framework. *Technological Forecasting and Social Change*, *82*(1), 42–51. https://doi.org/10.1016/j.techfore.2013.05.008

Campanella, F., Della Peruta, M. R., Bresciani, S., & Dezi, L. (2017). Quadruple Helix and firms' performance: an empirical verification in Europe. *Journal of Technology Transfer*, *42*(2), 267–284. https://doi.org/10.1007/s10961-016-9500-9

Carayannis, E. G., & Campbell, D. F. (2014). Developed democracies versus emerging autocracies: arts, democracy, and innovation in Quadruple Helix innovation systems. *Journal of Innovation and Entrepreneurship*, *3*(1), 12. https://doi.org/10.1186/s13731-014-0012-2

Carayannis, E. G., & Campbell, D. F. J. (2009). "Mode 3" and "Quadruple Helix": toward a 21st century fractal innovation ecosystem. *International Journal of Technology Management*, *46*(3/4), 201. https://doi.org/10.1504/IJTM.2009.023374

Carayannis, E. G., & Campbell, D. F. J. (2011). Open Innovation Diplomacy and a 21st Century Fractal Research, Education and Innovation (FREIE) Ecosystem: Building on the Quadruple and Quintuple Helix Innovation Concepts and the "Mode 3" Knowledge Production System. *Journal of the Knowledge Economy*, *2*(3), 327–372. https://doi.org/10.1007/s13132-011-0058-3

Carayannis, E. G., & Campbell, D. F. J. (2012). *Mode 3 Knowledge Production in Quadruple Helix Innovation Systems*. SpringerBriefs in Business 7. https://doi.org/10.1007/978-1-4614-2062-0_1

Carayannis, E. G., & Grigoroudis, E. (2016). Quadruple innovation Helix and smart specialization: Knowledge production and national competitiveness. *Foresight and STI Governance*, *10*(1),

31–42. https://doi.org/10.17323/1995-459x.2016.1.31.42

Carayannis, E. G., Grigoroudis, E., Campbell, D. F. J., Meissner, D., & Stamati, D. (2018). The ecosystem as helix: an exploratory theory-building study of regional co-opetitive entrepreneurial ecosystems as Quadruple/Quintuple Helix Innovation Models. *R&D Management*, *48*(1), 148–162. https://doi.org/10.1111/radm.12300

Carl, J. (2020). From technological to social innovation – the changing role of principal investigators within entrepreneurial ecosystems. *Journal of Management Development*, *39*(5), 739–752. https://doi.org/10.1108/JMD-09-2019-0406

Carlsson, B., Jacobsson, S., Holmen, M., & Rickne, A. (2002). Innovation systems: Analytical and methodological issues. *Research Policy*, *31*(2), 233–245. https://doi.org/10.1016/S0048-7333(01)00138-X

Carlsson, B., & Stankiewicz, R. (1991). On the nature, function and composition of technological systems. *Journal of Evolutionary Economics*, *1*(2), 93–118. https://doi.org/10.1007/BF01224915

Catterall, M. (2000). *Research Methods for Business Students*. *Qualitative Market Research: An International Journal* (Fifth ed., Vol. 3). Essex: Pearson Education Limited. https://doi.org/10.1108/qmr.2000.3.4.215.2

Cavallini, S., Soldi, R., Friedl, J., & Volpe, M. (2016). *Using the Quadruple Helix Approach to Accelerate the Transfer of Research and Innovation Results to Regional Growth*. https://doi.org/10.2863/408040

Charles, D. (2003). Universities and Territorial Development: Reshaping the Regional Role of UK Universities. *Local Economy*, *18*(1), 7–20. https://doi.org/10.1080/0269094032000073780

Charles, D. (2006). Universities as key knowledge infrastructures in regional innovation systems. *Innovation*, *19*(1), 117–130. https://doi.org/10.1080/13511610600608013

Charles, D., Kitagawa, F., & Uyarra, E. (2014). Universities in crisis?-new challenges and strategies in two English city-regions. *Cambridge Journal of Regions, Economy and Society*, *7*(2), 327–348. https://doi.org/10.1093/cjres/rst029

Cinar, R. (2019). Delving into social entrepreneurship in universities: is it legitimate yet? *Regional Studies, Regional Science*, *6*(1), 217–232. https://doi.org/10.1080/21681376.2019.1583602

Clausen, T. H., Demircioglu, M. A., & Alsos, G. A. (2020). Intensity of innovation in public sector organizations: The role of push and pull factors. *Public Administration*, *98*(1), 159–176. https://doi.org/10.1111/padm.12617

Coenen, L. (2007). The role of universities in the regional innovation systems of the North East of England and Scania, Sweden: Providing missing links? *Environment and Planning C: Government and Policy*, *25*(6), 803–821. https://doi.org/10.1068/c0579

Coenen, L., & Díaz López, F. J. (2010). Comparing systems approaches to innovation and technological change for sustainable and competitive economies: An explorative study into conceptual commonalities, differences and complementarities. *Journal of Cleaner Production*, *18*(12), 1149–1160. https://doi.org/10.1016/j.jclepro.2010.04.003

Compagnucci, L., Spigarelli, F., Coelho, J., & Duarte, C. (2021). Living Labs and user engagement for innovation and sustainability. *Journal of Cleaner Production*, *289*, 125721. https://doi.org/10.1016/j.jclepro.2020.125721

Cooke, P. (2002). Regional innovation systems: General findings and some new evidence from biotechnology clusters. *Journal of Technology Transfer*, *27*(1), 133–145.

https://doi.org/10.1023/A:1013160923450

Cooke, P. (2005). Regionally asymmetric knowledge capabilities and open innovation: Exploring "Globalisation 2" - A new model of industry organisation. *Research Policy*, *34*(8), 1128–1149. https://doi.org/10.1016/j.respol.2004.12.005

Cooke, P. (2010). Regional innovation systems: Development opportunities from the "green turn." *Technology Analysis and Strategic Management*, *22*(7), 831–844. https://doi.org/10.1080/09537325.2010.511156

Cooke, P., Gomez Uranga, M., & Etxebarria, G. (1997). Regional innovation systems: Institutional and organisational dimensions. *Research Policy*, *26*(4–5), 475–491. https://doi.org/10.1016/s0048-7333(97)00025-5

Cooper, D. (2017). Concepts of "Applied and Public Sociology": Arguments for a Bigger Theoretical Picture around the Idea of a "University Third Mission." *Journal of Applied Social Science*, *11*(2), 141–158. https://doi.org/10.1177/1936724417722580

Cunha, J., & Benneworth, P. (2020). How to measure the impact of social innovation initiatives? *International Review on Public and Nonprofit Marketing*, *17*(1), 59–75. https://doi.org/10.1007/s12208-019-00240-4

De Vries, H., Bekkers, V., & Tummers, L. (2016). Innovation in the public sector: A systematic review and future research agenda. *Public Administration*, *94*(1), 146–166. https://doi.org/10.1111/padm.12209

Domanski, D., Howaldt, J., & Kaletka, C. (2020). A comprehensive concept of social innovation and its implications for the local context–on the growing importance of social innovation ecosystems and infrastructures. *European Planning Studies*, *28*(3), 454–474. https://doi.org/10.1080/09654313.2019.1639397

Edquist, C. (2005). *Systems of Innovation: Technologies, Institutions and Organizations*. Routledge. https://doi.org/10.4324/9780203357620

Edquist, C., & Hommen, L. (1999). Systems of innovation: Theory and policy for the demand side. *Technology in Society*, *21*(1), 63–79. https://doi.org/10.1016/S0160-791X(98)00037-2

Edwards-Schachter, M., & Wallace, M. L. (2017). "Shaken, but not stirred": Sixty years of defining social innovation. *Technological Forecasting and Social Change*, *119*, 64–79. https://doi.org/10.1016/j.techfore.2017.03.012

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *The Academy of Management Review*, *14*(4), 532. https://doi.org/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. https://doi.org/10.1016/j.techfore.2018.08.020

Engels, F., Wentland, A., & Pfotenhauer, S. (2019). Testing future societies? Developing a framework for test beds and living labs as instruments of innovation governance. *Research Policy*, *103826*, 1–25. https://doi.org/10.1016/j.respol.2019.103826

ENoLL. (2019). About us - European Network of Living Labs. Retrieved August 6, 2019, from https://enoll.org/about-us/

Eriksson, M., Niitamo, V., & Kulkki, S. (2005). State-of-the-art in utilizing Living Labs approach to user-centric ICT innovation - a European approach. *Technology*, *1*(13), 1–13.

Etzkowitz, H. (2003). Innovation in innovation: the Triple Helix of university-industry-government

relations. *Social Science Information*, *42*(3), 293–337. https://doi.org/10.1023/A:1026276308287

Etzkowitz, H. (2004). The evolution of the entrepreneurial university. *International Journal of Technology and Globalisation*, *1*(1), 64–77. https://doi.org/10.1504/IJTG.2004.004551

Etzkowitz, H. (2008). *The Triple Helix: University–Industry–Government Innovation in Action*. New York: Taylor & Francis.

Etzkowitz, H., & Leydesdorff, L. (1995). The Triple Helix --- University-Industry- Government Relations: A Laboratory for Knowledge Based Economic Development. *EASST Review*, *14*(1), 14–19. Retrieved from http://ssrn.com/abstract=2480085

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "Mode 2" to Triple Helix of university-industry-government relations. *Research Policy*, *29*(2), 109–123. https://doi.org/10.22503/inftars.XVII.2017.4.2

Etzkowitz, H., Ranga, M., Benner, M., Guaranys, L., Maculan, A. M., & Kneller, R. (2008). Pathways to the entrepreneurial university: Towards a global convergence. *Science and Public Policy*, *35*(9), 681–695. https://doi.org/10.3152/030234208X389701

Etzkowitz, H., Webster, A., Gebhardt, C., & Terra, B. R. C. (2000). The future of the university and the university of the future: Evolution of ivory tower to entrepreneurial paradigm. *Research Policy*, *29*(2), 313–330. https://doi.org/10.1016/S0048-7333(99)00069-4

European Commission. (2014). *Responsible Research and Innovation: Europe's ability to respond to societal challenges*. https://doi.org/10.2777/95935

European Commission. (2017). Strengthening Innovation in Europe's Regions: Strategies for resilient, inclusive and sustainable growth, 11. Retrieved from https://cohesiondata.ec.europa.eu/themes.

European Commission, International Monetary Fund, OECD, United Nations, & World Bank. (2009). *System of National Accounts 2008*. Retrieved from https://unstats.un.org/unsd/nationalaccount/docs/SNA2008.pdf

Fagerberg, J., & Verspagen, B. (2009). Innovation studies-The emerging structure of a new scientific field. *Research Policy*, *38*, 218–233. https://doi.org/10.1016/j.respol.2008.12.006

Fagiewicz, K., Churski, P., Herodowicz, T., Kaczmarek, P., Lupa, P., Morawska-Jancelewicz, J., & Mizgajski, A. (2021). Cocreation for climate change-needs for actions to vitalize drivers and diminish barriers. *Weather, Climate, and Society*, *13*(3), 555–570. https://doi.org/10.1175/WCAS-D-20-0114.1

Fernandes, C., Farinha, L., Ferreira, J. F., Asheim, B., & Rutten, R. (2020). Regional Innovation Systems: what can we learn from 25 years of scientific achievements? *Regional Studies*. https://doi.org/10.1080/00343404.2020.1782878

Fink, A. (2014). *Conducting Research Literature Reviews* (fourth). SAGE.

Fitjar, R. D., Benneworth, P., & Asheim, B. T. (2019). Towards regional responsible research and innovation? Integrating RRI and RIS3 in European innovation policy. *Science and Public Policy*, *46*(5), 772–783. https://doi.org/10.1093/scipol/scz029

Fitjar, R. D., & Rodríguez-Pose, A. (2020). Where cities fail to triumph: The impact of urban location and local collaboration on innovation in Norway. *Journal of Regional Science*, *60*(1), 5–32. https://doi.org/10.1111/jors.12461

Florida, R., Adler, P., & Mellander, C. (2017). The city as innovation machine. *Regional Studies*,

51(1), 86–96. https://doi.org/10.1080/00343404.2016.1255324

Foray, D. (2020). Six additional replies – one more chorus of the S3 ballad. *European Planning Studies*, *8*(9), 1685–1690. https://doi.org/10.1080/09654313.2020.1797307

Foray, D., Goddard, J., Beldarrain, X. G., Landabaso, M., McCann, P., Morgan, K., … Ortega-Argilés, R. (2012). *Guide to Research and Innovation Strategies for Smart Specialization (RIS3)*. Luxembourg. https://doi.org/10.2776/65746

Foroudi, P., Akarsu, T. N., Marvi, R., & Balakrishnan, J. (2020). Intellectual evolution of social innovation: A bibliometric analysis and avenues for future research trends. *Industrial Marketing Management*. https://doi.org/10.1016/j.indmarman.2020.03.026

Freeman, C. (2002). Continental, national and sub-national innovation systems - Complementarity and economic growth. *Research Policy*, *31*(2), 191–211. https://doi.org/10.1016/S0048-7333(01)00136-6

Galvao, A., Mascarenhas, C., Marques, C., Ferreira, J., & Ratten, V. (2019). Triple helix and its evolution: a systematic literature review. *Journal of Science and Technology Policy Management*, 2053–4620. https://doi.org/10.1108/jstpm-10-2018-0103

García-Terán, J., & Skoglund, A. (2018). A Processual Approach for the Quadruple Helix Model: the Case of a Regional Project in Uppsala. *Journal of the Knowledge Economy*. https://doi.org/10.1007/s13132-018-0521-5

Gascó, M. (2017). Living labs: Implementing open innovation in the public sector. *Government Information Quarterly*, *34*(1), 90–98. https://doi.org/10.1016/j.giq.2016.09.003

Gibbons, M., Limoges, C., Nowotny, H., Schwartzman, S., Scott, P., & Trow, M. (1994). *The new production of knowledge: The dynamics of science and research in contemporary societies*. SAGE.

Göransson, B., Donati, L., & Wigren-Kristoferson, C. (2021). Introduction to the special issue on universities and social innovation. *Technological Forecasting and Social Change*, *173*. https://doi.org/10.1016/j.techfore.2021.121186

Government of Catalonia. (2010). *Research and Innovation Plan (PRI) of Catalonia: 2010-2013*. Barcelona.

Gregersen, B., Linde, L. T., & Rasmussen, J. G. (2009). Linking between Danish universities and society. *Science and Public Policy*, *36*(2), 151–156. https://doi.org/10.3152/030234209X406818

Guerrero, M., Urbano, D., & Fayolle, A. (2016). Entrepreneurial activity and regional competitiveness: evidence from European entrepreneurial universities. *Journal of Technology Transfer*, *41*(1), 105–131. https://doi.org/10.1007/s10961-014-9377-4

Gunasekara, C. (2006). Reframing the role of Universities in the development of regional innovation systems. *Journal of Technology Transfer*, *31*(1), 101–113. https://doi.org/10.1007/s10961-005-5016-4

Hartley, J. (2005). Innovation in governance and public services: Past and present. *Public Money and Management*, *25*(1), 27–34. https://doi.org/10.1111/j.1467-9302.2005.00447.x

Hertting, N., & Kugelberg, C. (2018). Representative Democracy and the Problem of Institutionalizing Local Participatory Governance. In H. Nils & C. Kugelberg (Eds.), *Local Participatory Governance and Representative Democracy* (pp. 1–17). Routledge. https://doi.org/10.4324/9781315471174

Höglund, L., & Linton, G. (2018). Smart specialization in regional innovation systems: a quadruple helix perspective. *R&D Management*, *48*(1), 60–72. https://doi.org/10.1111/radm.12306

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

Howells, J. R. L. (2002). Tacit knowledge, innovation and economic geography. *Urban Studies*, *39*(5–6), 871–884. https://doi.org/10.1080/00420980220128354

Huxham, C., & Vangen, S. (2005). *Managing to Collaborate: The theory and practice of collaborative advantage*. Routledge.

Hyysalo, S., & Hakkarainen, L. (2014). What difference does a living lab make? Comparing two health technology innovation projects. *CoDesign*, *10*(3–4), 191–208. https://doi.org/10.1080/15710882.2014.983936

Indrawati, Dayarani, T., & Amani, H. (2019). Smart security and safety index measurement: A case study in Bandung Indonesia. *Humanities and Social Sciences Reviews*, *7*(5), 141–149. https://doi.org/10.18510/hssr.2019.7518

Isaksen, A., Martin, R., & Trippl, M. (2018). *New avenues for regional innovation systems - theoretical advances, empirical cases and policy lessons*. *New Avenues for Regional Innovation Systems - Theoretical Advances, Empirical Cases and Policy Lessons*. https://doi.org/10.1007/978-3-319-71661-9

Jensen, C., & Trägårdh, B. (2004). Narrating the Triple Helix concept in "weak" regions: Lessons from Sweden. *International Journal of Technology Management*, *27*(5), 513–530. https://doi.org/10.1504/IJTM.2004.004287

Kline, S. J., & Rosenberg, N. (1986). An Overview of Innovation. In R. Landau & N. Rosenberg (Eds.), *The Positive Sum Strategy: Harnessing Technology for Economic Growth* (pp. 275–305). Washington DC: National Academy Press.

Kolehmainen, J., Irvine, J., Stewart, L., Karacsonyi, Z., Szabó, T., Alarinta, J., & Norberg, A. (2016). Quadruple Helix, Innovation and the Knowledge-Based Development: Lessos from Remote, Rural and Less-Favoured Regions. *Journal of the Knowledge Economy*, *7*(1), 23–42. https://doi.org/10.1007/s13132-015-0289-9

Krlev, G., Mildenberger, G., & Anheier, H. K. (2020). Innovation and societal transformation – what changes when the "social" comes in? *International Review of Applied Economics*, *34*(5), 529–540. https://doi.org/10.1080/02692171.2020.1820247

Kronberga, G., Paula, L., & Bite, D. (2010). The University as an Agent of Knowledge Transfer: The Case of the Latvia University of Agriculture. *Problems of Education in the 21st Centrury*, *26*, 79–89.

Kronsell, A., & Mukhtar-Landgren, D. (2018). Experimental governance: the role of municipalities in urban living labs. *European Planning Studies*. https://doi.org/10.1080/09654313.2018.1435631

Lee, S. M., Hwang, T., & Choi, D. (2012). Open innovation in the public sector of leading countries. *Management Decision*, *50*(1), 147–162. https://doi.org/10.1108/00251741211194921

Lew, Y. K., Khan, Z., & Cozzio, S. (2018). Gravitating toward the quadruple helix: international connections for the enhancement of a regional innovation system in Northeast Italy. *R&D Management*, *48*(1), 44–59. https://doi.org/10.1111/radm.12227

Lewis, J. M., Ricard, L. M., & Klijn, E. H. (2018). How innovation drivers, networking and

leadership shape public sector innovation capacity. *International Review of Administrative Sciences*, *84*(2), 288–307. https://doi.org/10.1177/0020852317694085

Leydesdorff, L. (2000). The triple helix: An evolutionary model of innovations. *Research Policy*, *29*(2), 243–255. https://doi.org/10.1016/S0048-7333(99)00063-3

Leydesdorff, L. (2012). The Triple Helix, Quadruple Helix, ..., and an N-Tuple of Helices: Explanatory Models for Analyzing the Knowledge-Based Economy? *Journal of the Knowledge Economy*, *3*(1), 25–35. https://doi.org/10.1007/s13132-011-0049-4

Leydesdorff, L., & Etzkowitz, H. (1996). Emergence of a Triple Helix of university—industry—government relations. *Science and Public Policy*, *23*(5), 279–286. https://doi.org/10.1093/spp/23.5.279

Leydesdorff, L., & Etzkowitz, H. (1998). The Triple Helix as a model for innovation studies. *Science and Public Policy*, *25*(3), 195–203. https://doi.org/10.1016/j.vaccine.2010.03.035

Leydesdorff, L., & Etzkowitz, H. (2003). Can "the public" be considered as a fourth helix in university-industry-government relations? Report on the Fourth Triple Helix Conference 2002. *Science and Public Policy*, *30*(1), 55–61. https://doi.org/10.1007/BF02647154

Leydesdorff, L., & Porto-Gomez, I. (2019). Measuring the expected synergy in Spanish regional and national systems of innovation. *Journal of Technology Transfer*, *44*(1), 189–209. https://doi.org/10.1007/s10961-017-9618-4

Leydesdorff, L., & Strand, Ø. (2013). The Swedish system of innovation: Regional synergies in a knowledge-based economy. *Journal of the American Society for Information Science and Technology*, *64*(9), 1890–1902. https://doi.org/10.1002/asi.22895

Leydesdorff, L., & Zawdie, G. (2010). The triple helix perspective of innovation systems. *Technology Analysis and Strategic Management*, *22*(7), 789–804. https://doi.org/10.1080/09537325.2010.511142

Lindberg, M., Danilda, I., & Torstensson, B. M. (2012). Women Resource Centres-A Creative Knowledge Environment of Quadruple Helix. *Journal of the Knowledge Economy*, *3*(1), 36–52. https://doi.org/10.1007/s13132-011-0053-8

Lindberg, M., Lindgren, M., & Packendorff, J. (2014). Quadruple Helix as a Way to Bridge the Gender Gap in Entrepreneurship: The Case of an Innovation System Project in the Baltic Sea Region. *Journal of the Knowledge Economy*, *5*(1), 94–113. https://doi.org/10.1007/s13132-012-0098-3

Lundvall, B.-Å. (2007). National innovation systems - Analytical concept and development tool. *Industry and Innovation*, *14*(1), 95–119. https://doi.org/10.1080/13662710601130863

Lundvall, B.-Å. (2010). *National Systems of Innovation: Toward a Theory of Innovation and Interactive Learning* (Reprint). London: Anthem Press.

Lundvall, B.-Å., Johnson, B., Andersen, E. S., & Dalum, B. (2002). National systems of production, innovation and competence building. *Research Policy*, *31*(2), 213–231. https://doi.org/10.1016/S0048-7333(01)00137-8

MacGregor, S. P., Marques-Gou, P., & Simon-Villar, A. (2010). Gauging Readiness for the Quadruple Helix: A Study of 16 European Organizations. *Journal of the Knowledge Economy*, *1*(3), 173–190. https://doi.org/10.1007/s13132-010-0012-9

Mackinnon, D., Cumbers, A., & Chapman, K. (2002). Learning, innovation and regional development: A critical appraisal of recent debates. *Progress in Human Geography*, *26*(3), 293–312. https://doi.org/10.1191/0309132502ph371ra

Malerba, F. (2002). Sectoral systems of innovation and production. *Research Policy*, *31*(2), 247–264. https://doi.org/10.1016/S0048-7333(01)00139-1

Malmberg, K., Vaittinen, I., Ståhlbröst, A., Vervoort, K., Schuurman, D., & Evans, P. (2017). *Living Labs Methdology Handbook in IoT context*.

Manrique, S., & Nguyen, H. (2017). *Balancing Regional Engagement and Internationalisation: The Case of Autonomous University of Barcelona* (RUNIN Working Paper Series No. 02/2017).

Marques, C., Marques, A. V., Braga, V., & Ratten, V. (2021). Technological transfer and spillovers within the RIS3 entrepreneurial ecosystems: a quadruple helix approach. *Knowledge Management Research and Practice*, *19*(1), 127–136. https://doi.org/10.1080/14778238.2020.1777909

Marques, P., Morgan, K., & Richardson, R. (2018). Social innovation in question: The theoretical and practical implications of a contested concept. *Environment and Planning C: Politics and Space*, *36*(3), 496–512. https://doi.org/10.1177/2399654417717986

Martin, B. R. (2012). The evolution of science policy and innovation studies. *Research Policy*, *41*(7), 1219–1239. https://doi.org/10.1016/j.respol.2012.03.012

Martin, B. R. (2016). Twenty challenges for innovation studies. *Science and Public Policy*, *43*(3), 432–450. https://doi.org/10.1093/scipol/scv077

Martinelli, A., Meyer, M., & Tunzelmann, N. (2008). Becoming an entrepreneurial university? A case study of knowledge exchange relationships and faculty attitudes in a medium-sized, research-oriented university. *Journal of Technology Transfer*, *33*(3), 259–283. https://doi.org/10.1007/s10961-007-9031-5

McAdam, M., Miller, K., & McAdam, R. (2018). Understanding Quadruple Helix relationships of university technology commercialisation: a micro-level approach. *Studies in Higher Education*, *43*(6), 1058–1073. https://doi.org/10.1080/03075079.2016.1212328

Miller, K., Mcadam, R., Moffett, S., Alexander, A., & Puthusserry, P. (2016). Knowledge transfer in university quadruple helix ecosystems: An absorptive capacity perspective. *R&D Management*, *46*(2), 383–399. https://doi.org/10.1111/radm.12182

Mytelka, L. K., & Smith, K. (2002). Policy learning and innovation theory: An interactive and co-evolving process. *Research Policy*, *31*(8–9), 1467–1479. https://doi.org/10.1016/S0048-7333(02)00076-8

Nguyen, H. T., & Marques, P. (2021). The promise of living labs to the Quadruple Helix stakeholders: exploring the sources of (dis)satisfaction. *European Planning Studies*, 1–20. https://doi.org/10.1080/09654313.2021.1968798

Nordberg, K. (2015). Enabling regional growth in peripheral non-university regions—The impact of a quadruple helix intermediate organisation. *Journal of the Knowledge Economy*, *6*(2), 334–356. https://doi.org/10.1007/s13132-015-0241-z

Nordberg, K., Mariussen, Å., & Virkkala, S. (2020). Community-driven social innovation and quadruple helix coordination in rural development. Case study on LEADER group Aktion Österbotten. *Journal of Rural Studies*, *79*, 157–168. https://doi.org/10.1016/j.jrurstud.2020.08.001

OECD/Eurostat. (2005). *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*. *The Measurement of Scientific and Technological Activities* (Third). https://doi.org/10.1787/9789264013100-en

OECD/Eurostat. (2018). *Oslo Manual 2018: Guidelines for Collecting, Reporting and Using Data*

on Innovation. *The Measurement of Scientific, Technological and Innovation Activities* (Fourth). https://doi.org/10.1787/9789264304604-en

Oliver, R. L. (1980). A Cognitive Model of the Antecedents and Consequences of Satisfaction Decisions. *Journal of Marketing Research*, *17*(4), 460–469.

Osborne, S. P. (Ed.). (2010). *The New Public Governance? Emerging Perspectives on the Theory and Practice of Public Governance* (1st ed.). Abingdon: Routledge. https://doi.org/10.4324/9780203861684

Ott, C., & Kiteme, B. (2016). Concepts and practices for the democratisation of knowledge generation in research partnerships for sustainable development. *Evidence and Policy*, *12*(3), 405–430. https://doi.org/10.1332/174426416X14700793045951

Paredes-Frigolett, H. (2016). Modeling the effect of responsible research and innovation in quadruple helix innovation systems. *Technological Forecasting and Social Change*, *110*, 126–133. https://doi.org/10.1016/j.techfore.2015.11.001

Paskaleva, K., Evans, J., & Watson, K. (2021). Co-producing smart cities: A Quadruple Helix approach to assessment. *European Urban and Regional Studies*. https://doi.org/10.1177/09697764211016037

Petrovsky, N., Mok, J. Y., & León-Cázares, F. (2017). Citizen Expectations and Satisfaction in a Young Democracy: A Test of the Expectancy-Disconfirmation Model. *Public Administration Review*, *77*(3), 395–407. https://doi.org/10.1111/puar.12623

Petticrew, M., & Roberts, H. (2006). *Systematic Reviews in the Social Sciences: A Practical Guide*. Blackwell Publishing.

Pirlone, F., & Spadaro, I. (2020). The resilient city and adapting to the health emergency. Towards sustainable university mobility. *TeMA - Journal of Land Use, Mobility and Environment*.

Popa, E. O., Blok, V., & Wesselink, R. (2020). A processual approach to friction in quadruple helix collaborations. *Science and Public Policy*. https://doi.org/10.1093/scipol/scaa054

Porto-Gomez, I., Zabala-Iturriagagoitia, J. M., & Leydesdorff, L. (2019). Innovation systems in México: A matter of missing synergies. *Technological Forecasting and Social Change*, *148*. https://doi.org/10.1016/j.techfore.2019.119721

Porto, J. B., & Oliveira, M. (2020). The smart cities methodology based on public value: The first evaluation cycle. *BAR - Brazilian Administration Review*, *17*(1). https://doi.org/10.1590/1807-7692bar2020190048

Prónay, S., & Buzás, N. (2015). The Evolution of Marketing Influence in the Innovation Process: Toward a New Science-to-Business Marketing Model in Quadruple Helix. *Journal of the Knowledge Economy*, *6*(3), 494–504. https://doi.org/10.1007/s13132-015-0248-5

Puerari, E., De Koning, J. I. J. C., Von Wirth, T., Karré, P. M., Mulder, I. J., & Loorbach, D. A. (2018). Co-creation dynamics in Urban Living Labs. *Sustainability*, *10*(6). https://doi.org/10.3390/su10061893

Pugh, R. (2017). Universities and economic development in lagging regions: 'triple helix' policy in Wales. *Regional Studies*, *51*(7), 982–993. https://doi.org/10.1080/00343404.2016.1171306

Ranga, M., & Etzkowitz, H. (2013). Triple Helix Systems: An Analytical Framework for Innovation Policy and Practice in the Knowledge Society. *Industry and Higher Education*, *27*(4), 237–262. https://doi.org/10.5367/ihe.2013.0165

Romero, T. (2022). Gross domestic product in Catalonia and Spain 2003-2021. Retrieved from

https://www.statista.com/statistics/327063/gross-domestic-product-in-catalonia-and-spain/

Saunders, M., Lewis, P., & Thornhill, A. (2016). *Research Methods for Business Students* (7th ed.). Essex: Pearson.

Scholl, C., & Kemp, R. (2016). City labs as vehicles for innovation in urban planning processes. *Urban Planning*, *1*(4), 89–102. https://doi.org/10.17645/up.v1i4.749

Schoonmaker, M. G., & Carayannis, E. G. (2013). Mode 3: A Proposed Classification Scheme for the Knowledge Economy and Society. *Journal of the Knowledge Economy*, *4*(4), 556–577. https://doi.org/10.1007/s13132-012-0097-4

Schumpeter, J. A. (1983). *The Theory of Economic Development*. *Translated from German by Redvers Opie* (Reprint). Transaction Publishers.

Schütz, F., Heidingsfelder, M. L., & Schraudner, M. (2019). Co-shaping the Future in Quadruple Helix Innovation Systems: Uncovering Public Preferences toward Participatory Research and Innovation. *She Ji*, *5*(2), 128–146. https://doi.org/10.1016/j.sheji.2019.04.002

Shane, S., & Venkataraman, S. (2000). The Promise of Entrepreneurship as a Field of Research. *The Academy of Management Review*, *25*(1), 217–226.

Siebers, V., & Torfing, J. (2018). Co-creation as a new form of citizen engagement: Comparing Danish and Dutch experiences at the local government level. *International Public Management Review*, *18*(2), 187–208. Retrieved from www.ipmr.net

Simon, A., & Marques, P. (2021). University-industry collaboration for sustainable development: The case of innovation intermediaries. *International Journal of Intellectual Property Management*, *11*(4), 459–485. https://doi.org/10.1504/IJIPM.2021.118712

Skarzauskiene, A., & Mačiulienė, M. (2021). Citizen science addressing challenges of sustainability. *Sustainability*, *13*(24), 1–11. https://doi.org/10.3390/su132413980

Skelcher, C., & Torfing, J. (2010). Improving democratic governance through institutional design: Civic participation and democratic ownership in Europe. *Regulation and Governance*, *4*(1), 71–91. https://doi.org/10.1111/j.1748-5991.2010.01072.x

Smith, H. L., & Bagchi-Sen, S. (2010). Triple helix and regional development: A perspective from Oxfordshire in the UK. *Technology Analysis and Strategic Management*, *22*(7), 805–818. https://doi.org/10.1080/09537325.2010.511143

Sønderskov, M. (2020). Councillors' attitude to citizen participation in policymaking as a driver of, and barrier to, democratic innovation. *Innovation Journal*, *25*(3), 1–20.

Statistics Denmark. (n.d.). Population figures. Retrieved from https://www.dst.dk/en/Statistik/emner/borgere/befolkning/befolkningstal

Strokosch, K., & Osborne, S. P. (2020). Debate: If citizen participation is so important, why has it not been achieved? *Public Money and Management*, *40*(1), 8–10. https://doi.org/10.1080/09540962.2019.1654322

Thøgersen, D., Waldorff, S. B., & Steffensen, T. (2020). Public Value through Innovation: Danish public managers' views on barriers and boosters. *International Journal of Public Administration*. https://doi.org/10.1080/01900692.2020.1750030

Tidd, J., Bessant, J., & Pavitt, K. (2005). *Managing Innovation: Integrating Technological, Market and Organizational Change* (Third). John Wiley & Sons, Ltd. https://doi.org/10.1086/421629

Tödtling, F., & Trippl, M. (2005). One size fits all?: Towards a differentiated regional innovation policy approach. *Research Policy*, *34*(8), 1203–1219.

https://doi.org/10.1016/j.respol.2005.01.018

Tödtling, F., & Trippl, M. (2018). Regional innovation policies for new path development–beyond neo-liberal and traditional systemic views. *European Planning Studies*, *26*(9), 1779–1795. https://doi.org/10.1080/09654313.2018.1457140

Torfing, J., & Ansell, C. (2017). Strengthening political leadership and policy innovation through the expansion of collaborative forms of governance. *Public Management Review*, *19*(1), 37–54. https://doi.org/10.1080/14719037.2016.1200662

Trousset, S. (2014). Current trends in science and technology policy research: An examination of published works from 2010-2012. *Policy Studies Journal*, *42*(S1), 87–117. https://doi.org/10.1111/psj.12053

Vallance, P. (2017). The co-evolution of regional innovation domains and institutional arrangements: Smart specialisation through quadruple helix relations? In P. McCann, F. van Oort, & J. Goddard (Eds.), *The Empirical and Institutional Dimensions of Smart Specialisation* (pp. 127–144). Routledge. https://doi.org/10.4324/9781315526218

Vallance, P., Tewdwr-Jones, M., & Kempton, L. (2020). Building collaborative platforms for urban innovation: Newcastle City Futures as a quadruple helix intermediary. *European Urban and Regional Studies*, 1–17. https://doi.org/10.1177/0969776420905630

Van Ryzin, G. G. (2004). Expectations, performance, and citizen satisfaction with urban services. *Journal of Policy Analysis and Management*, *23*(3), 433–448. https://doi.org/10.1002/pam.20020

Vickers, I., Lyon, F., Sepulveda, L., & McMullin, C. (2017). Public service innovation and multiple institutional logics: The case of hybrid social enterprise providers of health and wellbeing. *Research Policy*, *46*(10), 1755–1768. https://doi.org/10.1016/j.respol.2017.08.003

Vilkė, R., Gedminaitė-Raudonė, Ž., & Vidickienė, D. (2020). Collaboration for the socially responsible development of rural regions: biogas production in Lithuanian farms. *Social Responsibility Journal*, *16*(6), 877–898. https://doi.org/10.1108/SRJ-07-2019-0235

Vogel, R., Hattke, F., & Petersen, J. (2017). Journal rankings in management and business studies: What rules do we play by? *Research Policy*, *46*(10), 1707–1722. https://doi.org/10.1016/j.respol.2017.07.001

von Hippel, E. (1988). *The sources of innovation*. Oxford University Press. https://doi.org/10.1016/0169-2070(89)90046-0

Von Hippel, E. (2005). *Democratizing Innovation*. Massachusetts: MIT Press.

Von Wirth, T., Fuenfschilling, L., Frantzeskaki, N., & Coenen, L. (2019). Impacts of urban living labs on sustainability transitions: mechanisms and strategies for systemic change through experimentation. *European Planning Studies*, *27*(2), 229–257. https://doi.org/10.1080/09654313.2018.1504895

Waardenburg, M., Groenleer, M., de Jong, J., & Keijser, B. (2020). Paradoxes of collaborative governance: investigating the real-life dynamics of multi-agency collaborations using a quasi-experimental action-research approach. *Public Management Review*, *22*(3), 386–407. https://doi.org/10.1080/14719037.2019.1599056

Yang, Y., Holgaard, J. E., & Remmen, A. (2012). What can triple helix frameworks offer to the analysis of eco-innovation dynamics? Theoretical and methodological considerations. *Science and Public Policy*, *39*(3), 373–385. https://doi.org/10.1093/scipol/scs025

Yin, R. K. (2003). *Case Study Research. Design and Methods* (Third). SAGE Publications.

II. Papers

Paper 1. Nguyen, H. T., Marques, P., & Benneworth, P. Living Labs: Challenging and Changing the Smart City Power Relations? *Under peer-review process. Revised and resubmitted.*

Paper 2. Nguyen, H. T., & Marques, P. (2021). The Promise of Living Labs to the Quadruple Helix Stakeholders: Exploring the Sources of (Dis)satisfaction. *European Planning Studies*, https://doi.org/10.1080/09654313.2021.1968798

Paper 3. Nguyen, H.T. Collaborative Public Sector Innovation as a Quadruple Helix Model? Insights from Denmark. *Working paper. Prepared to submit.*

Paper 1. Living Labs: Challenging and Changing the Smart City Power Relations?

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Abstract

Smart cities refer to place-specific collaborative systems where multiple actors collaborate to collectively address public problems. However, smart city initiatives regularly frame citizens as the weakest link, as passive consumers rather than active creative agents. This article argues that power imbalances between citizens and other organisational participants structurally mute citizens' voices, ultimately compromising smart cities' aims. Living laboratories are a popular smart city intervention that have the potential to address this power imbalance and empower citizens to influence smart city development. This research theoretically and empirically explores this role of living labs through a multiple-case study of urban living labs in the region of Catalonia. The findings uncover a 'power banking' mechanism which, coupled with other critical factors, facilitates the effectiveness of such initiatives. The considerable efforts required to engage citizens at a fairly basic level suggest that incorporating citizens into smart city models is more challenging than simplistic Quadruple Helix discourses convey.

Keywords: citizen inclusion; living labs; organising collaborative systems; power relations; smart cities

This paper is under peer-review process.

1 Introduction

Cities face increasingly complex sustainability issues, such as social inequality and environmental pollution, and 'smart city' notion have emerged as a promising solution to these challenges (Albino et al., 2015; Kummitha & Crutzen, 2017). Smart city development is a rapidly growing interdisciplinary area of research conducted across various contexts, a situation which has led to the absence of a singular definition (Mora et al., 2017; Ricciardi & Za, 2015), although the term was first used in the 1990s (Mahizhnan, 1999). Meijer and Bolívar (2016, p. 398) propose that a city is smart when it is able 'to attract human capital and to mobilize this human capital in collaborations between the various (organized and individual) actors through the use of information and communication technologies' (ICT). Combinations of three aspects are emphasised, including technology (smart technology), governance (smart collaboration) and human resources (smart people).

The concept of a smart city emerged as a primarily technological discourse about the opportunity for ICT to improve quality of life through innovative urban infrastructures (Borkowska & Osborne, 2018). This approach grew encompass the idea of governments and knowledge institutions co-operating with businesses, in what is known as the Triple Helix innovation model, to solve diverse urban challenges (Dameri, 2017; Leydesdorff & Deakin, 2011). However, the actors in these collaborations tended to prioritise deploying technologies above aligning those technologies with citizens' needs (Hollands, 2008; Kummitha, 2018). Critics have therefore called for a human-centred vision of smart cities, one that involves citizens in the development process (Andreani et al., 2019; Vanolo, 2016).

Living labs (LLs), a recently popular urban policy instrument in Europe, aim to stimulate an inclusive and collaborative ecosystem in shaping smart cities (Bifulco et al., 2017; Santonen et al., 2017). LLs facilitate multiple stakeholder collaborations and are user-centred in their efforts to co-create innovation in real-life contexts (Eriksson et al., 2005; Leminen et al., 2012). The rise of several LLs comprising local (place-based) and social (citizen-driven) dimensions (Neirotti et al., 2014; Scholl & Kemp, 2016) could be regarded as a new urban phenomenon that favours citizen inclusion.

However, despite the perceived importance of citizen inclusion, power imbalances between individual citizens and organisational interests remain fundamental concerns of LL practice (Engels et al., 2019) and undermine collaboration outcomes (Kähkönen, 2014). Scholars have thus cited the need to explore the mechanisms that LLs have in place to address concerns about inclusion and power and fulfil their goals in urban contexts (Hossain et al., 2019; Kronsell & Mukhtar-Landgren, 2018). Accordingly, this paper explores whether and how LLs include citizens in ways that change power relations with other organisational participants in smart city collaborative systems. This theoretical and empirical enquiry starts by seeking to understand how citizen power is sourced and acknowledged, the practices that LLs implement to include citizens and the impact of those practices on power relations.

Understanding power relations is critical to successfully organising inclusive and collaborative ecosystems in urban contexts. According to Clegg et al. (2006, p. 1), 'Power is the most central concept in the analysis of organization(s) and organizing', as power relations among different stakeholders, including citizens, shape and reshape participant capabilities and decisions, and vice versa. However, while power has been largely explored inside organisations (Barley, 2010), it has been relatively neglected in the field of organising collaborative systems.

The research question is explored through a multiple-case study of seven LLs in Catalonia which sought citizen participation and knowledge input in smart city processes. The findings provide insight into the citizen participation process within LLs and analyse the perceived shift in power relations between citizens and other stakeholders. Based on the evidence, the discussion and conclusions suggest a mechanism for organising a more inclusive and collaborative ecosystem for smart city development purposes.

2 Theoretical Background

2.1 Power as a contested concept

Scholars are paying increasing attention to the concept of 'power' and the role it plays in the organisation of society (Anderson & Brion, 2014; Clegg, 2010). The definition of power is manifold and constantly contested, as it embodies 'a cluster of concepts' (Avelino, 2021;

Clegg & Haugaard, 2009, p. 3). Among those contestations is a classic debate over whether power is possessed (i.e. '*power to* do or accomplish something') or exercised (i.e. '*power over* another or others') (Pitkin, 1972, p. 277). Accordingly, power can be broadly conceived as the capacity of actors to mobilise means or to influence others' behaviours to achieve a specific purpose (Avelino, 2021; Turner, 2005).

Actors possess three main sources of power (Hardy & Phillips, 1998; Purdy, 2012; Ran & Qi, 2018): (i) *formal authority*, which is the acknowledged legitimate right to make decisions and is usually embedded within a given institutional context; (ii) *critical resource control*, which is participating actors' access to necessary tangible and intangible resources; and (iii) *discursive legitimacy*, which is the ability to influence social constructions by invoking values and societal norms while discussing certain topics, such as the environment or democracy. Classical theories of power from the 1950s relied heavily on resource dependency – control over necessary resources such as funds, technologies and knowledge – to explain actors' power positions (Turner, 2005).

The fact that power is relational has long been acknowledged, emphasising the dimension of exercised power (Foucault, 1982) over the mere possession of power. The contemporary literature on power tends to combine these two perspectives, proposing that the power positions of actors are dependent not only on power sources but also the relations and perceptions of others (Kähkönen, 2014; Purdy, 2012). Overall, within collaborative settings, shifting power relations is 'not just a matter of asking who has *more or less* power, but also about analysing the different types of power they exercise and how subsequent inter-dependencies change over time' (Avelino & Wittmayer, 2016, p. 644).

Power relations and positions affect collaboration outcomes, both positively and negatively (Clegg et al., 2006). On the one hand, balanced power produces deeper collaboration in which partners have equal possibilities to contribute (Kähkönen, 2014). On the other hand, power balance poses a risk of 'stalemate and inaction' (Gray, 1985, p. 927) in a 'shared-power' but 'no-one-in-charge' world (Bryson & Crosby, 2005, p. 1). However, it is commonly acknowledged that strong power imbalances limit the collaboration quality; the presence of dominant participants undermines other actors' trust, interest and commitment, preventing the inclusive involvement of new partners and, in later stages,

intensive collaboration (Kähkönen, 2014; Ran & Qi, 2018). Furthermore, a substantial power imbalance drives compliance behaviours when weaker actors face stronger actors that are capable of manipulating collective processes for private benefit (Ansell & Gash, 2008; Hardy & Phillips, 1998).

A delicate balance of power is achieved when no party has considerable domination and when underrepresented or less powerful actors have a sufficient voice in the system (Gray, 1985; Hardy & Phillips, 1998; Kähkönen, 2014; Menny et al., 2018; Purdy, 2012). In such cases, actors can shape the direction of the network and improve outcomes by influencing the decision-making process (Bickerstaff & Walker, 2005; Ribeiro et al., 2018). Empowering others by motivating them to participate in decisions increases the joint capacity for effective action (Purdy, 2012). That said, addressing imbalances requires the application of appropriate mechanisms; it does not happen spontaneously in collaborative arrangements (Huxham & Vangen, 2005).

2.2 Citizen inclusion in smart cities: A tale of power imbalance

Any kind of multi-actor collaboration is complex and achieving an ideal synergy of dissimilar logics (public vs. private vs. civic) is difficult (Jensen & Trägårdh, 2004). While considering the balance of different logics and purposes, collaboration theories tend to assume – implicitly, if not explicitly – that all actors have similar power positions (Hardy & Phillips, 1998; Lin et al., 2018). Including citizens in urban collaboration is not easy because, unlike other urban actors, citizens are diffuse and weakly coordinated. Citizens lack resources and the collective power to deploy resources effectively (Huxham & Vangen, 2005; Rodrigues & Teles, 2017).

Smart city collaborative ecosystems can be conceptualised as a set of arrangements among Quadruple Helix actors, each of which has different sources of power (Figure 1). In these collaborations, *governments* possess the strongest formal authority. They provide regulatory support for the collaboration (Etzkowitz, 2008), and they can offer or withhold critical resources, such as funding (Miller et al., 2016). Governments generally, and politicians in particular, rely on discursive legitimacy, so long as they are elected representatives of their citizens. However, doubts have been raised about the representative democracy model and

its capacity to truly identify and fulfil citizen demands (Sønderskov, 2020), suggesting that governments' discursive legitimacy is weak. The power of *industry* relies on the resource advantages provided by staff and technologies, which are used to produce products and services (Yang & Holgaard, 2012). While industry lacks formal authority, it has economic authority by creating economic value in society and determining citizens' economic welfare. Industry may have less legitimacy in this context than public sector actors; however, innovation imperatives have acquired a strong economic aspect in recent years (Fitjar et al., 2019). *Knowledge institutions'* main sources of power lie in critical resources, such as human capital and research expertise (Etzkowitz, 2008).

Lastly, participant *citizens* can exert power through their discursive legitimacy: citizens mobilised under civil society organisations (CSOs) are empowered to speak on behalf of society, and general citizens are affected by changes in social prosperity and environmental sustainability (Purdy, 2012). One could also argue that citizens represent a source of user know-how which could have value, especially for industry and public service providers (Von Hippel, 2005). However, there is asymmetry in this relationship; users provide their knowledge to innovators, who use that knowledge to develop better products that benefit citizens. If citizens withhold their knowledge to create leverage, then they suffer by receiving less useful solutions to their problems.

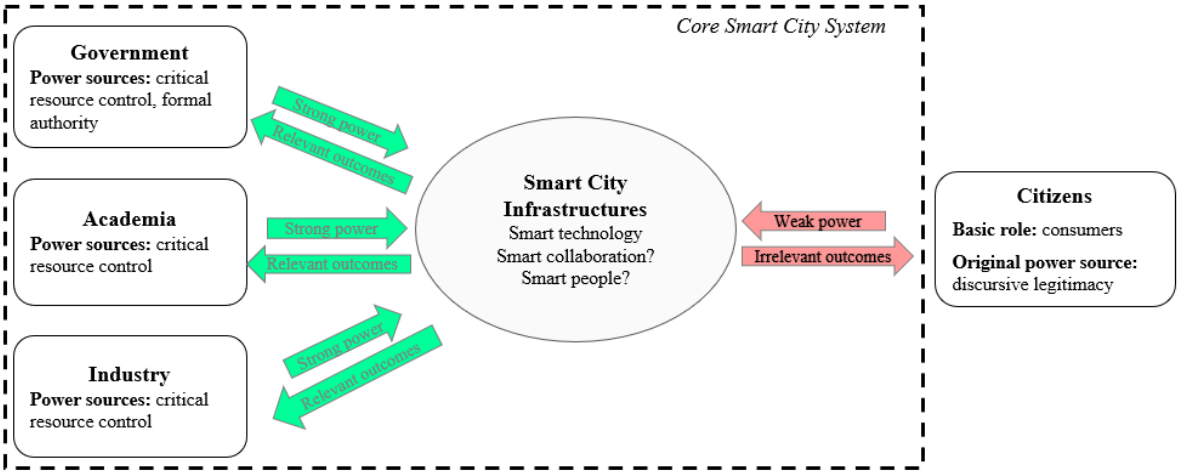

Figure 1. Citizen power positions in smart city systems.

From a capacity-based perspective of power, citizen power positions may be eroded because citizens do not often possess 'the political power and authority of government and academia, and the economic power of industry' (Borkowska & Osborne, 2018, p. 363). Similarly, from a relation-based approach, citizen roles may be undermined because they are loosely related to the Triple Helix participants and, therefore, lack opportunities to exercise power. In urban collaborative ecosystems, the strong co-dependencies and ties among the Triple Helix participants tend to have a technological focus (Mora et al., 2019), and these partnerships are resistant to new partners (Grundel & Dahlström, 2016; MacGregor et al., 2010).

The strong power imbalance is a hindrance to effective citizen inclusion in solving urban problems. Citizen exclusion may jeopardise the governments' capacity to represent its citizens in decision-making and instead encourage the promotion of its immediate partners in the business and university sectors. In this scenario, smart cities are failing to ensure that the voices of different citizen groups are heard, which reduces smart cities' capacity to better align services, infrastructure and management with what citizens want and need. Instead, smart cities' services, infrastructure and management are aligned with what technology corporations and knowledge institutions desire, engaging only citizens who are keen to embrace these high-tech niches (Andreani et al., 2019; Engelbert et al., 2019).

Overall, the issue of citizen inclusion is often oversimplified in the extant literature. First, scholars and planners who call for citizen inclusion – for example, through the Quadruple Helix model – rarely consider who citizens really are and 'which […] opposing interests people in cities may have' (Engelbert et al., 2019, p. 347). Second, typical roles assigned to citizens, such as consumers, implicitly reflect power imbalances by imposing the dominance of market logic and tending to diminish the power and agency of actors who could concurrently be voters and activists (Avelino & Wittmayer, 2016).

2.3 Living labs as orchestrators of power relations

LLs are characterised by three main features: the involvement of users as early as possible in the innovation process; the use of co-creation processes with multiple actors; and attempts to simulate real-life problem contexts (Almirall & Wareham, 2011; Dell'Era & Landoni, 2014). In this way, LLs can be considered orchestrators (Reypens et al., 2019) that may facilitate a

shift in power relations between citizens and other participants in collaborative ecosystems involving Quadruple Helix actors (Miller et al., 2016).

LLs seek to put users at the centre of their activities – as key sources of knowledge creation and innovation – and allow that knowledge to be influential from the outset (Bergvall-Kåreborn & Ståhlbröst, 2009; Eriksson et al., 2005; Leminen et al., 2015). Although citizens, as users, may play both passive and active roles in LLs, some authors have emphasised the particular advantages of the latter case where citizens act as not only consumer agents but also creative agents (Leminen et al., 2015). LLs typically facilitate intensive interaction between 'innovators' and 'users' in ways that allow users to co-determine and shape innovation processes (Feurstein et al., 2008). Finally, LLs organise these activities in environments that are familiar to users, such as care homes (Kanstrup, 2017), or attempt to create or replicate specific contexts within which problems arise to facilitate the development of solutions that account for the complexity of real-world environments.

Taken together, these features mean that LLs could conceivably serve as not only co-creative environments that foster collaborations that advance social change but also power-exercising arenas where dominant actors potentially impose their logics (Arnkil et al., 2010; Puerari et al., 2018). Understanding how LLs facilitate citizen inclusion in ways that challenge and change power relations between participants is therefore critical but underexplored (Hossain et al., 2019; Kronsell & Mukhtar-Landgren, 2018). This article investigates this overarching question by testing whether the theoretical possibilities associated with LLs are deployed in practice. Following the concept of power as something that is possessed and exercised (Pitkin, 1972), this empirical analysis of LL practices explores first the power acknowledged to citizens and other stakeholders and second how this power is exercised, as well as how it mobilises means and influences others' behaviours to achieve a purpose (Avelino, 2021; Turner, 2005). Finally, the article explores the impact of LL activities in changing power relations.

3 Research Method and Context

We adopted an exploratory multiple-case study approach to investigate this research area (Yin, 2003). Research based on cases enables the generation of deep context-dependent

knowledge (Flyvbjerg, 2006), which is especially valuable for understanding multiple-actor interactions (Ott & Kiteme, 2016) and therefore applicable to smart city research (Bibri & Krogstie, 2017). As LL activities typically operate with a local and regional scope (Mulvenna & Martin, 2013), studying several LLs in the same region allowed us to observe the diverse nature of stakeholder engagement, which is shaped by common regional factors. Cases were included when they seemed likely to cover specific processes, such as the potential power relations between citizens and other Quadruple Helix players in smart city contexts. The selected cases included LLs that aimed to (i) include citizens through active roles in working processes, (ii) work with other Quadruple Helix actors, and (iii) address different urban challenges, irrespective of its working area.

We selected Catalonia, a region located in northeast Spain, to study smart cities, citizen inclusion and LLs. First, the region is known for its smart city focus. Barcelona, the region's capital, has long been recognised as a model city for global urbanism (Charnock et al., 2019) and was ranked the second smart city in the world especially in energy and sustainability policies (Juniper Research, 2016). In 2014, the regional government officially approved the SmartCatalonia strategy (SmartCat), seeking to elevate the smart city concept to a regional level and to innovate public services, among other purposes (Government of Catalonia, 2014). Second, the idea of citizen inclusion was explicitly emphasised in SmartCat, as part of a regional effort to promote a 'more inclusive society'. The focus aligned with and was likely reinforced by the European Commission's Horizon 2020 programme. It also took advantage of the existing regional innovation system in which citizens were already acknowledged as actors. In Barcelona particularly, the transition towards a citizen-focused smart city strategy was seen as a result of a political change in the municipality in 2015 (Charnock et al., 2019). Third, Catalonia possessed a large number of LLs and embedded the LL approach within its regional smart city and innovation strategy (Government of Catalonia, 2017). Catalonia is home to several of Spain's and Europe's first LLs as well as one-third of all Spanish LLs within the European Network of Living Labs (ENoLL). In 2017, the CatLabs programme was created under the dual direction of SmartCat and the regional innovation strategy (RIS3CAT). It sought to promote a regional network of existing LLs and other organisations that worked towards (digital) social innovation and smart city initiatives

(Government of Catalonia, 2017). Overall, the scale and characteristics of LL activity in Catalonia promised a high rate of eligible cases.

Based on these criteria, seven LLs located in Catalonia's urban areas were selected as cases (Figure 2). All the selected LLs explicitly expressed their commitment to engaging citizens and other actors in activities related to several urban sectors such as culture, ICT, and health and mobility. This commitment was articulated through their participation in either the ENoLL (six cases) or the regional CatLabs programme (six cases); five of the seven cases were part of both networks. ENoLL, a European movement established in 2006, accredits LL members via a two-round expert evaluation of the extent to which LLs empower citizens and users to participate in the innovation process (ENoLL, 2019; Mastelic et al., 2015). The CatLabs programme prioritises the involvement of LLs as organisations that work under a new open and collaborative structure of innovation and smart cities, such as the Quadruple Helix model (Government of Catalonia, 2017).

Although the selected LLs were participants of ENoLL and CatLabs, they maintained their autonomy and idiosyncrasies because their participation in these networks was voluntary. At the same time, regional policies and strategies neither established strong directions for LLs nor ensured funding for all of them. The studied LLs' working structures and outcomes were hence bound to the main organisations and various funders they collaborated with. The main lead organisations included municipalities and knowledge institutes (i.e. universities and research centres), while a typical funder was the European Commission, funding different schemes under fixed- and short-term projects, including pilot programmes.

Appendix 1 provides details about the year each LL was established, the sector or purpose of its activity, and other information about the main participating stakeholders.

Figure 2. Map of the studied Catalan Living Labs. Source: authors' design based on OpenStreetMap.

3.1 Data collection and sources

Both primary and secondary data were collected (Appendix 2). At the end of 2017, a list of Spanish members was extracted from the ENoLL webpage, and seven LLs were located in Catalonia's urban areas. We contacted these LLs and scheduled interviews with persons who understood and facilitated LL stakeholder engagement. All the LLs responded positively to participating in the research, although one LL described themselves as 'inactive' and was subsequently excluded from the research. During the data collection, an additional LL that actively participated in the CatLabs programme was added, leading to the total inclusion of seven LLs in this study.

The primary data for the analysis included 29 semi-structured interviews with 36 respondents, referred to as R1 to R36, as well as follow-up emails in some cases. The first round involved interviews with the LL management team and coordinators, defined as people explicitly dedicated (although not always full-time) to promoting LL activity. A snowball technique was employed to identify key Catalan LL stakeholders that represented all Quadruple Helix actors. Some stakeholders were familiar with and were connected to more than one of the research sites. Each interview lasted an average of 70 minutes. Although regional LLs are a small community, the respondents were diverse. They included key Quadruple Helix actors and provided sufficient information to address our research question.

In addition, for research purposes, one author was invited to observe and participate in several LL activities by interviewees who were organisers or active participants in these activities. Site visits were used for triangulation. Secondary sources included the LLs' webpages and annual reports as well as other documents provided and recommended by interviewees.

3.2 Data analysis

All interviews were recorded and transcribed except for two cases where interviewees preferred that only notes were taken. Thematic analysis (Braun & Clarke, 2006) was conducted with an abductive coding strategy (Ashworth et al., 2019; Linneberg & Korsgaard, 2019) using NVivo (12) software. While we embrace the inductive principle of building theory with a qualitative methodology (Bryman & Bell, 2011), we agree with Snape and Spencer (2003), who claim that this methodology involves both induction and deduction in which the data generation and interpretation are partially based on current theory. We adapted the thematic analysis in three steps: (i) categorising interviewees' narratives into codes; (ii) assigning these codes to subthemes; and (iii) ultimately assigning these codes to broader themes that potentially address the research questions.

To fill research gaps, we explored how LLs included citizens in ways that changed power relations between citizens and other organisational participants. First, we identified the citizens' initial power sources by tracing back the reasons that LLs engaged with the citizens. Next, we deductively analysed LL operations based on the theoretical framework, considering how three characteristics of LLs might affect the power sources of citizens and their relationships with other stakeholders. During the process of assigning codes into themes, some interviewee narratives clearly conveyed the steps that LLs took, and we used these as guidelines for our analysis. The codes were accordingly re-organised into a common process shared by the seven cases. A final stage involved examining the impact of LLs on power relations, particularly citizens' perceptions of empowerment and other stakeholders' perspective on citizen input.

4 The Case of the Catalan Living Labs

One common characteristic of the studied Catalan LLs is that they were launched by either governments or knowledge institutions initially dedicated to providing and mobilising operational resources, such as human capital and finance. Among other Quadruple Helix actors, the business sector was occasionally involved but lacked formal and critical contributions to LL activities. Citizens participating in the studied LLs were 'not a mass' but 'different collectives' (R4, management), which will be further explained. The flow of empirical data is depicted in Figure 3.

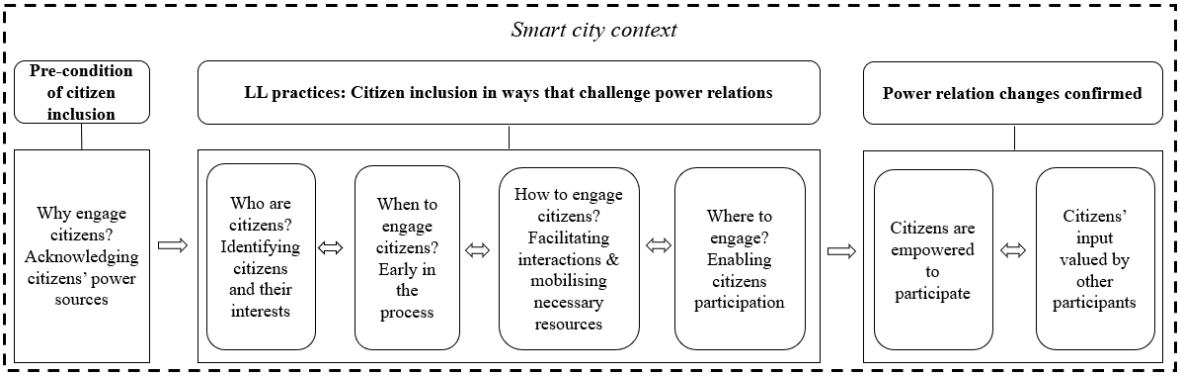

Figure 3. A process for challenging and changing smart city power relations.

4.1 Why engage citizens? Acknowledging citizens' power sources

In the interviews, the urge to include citizens in efforts to effectively respond to urban challenges was emphasised explicitly: 'The transition to a more inclusive approach to the notion of the smart city is not a luxury, but a pressing necessity' (R1, management). Two main power sources of citizens were identified. First, citizens had strong discursive legitimacy, justified by their rights, as made clear in three cases (BCNLab, Citilab, i2Cat):

> You include citizens, not because they are going to buy the innovation, but because they have the right to innovate; because they have the right to be involved in the innovation that will impact society. (R9, management)

> Citizens have access to this public technology, and they are participants; they can innovate without permission. This is permission-less innovation. (R8, management)

This approach also aimed to encourage and provide opportunities for everyone to innovate, pursuing increased social equality, especially because ‘a growing number of citizens who feel left behind by the digital revolution are becoming disaffected’ (R1, management). The same interviewee clarified as follows:

> The benefits of the productivity increases brought by new digital products and services are not shared equally. […] Because of these asymmetries, we are witnessing some reactions against digital technology, a kind of neo-Luddism which is often directed to applications such as Uber or Airbnb.

Furthermore, citizens were believed to possess critical resources or capabilities in all the case studies. Their most valued resource was their co-creation capabilities, especially enhanced in the Internet era, following a ‘digital social innovation’ notion whereby ‘innovators, users and communities collaborate using digital technologies to co-create knowledge and solutions for a wide range of social needs, and at a scale and speed that was unimaginable before the rise of the Internet’ (R1, management). Finally, most interviewees perceived the importance of engaging with citizens in delivering meaningful impacts specifically through their activities and generally in developing the region. Citizens’ know-how as users was also a crucial capability for developing products that were ‘useful for health’ (R5, management) and to conduct research in a ‘responsible manner’ (R15, management). Additionally, citizens were residents and potential users whose behaviour changes could boost a ‘healthy city’ (R7, academic) and develop more ‘sustainable mobility’ (R13, management). This agency or capacity demonstrates that citizens possess the critical ability to advance urban change, since they are likely to be the most impactful type of actors.

These perceptions align with several community-based normative and policy concepts of European and regional research and innovation programmes mentioned by interviewees, including ‘responsible research and innovation’, ‘open science’, ‘open innovation 2.0’, ‘citizen science’ and ‘Quadruple Helix’. These perceptions were also derived from the needs of some stakeholders, particularly governments and knowledge institutions, to address social changes arising from digital transformation or to meet institutional missions. A public authority indicated that ‘digitalisation changes the ways of our learning, teaching, working, and manufacturing’ (R17, government). Today, for example, few citizens use conventional

public services (e.g. libraries, museums) because ‘young people don’t need to go to libraries to find books, they can search for information on Internet’ (R17, government). In turn, knowledge institutions wished to ‘bring laboratories out of the research centre’ (R11, management) and ‘make an impact with university research in the territory’ (R27, management).

4.2 Who are citizens? Identifying citizens and their interests

There was a major belief that citizens were independent actors who potentially brought their own insights into the ecosystem:

> The approach that we always try to champion from Barcelona is the one we believe. It’s more inclusive because you don’t just try, let’s say, to fix an old innovation system, in which you don’t try to push citizens into [the interests of] Triple Helix, but you try to include them as they need. (R9, management)

As addressed by several interviewees, it was thus imperative to identify target citizens and their interests:

> The first step is to understand who they are, where they are, what they need to be involved in the projects, and the barriers they face. So, we focus on contacts, even defining them, mapping them like mapping other stakeholders from the ecosystem. (R4, management)

> We try to discover ‘what is the community?’, ‘what are their interests?’ and provide a tool to develop their own interests. We don’t want to force citizens into our interests. This is our main concern. […] First of all, listen to them. (R24, management)

According to interviewees, citizens were distinct collectives contingent on each LL’s focus, stakeholders’ networks, project purposes and location. Citizens were a group of individuals who shared the same interests or CSOs that represented them, such as resident associations and patient associations.

Target citizens were classified into four main categories based on their interests in both personal and collective purposes. These interests were not static and could change over time. The first type included people who potentially desired to grow as entrepreneurs (e.g.

professionals, such as artists, or open data community members). The second type referred to citizens wishing to pursue personal interests (e.g. library users, seniors). The third type included those who would like to improve living areas by identifying and attempting to address problems (e.g. education community: high school pupils and teachers, residents). The last group was people affected by, and willing to contribute to, specific projects (e.g. patients; university campus community: students and employees). For citizens outside CSOs, the LL activities transformed some of these sets of people into more socialised communities and groups.

4.3 When to engage citizens? Early in the process

Although LLs aimed to include citizens in all phases, engaging them early was perceived as one of the ways that citizens were able to meaningfully shape choices about the innovation trajectory: 'We try to involve users from the beginning. That's the key point' (R13, management). 'Early' was interpreted in different ways: at the beginning of the LL's establishment or at the beginning of LL projects.

The earliest option of engagement was evident in two university-promoted LLs (L3, UABSSC), in which citizens shaped the LL establishment and purpose. L3 was 'rooted from the community' with significant influence from an association of residents who expressed their needs in the creation phase (R10, management). UABSSC organised a series of co-creation sessions in their extension phase that aimed to jointly 'define the [LL's] structure, activities, management model and relations with the other services of the campus or with external projects' (co-creation invitation letter).

The engagement of citizens in later phases – that is, at the project level – was present in all cases. Some LL projects facilitated proactive citizen involvement in which citizens were given a degree of freedom in subject choice (Citilab, L3). Several interviewees reflected on this 'citizen-first' attitude, asking citizens, 'We begin with your interest. What do you want to do?' (R8, management). Some citizen groups (BCNLab, i2Cat, LLH) also suggested individual projects within larger, pre-defined themes, such as 'merging arts and technology' or 'mental health':

> To have a clear visualisation of our communities, at the first stage, we did a co-creation process for two days and a half. Well, [it means that] inviting interdisciplinary profiles, we tried to co-design projects. Our main purpose was to structure the projects and then try to find resources to implement them. (R1, management)

In some cases, citizens were engaged early in the working process to identify challenges and provide needs that were incorporated into the agendas of the other actors. This approach was notably observed in health and mobility projects (HCLLC, LLH, UABSSC). One interviewee clarified the following: 'Patients were involved at the beginning of the innovation part, but not in the design of the proposal and the design of the clinical trial. We included them partially, but we tried to include them […] We enquired about their experience, how they did it, and what they wanted' (R7, academic). This effort was perceived as a 'new fashion [way of doing]' (R13, management), whereas 'in the past, patient involvement was so passive' (R7, academic).

4.4 How to engage citizens? Facilitating interactions among stakeholders and mobilising necessary resources

4.4.1 Co-creating

The LLs used various techniques to enrol citizens and elicit their input in ways that could steer new and ongoing projects and promote interactions among diverse participants in an open environment. The techniques were largely grouped under the 'co-creation' umbrella, sometimes also referred as the 'participatory' or 'co-designing' methodology by interviewees. These techniques were facilitated by either LL coordinators or external co-creating professionals. Co-creation was used for short-term projects, such as a mental health project, or one-off intensive events, such as workshops, panel sessions and hackathons. There were two main directions: co-creation in groups of diverse stakeholders, irrespective of their sectors, and co-creation among participants of the same sector (e.g. only citizens).

The first direction directly endowed citizens with agency and was adopted in most of the LL projects because of its 'openness' (R16, academic) and its value for holistically understanding and tackling the issues: 'In my experience, it is always very useful, and people, for the first session only, were very satisfied. This is a challenge, but if you do some design

thinking or have technical dynamics for people to interreact with, you break barriers, and people open up' (R13, management). The 'challenge' this interviewee mentioned refers to different languages, different purposes and previous misconceptions among different types of participants.

This challenge motivated one case LL in the health sector (LLH) to move from the first direction into the second – that is, towards single sector co-creation – in their latest project:

> People will talk freely without power relationships. It will be easier, and the power or knowledge of the group will be similar, so the conversation will come up more freely. In practice, what we do is organise separate workshops, one with experts from academia and one with representatives of the CSO. (R15, management)

This illustrates the effort to overcome the challenges of trust, confidentiality and knowledge gaps between citizens and other groups, especially in the health sector and in some other projects involving general citizens. Likewise, Citilab 'tried to lower the bar' in terms of co-creation topics, 'so citizens got into the project' (R4, management). Indeed, one of the reasons citizens declined to participate was that 'the topic was not exactly something [they] knew about' (R23, academic), according to several interviewees.

4.4.2 Enrolling citizens in projects (citizen-led vs. professional-led)

Citizens participated in two main types of projects: citizen-led or professional-led; both could exist in the same LL. In the first type, citizens worked on their own issues and were granted the autonomy to lead projects with various resources, such as funds and advice, provided by LLs; these efforts were sometimes positioned within the framework of European projects. In the latter type, 'researchers had specific projects – for example, within the H2020 programme, or SMEs [small and medium enterprises] proposed experiments' (R14, management).

The first type of project was observed most evidently in BCNLab projects, where, after co-creation sessions, citizens were provided with critical resources to undertake activities with visible outcomes. An open call was made for entrepreneurial activities, and then the responses were matched with available funding and consulting from the public sector. Other

projects produced open-sourced products for public purposes or solutions to identified problems (Citilab, L3, LLH), where spaces, tools and academic consultations were facilitated by LLs. Citizens exerted leadership roles in these short- or long-term activities and reached some degree of formal authority within their projects. For example, the academic who worked with education communities confirmed that 'students decided everything' (R16, academic).

Some professional-led projects also 'put citizens, as much as [they could], in the centre of the process' (R4, management). Citizens played different roles, such as improving the operations of other actors by testing applications or providing feedback on prototypes to technicians, SMEs or researchers. These activities appeared in the early stage of the LLs, when UABSSC 'did not have a strong LL methodology yet' (R14, management) or HCLLC 'had not yet received official funding' (R6, management). The main purpose was to 'make an efficient use of the existing resources, but in a collaborative manner' (R14, management), based on their existing industry contacts, research programmes and funding. The same happened in i2Cat, before the establishment of the LL unit in 2015, when the LL activities were integrated into research and innovation projects: 'It was technological in nature, and the LL participation in these projects was constrained to basically testing the prototypes with the user, managing the user interaction and user feedback, and the real-life qualification of these platforms' (R9, management).

Thus, it was clear that available resources and stakeholder goodwill in LLs affected the ways citizens participated. On the one hand, LLs did not expect financial returns, a fact confirmed by most interviewees in all cases, although some recognised that citizen inclusion might open funding opportunities: 'We are building a new concept for projects, and the benefit is clear because some European funds [prioritise] this line [of projects]. This benefit is direct for the stakeholders because they have the possibility to access the funding from projects' (R5, management). On the other hand, it was very difficult to organise citizen projects if they were not within funded research and innovation frameworks, especially when LLs did not have sustainable funding to maintain operations. The operations required a 'sustainable model', where 'you don't have to open any budget to feed it' (R11, management).

4.4.3 Co-opting citizens in governance

Citizens played the role of governors in only one case (L3) by means of an association of neighbourhood residents. This was because this CSO, together with the support of a research centre, had initially mobilised to demand the municipality provide the neighbourhood with an innovation location. The CSO then became involved in co-governance of the LL, specifically leading its communication strategy. The CSO was endowed with formal authority to shape the direction of the LL operation.

Offering this formal authority to civil society was not realised in the remaining cases, although several interviewees spoke positively about the example:

> We have 8,000 members of Citilab. But we still don't have anybody that represents the Citilabers in the board of the Citilab; it is something to do. These people can influence the orientation of the Citilab directly, not only orientation of their owned project, but the orientation of the whole foundation. (R8, management)

This realisation requires, on the one side, the capability and commitment of civil society, and, on the other side, the willingness of all stakeholders – or at least the ones with pre-existing formal authority. One interviewee hesitated about the possibility of co-opting civil society in the governance board at the current stage, arguing the following:

> Users' participation is important, but board members have different roles, completely different. They are people who have connections, have a professional entrance in developing whatever we do, to answer the needs of users. […] And now patient associations are not very organised. […] Also, this is a new kind of project, new concept for stakeholders, so it's hard and difficult. (R5, management)

Nonetheless, the same person conveyed a prospect: 'But in the future maybe, if we have strong patient associations, maybe we invite them to participate in the board, why not? The LL is not in a closed structure; it is open'.

In contrast, other respondents offered different views on CSOs in Catalonia generally and in the health sector particularly, noting that 'they are very active' (R15, management), and 'there are a lot of associations. They are well organised, they provide a lot of services to

patients, and patients are really linked to them. It's not only a lobby [influencing politicians]. There are clinicians there, also; they sometimes work as [service] providers' (R7, academic). Accordingly, some interviewees acknowledged the right or capacity for citizens to be involved in LL governance: 'Citizens should be involved. They have resources and experts. It depends on what you think when you say 'society', but it's organised. For example, neighbourhoods have their associations. And they are very active, and they have some money; they can also support some initiatives' (R23, academic).

Governance boards with that include civil society were perceived as possible because 'there is no political blocked mindset to say: "No, you cannot participate"'. However, the following reality was acknowledged:

> This is a slow process [...] You can invite them, but people say, 'No, I am an NGO dealing with social issues, why should I innovate – what is that?' This is a process to understand that innovation is an issue for everyone. It is not a business for the private sector or university. Everyone should be involved in innovation in some way. (R8, management)

4.5 Where to engage? Enabling citizen participation

From 2017 to early 2019, LL operations were both virtual (R6, management) and physical. As explained by several interviewees, virtual networks meant that there were LL activities and projects implemented that involved different stakeholders, yet the project team had no fixed space or otherwise considered the whole city and university campus as an LL workspace. Three cases operated in virtual environments by the time of the data collection (BCNLab, HLLC, UABSSC) but were in the process of establishing physical spaces. Among those cases, BCNLab had worked to 'shape the concept of the city laboratory', referring to the 'city as an ecosystem of experimentation and co-creation' among Quadruple Helix actors (R1, management). UABSSC sought to 'explore the possibilities of the network', where they 'made connections' virtually with different stakeholders to initiate and implement LL projects (R30, management).

A physical place was necessary to organise activities and improve citizen participation by providing an open space for citizens to come on a daily basis and propose their ideas while optimising public infrastructures. Five of the LLs were integrated into public spaces,

including the local public library (L3), university libraries (UABSSC), an art factory (BCNLab), and technological and research centres (HCLLC, Citilab). The remaining cases operated in certain locations on a project basis (i2Cat, LLH), mainly utilising public infrastructures. LLH used places it considered to be 'neutral' locations (R15, management) for all participants in terms of distance and discipline, depending on the project (e.g. a science museum for a science education project). It is worth noting that this multiple-case study was carried out before the COVID-19 pandemic and, therefore, any changes in organising citizen participation (i.e. virtual vs. physical) due to the pandemic were not observed.

4.6 LLs changing power relations

Based on the outcomes of some LL projects, evidence suggested that power relations between citizens, governments and knowledge institutions had changed. Citizens were motivated to participate in LL activities, while academics and public authorities confirmed the positive dynamics resulting from citizen input. The connections with industry were not very well observed because of their inconsistent presence, but the innovation managers we interviewed indicated that the interests of industry in citizen inclusion appeared to be for 'business-as-usual' purposes of innovation exploitation, noting that 'doing real-life tests is something important' for product development (R31, industry) and innovation exploration, including 'entrepreneurial idea discovery' (R32, industry).

4.6.1 Citizen power: Their self-perception

With the support of LLs, some citizens were motivated and enabled to achieve their initial goals. One citizen appreciated the regional pilot efforts to promote the active participation of other citizens, noting that 'we need to teach the citizens how to be able to solve problems by themselves' (R22, citizen). An academic confirmed the impact of LL activities in enabling citizens to address their problems: 'Students presented the results of their research to the director of the school, and the school made some changes. For them, it was very interesting, and it had a real impact in the moment' (R16, academic). An interviewed entrepreneur shared the value of the LL network: 'We have the city council as a client, as well as the regional government. We are exploring the university side and then the companies because we think

that it makes sense for companies to have this digital channel for the community. But at this moment, companies are not valuing it so much' (R2).

Interestingly, during the LL process, some local residents went beyond their initial personal interests and genuinely wanted to promote regional development by inviting industry to participate. This demonstrated the complexity of power where it was not always perceived as a 'zero-sum game' among actors but could be a collective effort to address common problems. One interviewee suggested, 'We need someone to go to company A and speak to someone: "We have this LL, and we want to collaborate – what can we do?" Here, we have a lot of big companies. […] The more people we have here, the more interesting it is' (R33, residents).

4.6.2 Citizen power: Perceived by other stakeholders

Citizen input was positively valued among governments and knowledge institutions, and a change in the citizen inclusion method was observed: 'It is interesting seeing how the discourse about how the smart city should look has affected the agenda of the government itself' (R20, industry). In the case of knowledge institutions, both management and researchers considered the positive aspects of citizen engagement for education and research purposes:

> The LL can be the first step to new ways of teaching, new ways of interacting among teachers, students, and companies and researchers. (R27, management).

> Before participating in the LL, all the projects I had were only [some interviews] for research. But in the last few years, as the European Commission also promotes this, I try to incorporate this method, that needs to work with the community in the whole process of the project and with the LL. (R16, Academic)

Academics were motivated to engage with citizens because of the derived benefits especially from learning opportunities, yet in some cases they needed institutional support to do so. While these initiatives were better valued by universities, academics faced challenges related to time and opportunity cost as they worked to meet different expectations. Academics thus 'have to look for the balance' (R16, academic).

4.6.3 The role of coordinators to change power relations

A crucial role of LL coordinators, if not the most important one, was to stimulate stakeholder commitment, especially from citizens. Citizen commitment refers to the willingness of citizens to participate in the LL and exercise their power. In five of the seven cases, the LL employed full-time coordinators at the time of the enquiry; during the course of the research, two other LLs also introduced this position. L3 acknowledged the need for a coordinator and was in the process of recruiting: 'Until now, the persons in charge of the LL are A or B; both are teachers and researchers from the university. They have no time to do that. […] It is very difficult if you go to the LL but it is closed because A is in class and B is at a conference' (R30, management).

In L3, individual citizens who had their representative, a CSO, on the governance board considered their governance board something that was 'highly political' (R34, resident). When they had concerns, they preferred to reach out to someone who coordinated their daily activities: 'The most important change [we would like] is to have someone here who we can speak to, or someone who organises courses and spends time here' (R34, resident). Having a dedicated person to address citizens' needs and reinforce trust was also a common theme: 'They can express more things they would like to change when they have some space and some reference persons to talk with. I think it is the key' (R21, NGO).

The LL coordinators bridged citizens and different stakeholders. In some cases, they helped citizens overcome their hesitation to directly contact other actors: 'The interesting thing here is that I do not need to be concerned about politics, that I am related to this public thing. I work with C [LL coordinator], who is channelling us to projects and events' (R2, entrepreneur).

5 Discussion: How do Living Labs Include Citizens in Ways that Change Power Relations?

A common finding across the studied cases was the presence of LL actors who acknowledged the agency of citizens in collaborative ecosystems. These actors, especially LL coordinators, were closely aligned with the interests of relevant citizens and keen to involve them in various

ways in different projects. This offered what might be considered a 'temporary' or 'borrowed' power position within LL collaborations, justified mainly by the discursive legitimacy of citizens and the critical need for their participation. When citizens were able to successfully leverage this initial power change, these closely aligned actors were able to once more 'lend' power positions to citizens to allow them to acquire critical resources through access to project funding and contacts. In these cases, citizens secured either their autonomy to lead projects and achieve goals or their formal authority through participation in formal governance structures. In the latter situation, citizens were able to be formally involved and constructively contribute to the governance of the collaborations. This constitutes what we call a 'power banking' mechanism in which the power bankers were mainly played by the coordinators funded by either governments or knowledge institutions.

The power banking mechanism includes two key self-reinforcing elements facilitating the power transfer process. The first element is citizens' willingness to borrow power and to use it productively to leverage their initial power sources. The second is the power bankers' commitment to reserving their own discursive legitimacy, critical resources and formal authority to better incorporate citizens into activities with other actors. Presenting our findings and discussion, Figure 4 visualises the overall mechanism by which intermediaries such as LLs may organise the inclusion and empowerment of citizens in collaborative ecosystems.

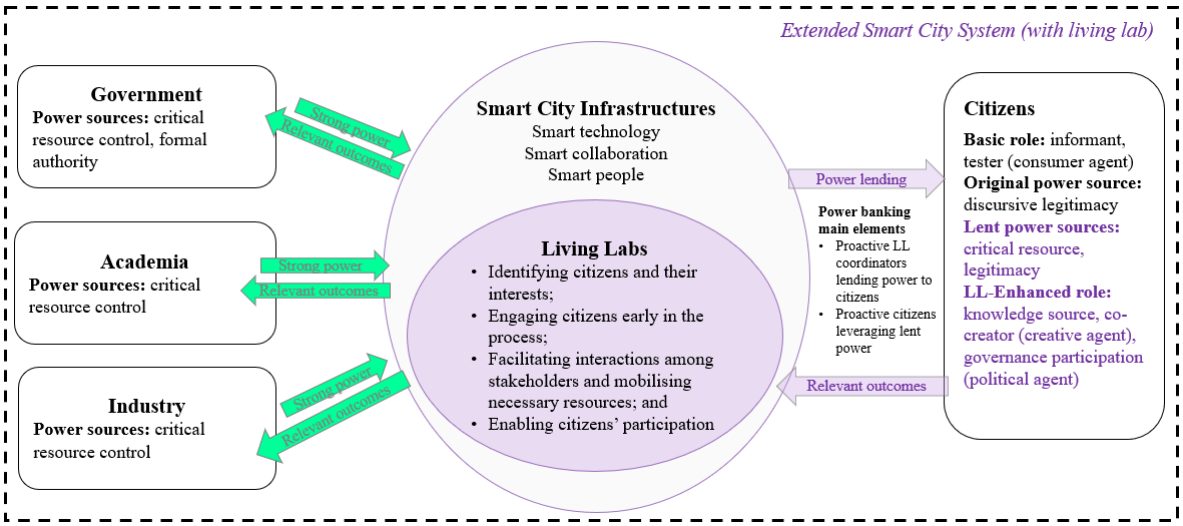

Figure 4. Citizens' power and inclusion in smart city systems with intermediaries (LLs).

A few studies in the collaboration literature have identified LLs as boundary spanners seeking to bridge various sectors (Van Geenhuizen, 2018) or LL coordinators as individuals who nurture the relationships among different actors (Palomo-Navarro & Navío-Marco, 2018). When it comes to citizen inclusion, the role of LL coordinators conventionally involves collecting and organising information provided by citizens, as users, and forwarding it to other Triple Helix actors (Nyström et al., 2014). Our analysis contributes to this discussion by illustrating a fundamental change in contemporary urban collaborative discourses and practices that are interested in exploring the agency of citizens in innovation and their likely undermined roles. In this context, power bankers are the focal actors who build trust, empower individual citizens to identify their desires, and effectively incorporate citizens into the collaborations as independent actors.

We acknowledge that organising collaborative systems requires the efforts of many individuals and organisations, rather than 'a single heroic agency' (Breznitz et al., 2018, p. 894). While our findings suggest that power bankers are central to challenging and changing smart city power relations in favour of citizens, several factors are critical for this endeavour to be sustained or scaled.

First, the existence of power bankers – a role exercised by LL coordinators – is largely contingent upon political and social support, as public funding was crucial to filling this role in most of the cases. The discursive legitimacy of citizens, perceived as their right to be involved in the system, especially in digital era, was primarily addressed by governmental actors first. This call was later echoed by knowledge institutions in the form of European community-based policy concepts, including several funding opportunities. Citizen inclusion in collaborative ecosystems seeking to 'democratise innovation' then became a learning process supported by public funding or included in funded research and innovation projects. If this had not been the case, according to our interviewees, then such collaboration would not have been possible. This points to the perceived emergent challenge of maintaining LL operations (Rizzo et al., 2021), a condition for power banking to function.

Second, although the voices and interests of citizens are better valued by participants in LL contexts, incentives are critical to maintain participants' commitment (Weaver, 2014). Citizens may also feel an incentive to participate in LLs if they expect to obtain outputs from

the collaborations. However, the expected outputs are vague and uncertain, considering the long process. In contrast, the cost of participation is clearer and observable, especially as regards the time investment. The feeble incentives and cost requirements raise important challenges in the effort to engage and retain citizens and other stakeholders, since the collaboration is voluntary (Nguyen & Marques, 2021). LLs or participating organisations would need to address the issue of incentives to enable changes in power relation at a structural level. Doing so would require either LLs to align the outcomes to the needs of each participant or Triple Helix organisations to allow citizen engagement activities to be recognised and best utilised at the institutional level.

In this regard, we note that the simple act of meaningfully involving citizens in ways that allow them to participate as equivalent (not even equal) actors to the other established organisational actors in these experimental ecosystems is extremely complex. The proposed mechanism involves enthusiastic coordinators who repeatedly provide power to citizens, a role justified by citizens' discursive legitimacy, so citizens can leverage that loaned power to create new power sources. This illustrates the challenge of the problem: it is not a trivial task to meaningfully involve citizens when the extant collaborations consistently marginalise and exclude citizen power. This suggests that we should be more critical of those who uncritically call for the use of the Quadruple Helix model to improve the quality of governance and decision-making. Primarily, we should focus on the mechanisms through which power can be 'lent' to civic actors to facilitate their exercise of agency.

As an additional challenge, although citizen inclusion is a precondition for leveraging citizens' capacity for innovation from a democratic perspective, their inclusion does not necessarily imply that collaborative projects are strategically successful. Even if Quadruple Helix collaboration takes place, satisfactory outcomes for all participants are difficult and endanger the continuation of the collaboration (Nguyen and Marques, 2021).

5.1 Theoretical and empirical contributions

Our findings contribute to the contemporary discussion on citizen inclusion in collaborative ecosystems by providing a process and mechanism, foregrounded by the theory of power, to meaningfully include citizens. By doing so, we make three contributions.

First, we address a major concern from several scholars about the vagueness of the terms 'citizens' and 'civil society' and their ontology in the context of including citizens in collaborative systems (Avelino & Wittmayer, 2016; Engelbert et al., 2019). Our findings highlight the primary importance of detecting citizens and their interests and uncovering different types of citizens according to their interests. *Second,* we underline that differential interests and power sources require different strategies and incentives when it comes to engaging different types of citizens, both in term of power relations and democratic representation. For example, this can be observed in the different directions of co-creation adopted in our case studies with the aim of facilitating citizen contributions. Some co-creation activities, such as the hackathon, attracted 'disproportionately young and tech-savvy' participants. Several interviewees were aware that different strategies would have needed to be implemented to if the goal had been 'to reach out to senior citizens or people from socially disadvantaged neighbourhoods'. As per our interviewee, 'This is especially important to avoid the pitfall of a well-intentioned public policy actually ending up increasing the digital gap between the capability-rich and the capability-poor' (R1, management). This issue is extremely relevant in debates related to the booming co-creation literature as a methodology to create an open environment for societal transformation. Failing to recognise power asymmetry in these activities in practice leads to negative consequences, as recently proposed in several conceptual studies (Turnhout et al., 2020). Some critics also importantly note that that co-creation and other participatory methods should not be a means for public authorities to elude their responsibilities (Hertting & Kugelberg, 2018). *Third,* the capability to influence decision-making and change may encourage citizen engagement, as suggested by current theory and policy discourses. That said, the evidence indicates that, at the time of this study, formal authority in the form of representative co-governance appears uncorrelated with individual citizens' motivation to participate. However, gaining the autonomy to identify and address their problems seems to generate immediate effects on citizen empowerment.

6 Conclusions

This paper addresses the contemporary interest in citizen inclusion in smart city collaborative ecosystems to effectively address urban problems. It contends that there is a need to address

the existing power imbalances in which institutionalised norms and the relationships between classic actors tend to frame citizens as passive consumers and prevent them from exerting power. We analysed how LLs challenge and change those power relations at the micro-scale and could potentially form the basis for a broader shift at the structural level of urban collaborative systems. Applying power theory, the success of power relation change is contingent upon two interrelated elements. On the one hand, citizens must be empowered to exercise their power sources and to influence the decision-making process. On the other hand, the strong ties between Triple Helix participants must be challenged: the actors must be better attuned to citizen voices and recognise the value of citizen input.

This paper presents an exploratory case study of seven LLs in a single region renowned for its social practices and relatively high levels of social cohesion. Our results suggest that a self-reinforcing mechanism that agencies exert through 'power bankers', coupled with factors such as political support and incentives, endows citizens with temporary positions of power. Citizens may leverage this power in smart city activities to deploy means, such as access to critical resources and (potentially) formal authority, to achieve their goals. The identified mechanism appears to be strongly reliant on publicly funded coordinators, who are unlikely to be present in all contexts. Although other mechanisms may occur, these findings may apply generally, thereby justifying a sceptical attitude towards the Quadruple Helix model. The efforts required to engage citizens at a basic level in a socially active region suggest that, in less social regions, it could be even harder to mobilise citizens to build smart cities. It would be valuable to have similar studies in other settings to compare and verify our findings and arguments.

This research is subject to two main limitations that future research could address. First, access to citizen interviewees was relatively limited in some cases; future interviews could uncover more nuances in citizen perceptions. Further research that offers broader citizen insights would be beneficial, although this issue may be difficult to overcome due to the dispersion of citizens. Second, this study examined LLs as a potential instrument for citizen inclusion to expand the problem-solving capacity of smart cities. The effect of LLs on democracy should be subject to deeper examination.

References

Albino, V., Berardi, U., & Dangelico, R. M. (2015). Smart cities: Definitions, dimensions, performance, and initiatives. *Journal of Urban Technology*, *22*(1), 3–21. https://doi.org/10.1080/10630732.2014.942092

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

Anderson, C., & Brion, S. (2014). Perspectives on Power in Organizations. *Annual Review of Organizational Psychology and Organizational Behavior*, *1*, 67–97. https://doi.org/10.1146/annurev-orgpsych-031413-091259

Andreani, S., Kalchschmidt, M., Pinto, R., & Sayegh, A. (2019). Reframing technologically enhanced urban scenarios: A design research model towards human centered smart cities. *Technological Forecasting and Social Change*, *142*, 15–25. https://doi.org/10.1016/j.techfore.2018.09.028

Ansell, C., & Gash, A. (2008). Collaborative governance in theory and practice. *Journal of Public Administration Research and Theory*, *18*(4), 543–571. https://doi.org/10.1093/jopart/mum032

Arnkil, R., Järvensivu, A., Koski, P., & Piirainen, T. (2010). *Exploring Quadruple Helix: Outlining user-oriented innovation models* (University of Tampere: No. 85/2010).

Ashworth, R. E., McDermott, A. M., & Currie, G. (2019). Theorizing from Qualitative Research in Public Administration: Plurality through a Combination of Rigor and Richness. *Journal of Public Administration Research and Theory*, *29*(2), 318–333. https://doi.org/10.1093/jopart/muy057

Avelino, F. (2021). Theories of power and social change. Power contestations and their implications for research on social change and innovation. *Journal of Political Power*, 1–24. https://doi.org/10.1080/2158379X.2021.1875307

Avelino, F., & Wittmayer, J. M. (2016). Shifting power relations in sustainability transitions: A multi-actor perspective. *Journal of Environmental Policy and Planning*, *18*(5), 628–649. https://doi.org/10.1080/1523908X.2015.1112259

Barley, S. R. (2010). Building an institutional field to corral a government: A case to set an agenda for organization studies. *Organization Studies*, *31*(6), 777–805. https://doi.org/10.1177/0170840610372572

Bergvall-Kåreborn, & Ståhlbröst. (2009). Living Lab: an open and citizen-centric approach for innovation. *Int. J. Innovation and Regional Development*, *1*(4), 356–370.

Bibri, S. E., & Krogstie, J. (2017). Smart sustainable cities of the future: An extensive interdisciplinary literature review. *Sustainable Cities and Society*, *31*, 183–212. https://doi.org/10.1016/j.scs.2017.02.016

Bickerstaff, K., & Walker, G. (2005). Shared visions, unholy alliances: Power, governance and deliberative processes in local transport planning. *Urban Studies*, *42*(12), 2123–2144. https://doi.org/10.1080/00420980500332098

Bifulco, F., Tregua, M., & Amitrano, C. C. (2017). Co-governing smart cities through living labs. Top evidences from EU. *Transylvanian Review of Administrative Sciences*, (50E), 21–37. https://doi.org/10.24193/tras.2017.0002

Borkowska, K., & Osborne, M. (2018). Locating the fourth helix: Rethinking the role of civil society in developing smart learning cities. *International Review of Education*, *64*, 1–18. https://doi.org/10.1007/s11159-018-9723-0

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Breznitz, D., Ornston, D., & Samford, S. (2018). Mission critical: The ends, means, and design of innovation agencies. *Industrial and Corporate Change*, *27*(5), 883–896. https://doi.org/10.1093/icc/dty027

Bryman, A., & Bell, E. (2011). *Business Research Methods* (Third). Oxford: Oxford University Press.

Bryson, J. M., & Crosby, B. (2005). *Leadership for the common good: Tackling public problems in a shared-power world*. John Wiley & Sons, Inc. https://doi.org/10.2307/977190

Clegg, S. (2010). The state, power, and agency: Missing in action in institutional theory? *Journal of Management Inquiry*, *19*(1), 4–13. https://doi.org/10.1177/1056492609347562

Clegg, S., Courpasson, D., & Phillips, N. (2006). *Power and organizations* (First). SAGE Publications. https://doi.org/10.4135/9781446215715

Clegg, S., & Haugaard, M. (2009). *The SAGE Handbook of Power*. SAGE Publications.

Dameri, R. P. (2017). The Conceptual Idea of Smart City: University, Industry, and Government Vision. In *Smart City Implementation: Creating Economic and Public Value in Innovative Urban Sysems* (pp. 23–43). Springer.

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. https://doi.org/10.1111/caim.12061

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. https://doi.org/10.1016/j.techfore.2018.08.020

Engels, F., Wentland, A., & Pfotenhauer, S. (2019). Testing future societies? Developing a framework for test beds and living labs as instruments of innovation governance. *Research Policy*, *103826*, 1–25. https://doi.org/10.1016/j.respol.2019.103826

Eriksson, M., Niitamo, V., & Kulkki, S. (2005). State-of-the-art in utilizing Living Labs approach to user-centric ICT innovation - a European approach. *Technology*, *1*(13), 1–13.

Etzkowitz, H. (2008). *The Triple Helix: University–Industry–Government Innovation in Action*. New York: Taylor & Francis.

Feurstein, K., Hesmer, A., Hribernik, K., Thoben, T., & Schumacher, J. (2008). Living lab: A new development strategy. In *European Living Labs - A new approach for human centric regional innovation* (pp. 1–14). Berlin: Wissenschaftlicher.

Fitjar, R. D., Benneworth, P., & Asheim, B. T. (2019). Towards regional responsible research and innovation? Integrating RRI and RIS3 in European innovation policy. *Science and Public Policy*, *46*(5), 772–783. https://doi.org/10.1093/scipol/scz029

Flyvbjerg, B. (2006). Five misunderstandings about case-study research. *Qualitative Inquiry*, *12*(2), 219–245.

Foucault, M. (1982). The Subject and Power. *Critical Inquiry*, *8*(4), 777–795. Retrieved from https://www.jstor.org/stable/1343197

Government of Catalonia. (2017). SmartCat: Catalonia's Smart Strategy. Retrieved Mar 2020, from http://smartcatalonia.gencat.cat/web/.content/01_SmartCAT/documents/SmartCatalonia_ENGLISH.pdf

Gray, B. (1985). Conditions facilitating interorganizational collaboration. *Human Relations*, *38*(10), 911–936.

Grundel, I., & Dahlström, M. (2016). A Quadruple and Quintuple Helix Approach to Regional Innovation Systems in the Transformation to a Forestry-Based Bioeconomy. *Journal of the Knowledge Economy*, *7*(4), 963–983. https://doi.org/10.1007/s13132-016-0411-7

Hardy, C., & Phillips, N. (1998). Strategies of Engagement: Lessons from the Critical Examination of Collaboration and Conflict in an Interorganizational Domain. *Organization Science*, *9*(2), 217–230. https://doi.org/10.1287/orsc.9.2.217

Hollands, R. G. (2008). Will the real smart city please stand up? Intelligent, progressive or entrepreneurial? *City*, *12*(3), 303–320. https://doi.org/10.1080/13604810802479126

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

Huxham, C., & Vangen, S. (2005). *Managing to Collaborate: The theory and practice of collaborative advantage*. Routledge.

Jensen, C., & Trägårdh, B. (2004). Narrating the Triple Helix concept in "weak" regions: Lessons from Sweden. *International Journal of Technology Management*, *27*(5), 513–530. https://doi.org/10.1504/IJTM.2004.004287

Kähkönen, A. K. (2014). The influence of power position on the depth of collaboration. *Supply Chain Management*, *19*(1), 17–30. https://doi.org/10.1108/SCM-03-2013-0079

Kanstrup, A. M. (2017). Living in the lab: an analysis of the work in eight living laboratories set up in care homes for technology innovation. *CoDesign*, *13*(1), 49–64. https://doi.org/10.1080/15710882.2016.1146304

Kronsell, A., & Mukhtar-Landgren, D. (2018). Experimental governance: the role of municipalities in urban living labs. *European Planning Studies*.

Kummitha, R. K. R. (2018). Entrepreneurial urbanism and technological panacea: Why Smart City planning needs to go beyond corporate visioning? *Technological Forecasting and Social Change*, *137*, 330–339. https://doi.org/10.1016/j.techfore.2018.07.010

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

Leminen, S., Nyström, A. G., & Westerlund, M. (2015). A typology of creative consumers in living labs. *Journal of Engineering and Technology Management*, *37*, 6–20. https://doi.org/10.1016/j.jengtecman.2015.08.008

Leminen, S., Westerlund, M., & Nyström, A. (2012). Living Labs as open-innovation networks. *Technology Innovation Management Review*, (September), 6–11.

Leydesdorff, L., & Deakin, M. (2011). The Triple-Helix Model of Smart Cities: A Neo-Evolutionary Perspective. *Journal of Urban Technology*, *18*(2), 53–63.

Lin, X., Ho, C. M. F., & Shen, G. Q. (2018). For the balance of stakeholders' power and responsibility: A collaborative framework for implementing social responsibility issues in construction projects. *Management Decision*, *56*(3), 550–569. https://doi.org/10.1108/MD-05-2016-0275

Linneberg, M. S., & Korsgaard, S. (2019). Coding qualitative data: a synthesis guiding the novice. *Qualitative Research Journal*, *19*(3), 259–270. https://doi.org/10.1108/QRJ-12-2018-0012

MacGregor, S. P., Marques-Gou, P., & Simon-Villar, A. (2010). Gauging Readiness for the Quadruple Helix: A Study of 16 European Organizations. *Journal of the Knowledge Economy*, *1*(3), 173–190. https://doi.org/10.1007/s13132-010-0012-9

Meijer, A., & Bolívar, M. P. R. (2016). Governing the smart city: a review of the literature on smart urban governance. *International Review of Administrative Sciences*, *82*(2), 392–408. https://doi.org/10.1177/0020852314564308

Menny, M., Voytenko Palgan, Y., & McCormick, K. (2018). Urban living labs and the role of users in co-creation. *GAIA*, *27*, 68–77. https://doi.org/10.14512/gaia.27.S1.14

Miller, K., Mcadam, R., Moffett, S., Alexander, A., & Puthusserry, P. (2016). Knowledge transfer in university quadruple helix ecosystems: An absorptive capacity perspective. *R&D Management*, *46*(2), 383–399. https://doi.org/10.1111/radm.12182

Mora, L., Bolici, R., & Deakin, M. (2017). The First Two Decades of Smart-City Research: A Bibliometric Analysis. *Journal of Urban Technology*, *24*(1), 3–27. https://doi.org/10.1080/10630732.2017.1285123

Mulvenna, M., & Martin, S. (2013). Living Labs: Frameworks and engagement. In *Innovation through knowledge transfer 2012*. Springer Berlin Heidelberg.

Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., & Scorrano, F. (2014). Current trends in smart city initiatives: Some stylised facts. *Cities*, *38*, 25–36. https://doi.org/10.1016/j.cities.2013.12.010

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. https://doi.org/10.1016/j.indmarman.2013.12.016

Ott, C., & Kiteme, B. (2016). Concepts and practices for the democratisation of knowledge generation in research partnerships for sustainable development. *Evidence and Policy*, *12*(3), 405–430. https://doi.org/10.1332/174426416X14700793045951

Palomo-Navarro, Á., & Navío-Marco, J. (2018). Smart city networks' governance: The Spanish smart city network case study. *Telecommunications Policy*, *42*(10), 872–880. https://doi.org/10.1016/j.telpol.2017.10.002

Pitkin, H. F. (1972). *Wittgenstein and Justice*. University of California Press.

Puerari, E., De Koning, J. I. J. C., Von Wirth, T., Karré, P. M., Mulder, I. J., & Loorbach, D. A. (2018). Co-creation dynamics in Urban Living Labs. *Sustainability*, *10*(6). https://doi.org/10.3390/su10061893

Purdy, J. M. (2012). A Framework for Assessing Power in Collaborative Governance Processes. *Public Administration Review*, *72*(3), 409–417. https://doi.org/10.1111/j.1540-6210.2011.02525.x

Ran, B., & Qi, H. (2018). Contingencies of Power Sharing in Collaborative Governance. *American Review of Public Administration*, *48*(8), 836–851. https://doi.org/10.1177/0275074017745355

Reypens, C., Lievens, A., & Blazevic, V. (2019). Hybrid Orchestration in Multi-stakeholder Innovation Networks: Practices of mobilizing multiple, diverse stakeholders across organizational boundaries. *Organization Studies*.

Ribeiro, B., Bengtsson, L., Benneworth, P., Bührer, S., Castro-Martínez, E., Hansen, M., …

Shapira, P. (2018). Introducing the dilemma of societal alignment for inclusive and responsible research and innovation. *Journal of Responsible Innovation*, *5*(3), 316–331. https://doi.org/10.1080/23299460.2018.1495033

Ricciardi, F., & Za, S. (2015). Smart City Research as an Interdisciplinary Crossroads: A Challenge for Management and Organization Studies. In L. Mola, F. Pennarola, & S. Za (Eds.), *From Information to Smart City: Environment, Politics and Economics* (pp. 163–171). Sringer.

Rizzo, A., Habibipour, A., & Ståhlbröst, A. (2021). Transformative thinking and urban living labs in planning practice: a critical review and ongoing case studies in Europe. *European Planning Studies*. https://doi.org/10.1080/09654313.2021.1911955

Rodrigues, C., & Teles, F. (2017). The Fourth Helix in Smart Specialization Strategies: The Gap Between Discourse and Practice. In S. P. Monteiro & E. G. Carayannis (Eds.), *The Quadruple Innovation Helix Nexus* (pp. 111–136). Palgrave Macmillan. https://doi.org/10.1057/978-1-137-55577-9_5

Santonen, T., Creazzo, L., Griffon, A., Bódi, Z., & Aversano, P. (2017). *Cities as Living Labs-Increasing the impact of investment in the circular economy for sustainable cities*. Brussels. https://ec.europa.eu/info/sites/default/files/research_and_innovation/groups/rise/cities_as_living_labs.pdf

Scholl, C., & Kemp, R. (2016). City labs as vehicles for innovation in urban planning processes. *Urban Planning*, *1*(4), 89–102. https://doi.org/10.17645/up.v1i4.749

Snape, D., & Spencer, L. (2003). *The Foundations of Qualitative Research*. (J. Ritchie & J. Lewis, Eds.), *Qualitative Research Practice: A Guide for Social Science Students and Researchers* (First). SAGE Publications. https://doi.org/10.18352/jsi.39

Turner, J. C. (2005). Explaining the nature of power: A three-process theory. *European Journal of Social Psychology*, *35*(1), 1–22. https://doi.org/10.1002/ejsp.244

Turnhout, E., Metze, T., Wyborn, C., Klenk, N., & Louder, E. (2020). The politics of co-production: participation, power, and transformation. *Current Opinion in Environmental Sustainability*, *42*, 15–21. https://doi.org/10.1016/j.cosust.2019.11.009

Van Geenhuizen, M. (2018). A framework for the evaluation of living labs as boundary spanners in innovation. *Environment and Planning C: Politics and Space*, *36*(7), 1280–1298. https://doi.org/10.1177/2399654417753623

Vanolo, A. (2016). Is there anybody out there? The place and role of citizens in tomorrow's smart cities. *Futures*, *82*, 26–36. https://doi.org/10.1016/j.futures.2016.05.010

Von Hippel, E. (2005). *Democratizing Innovation*. Massachusetts: MIT Press.

Weaver, R. K. (2014). Compliance Regimes and Barriers to Behavioral Change. *Governance*, *27*(2), 243–265. https://doi.org/10.1111/gove.12032

Weaver, R. K. (2015). Getting People to Behave: Research Lessons for Policy Makers. *Public Administration Review*, *75*(6), 806–816. https://doi.org/10.1111/puar.12412

Yang, Y., & Holgaard, J. E. (2012). The important role of civil society groups in eco-innovation: a triple helix perspective. *Journal of Knowledge-Based Innovation in China*, *4*(2), 132–148. https://doi.org/10.1108/17561411211235730

Yin, R. K. (2003). *Case Study Research. Design and Methods* (Third). Thousand Oaks, California: SAGE Publications.

Appendices

Appendix 1. Main characteristics of cases

Case	Est. year	Sector	Purposes relevant to LLs	Lead stakeholders
BCNLab	2012	Culture and technology	To combine traditional arts, science and technology; to support both existing initiatives and new entrepreneurial proposals.	Promoted by the Directorate of Creativity and Innovation within the Culture Institute of Barcelona (Barcelona City Council).
L3	2015	Culture and technology	To create links between culture, technology and society; to explore how technology can transform users' experience into new services and applications.	Located in a public library. Governed by Computer Vision Centre (a research centre of UAB), UAB, the Sant Cugat municipality and the Volpelleres Association of Residents.
HCLLC	2016	Health	To provide administrative infrastructure, management and a 'laboratory of ideas'.	Governed by long-standing LEITAT technological centre. Developed from the Terrassa municipality's innovation platform.
LLH	2014	Health	To promote health for and with society through educational and participatory programmes that empower citizens with the knowledge to make decisions about health and to engage in health research and innovation projects.	Governed by IrsiCaixa AIDS, a private research centre promoted by a bank and regional government.
Citilab	2007	ICT	To democratise innovation and promote a knowledge society through use of the Internet and a collaborative learning environment based on design thinking, computational thinking and user-centred co-creation.	Established by the Cornellà municipality. First citizen centre in Catalonia for social and digital innovation. Serves as a training centre, research centre and business and social incubator.
i2Cat	2002	ICT	To foster collaboration and empower citizens through open and participative digital social innovation.	Non-profit research and innovation centre, with a separate LL unit established in 2015. Promoted by the regional government. Pioneer of the Catalan LLs, founding member of the ENoLL. Consulted for the creation of other Catalan LLs.
UABSSC	2014	Mobility (and extending to other areas)	To assist the university in research, technology transfer and societal interaction by considering the university as a city LL that combines smart city technology with social innovation and actively engages end users.	Established by the UAB, Catalonia's second largest university. Part of the CORE strategic research communities at UAB.

Appendix 2. Data sources

	BCNLab	**L3**	**HCLLC**	**LLH**	**Citilab**	**i2Cat**	**UABSSC**
No. interviews	**5**	**12**	**2**	**3**	**3**	**8**	**6**
No. interviewees	**5**	**17**	**3**	**3**	**3**	**8**	**6**
Out of which ... *LL management and coordination*	2	5	2	1	2	3	4
Government	1	3		1	1	2	1
Academia	1	3	1	1			1
Industry		2				1	
Citizens	1 (Entrepreneur)	4 (Residents who participated in trainings)				2 (NGO & citizen)	
Observations and participations	Workshop on innovation programmes and projects (01/2018)	Public debate on artificial intelligence (01/2019)	Hospital visits (12/2017 & 02/2018)	Hospital and public health centre visit (12/2017)	Citizen co-working space visit (12/2017)		Co-creation workshop, opening day (02/2018)
	- Site visits (2017–2018) - Day of open innovation and fab LLs in Catalonia (CatLabs, 02/2018) - Open LL Days (ENoLL, 08/2018)						
Secondary data	Webpage, emails, presentation, LL introduction	Case studies, webpage, presentations, leaflets	Webpage	Webpage	Case studies, annual reports, webpage	Case studies, annual reports, webpage	Case studies, webpage, LL extension plan
	- Presentations and working papers on regional LL strategies - ENoLL webpage and members' profiles						

Paper 2. The Promise of Living Labs to the Quadruple Helix Stakeholders: Exploring the Sources of (Dis)satisfaction

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Abstract

Despite the normative view that Quadruple Helix collaborations (with government, academia, industry, and civil society) such as living labs are prescribed to enhance regional innovation performance, there is scarce knowledge of the sustainability of such collaborations from the perspective of the stakeholders who are supposed to engage in such initiatives. To address this gap, the purpose of this paper is to empirically explore the implementation of the Quadruple Helix for innovation from a stakeholder perspective through understanding the expectations as well as the perceived benefits and challenges of such a collaboration. Through a qualitative research design, this paper presents an in-depth case study of an urban living lab in the region of Catalonia. Our results challenge the normative view of Quadruple Helix approaches and of living labs; we also offer suggestions to manage future collaborations and to inform further evidence-based policy. On the whole, partnership leadership and coordination are critical to bridge the expectation-implementation gap towards stakeholder satisfaction and collaboration sustainability.

Keywords: Living labs; Quadruple Helix; innovation; expectations; stakeholder engagement

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1 Introduction

Regional innovation systems (RISs) have been widely stylised as the intertwining of several helices (Carayannis et al., 2018). Among them, the Triple Helix is a well-established model of innovation, which encourages interaction among academia, industry and government (Etzkowitz & Leydesdorff, 2000). This model is based on an underlying assumption of a dynamic and unstable equilibrium, in which there are likely tensions between two partners, and associating with the third helix will help to resolve these tensions and sustain the collaboration (Benneworth et al., 2015; Etzkowitz, 2008). Nevertheless, the effectiveness of the Triple Helix model has been increasingly questioned in innovation and regional development (McAdam & Debackere, 2018). In this sense, the Quadruple Helix model offers to be an improvement on the Triple Helix one, as it addresses some of the tensions for which the latter cannot resolve, especially the lack of society involvement (Carayannis & Campbell, 2012).

Developing a Quadruple Helix approach consists of engaging an additional type of participants in the process, who are often considered to be 'civil society' or 'users' (Arnkil et al., 2010; Grundel & Dahlström, 2016). The aim of this enlarged collaboration is to make the *fourth helix* explicitly participate in the process of knowledge generation and innovation in general; this is done for many reasons, not the least being that they are the ultimate users or beneficiaries of innovation (McAdam et al., 2018). One of the advantages of the Quadruple Helix model is the combination of both top-down and bottom-up approaches, in which bottom-up initiatives strengthened by top-down programs are believed to lead to the most successful results (Etzkowitz, 2003). Furthermore, with the engagement of a wider set of participants in the innovation process, the Quadruple Helix may offer a diversity of innovation outcomes rather than only technology-driven innovation (Nordberg, 2015).

The helix models have generally been used as an 'ideal-type' and normative framework for researchers and policymakers (Benneworth et al., 2015; Cai, 2015), but several authors have acknowledged the gap between the theory and the real functioning - what in practice means the discrepancy between expectations about the collaboration and the actual performance (Oliver, 1980) - which can create tensions while generating innovation

(Fogelberg & Thorpenberg, 2012). In the same vein, McAdam and Debackere (2018) state that there is a need to investigate the real functioning and effective management of such collaborations because Quadruple Helix collaboration should not be taken for granted (Vallance et al., 2020). Furthermore, some argue that Quadruple Helix research is still in its infancy (Galvao et al., 2019; Miller et al., 2018) and that most research has focused on exploring the Quadruple Helix at a macro regional level, highlighting the need for further research at the micro project and individual levels (Cunningham et al., 2018; Höglund & Linton, 2018; Miller et al., 2018). To address these micro-level gaps, the purpose of this paper is to empirically explore the expectations and perceptions of stakeholders in an ongoing Quadruple Helix initiative under the living lab (LL) form. In particular, this paper addresses the following research question: *How do expectations and perceived performance influence stakeholders' engagement in the Quadruple Helix collaboration, such as LLs?*

LLs attract interests from diverse fields and sectors (Mastelic et al., 2015) and are supposed to be capable of providing multiple benefits to stakeholders, yet sustaining collaboration is still a challenge, as evidenced by the slowing down of some European LL initiatives (Schuurman, 2015) and their high failure rate (Nesti, 2017b). Therefore, better understanding the participants' expectations is vital if these practices are to be sustained (Puerari et al., 2018; Von Wirth et al., 2019).

In the next section, we present the theoretical background on the implementation of the Quadruple Helix via LLs by exploring their expectations and performance. Then, we describe the qualitative methodology used and the case study of an urban LL in the region of Catalonia. Next is the findings section, in which we describe and analyse the viewpoints of all Quadruple Helix stakeholders regarding the manifested expectations, benefits and challenges of the collaboration. A final section ends the article with the main discussion and overview of its theoretical contributions, policy implications and future research proposals.

2 Implementing the Quadruple Helix Model through LLs

LL is a 'practice-driven phenomenon' with a large community of practitioners, predominantly in Europe, which may explain why it lacks a consistent and commonly accepted definition among scholars (Ballon & Schuurman, 2015; Leminen, 2015). A LL can

be defined as a methodology that is oriented by two main ideas: involving users at an early stage of the innovation process and experimenting in a real-life context (Almirall & Wareham, 2011; Rizzo et al., 2021). LLs facilitate co-creation based on public-private-civic partnerships, which are latterly known as the Quadruple Helix (Hyysalo & Hakkarainen, 2014). The concept of co-creation can be constructed from a conglomerate of disciplines and practices but often underlines the need for an active role of citizens, in addition to the classical Triple Helix actors (Marušić & Erjavec, 2020). Co-creation in LLs is facilitated by creating inclusive public spaces of multiple stakeholders, experimenting with new policies, co-designing and testing new methods, and exploring new governance models outside the conventional research and innovation models to produce pragmatic solutions for urban challenges (Bylund et al., 2020). These processes aim to develop tangible innovations, such as designs and services, or intangible ones, such as the generation of concepts and ideas (Feurstein et al., 2008; Hossain et al., 2019). In this vein, some scholars argue that LLs focus more on promoting discussion or dialogue to reach hybrid understandings among different participants and therefore, possibly produce innovation outputs, rather than target measurable outcomes (Rizzo et al., 2021). Hence, it is arguable that the expectations and outcomes of LLs are likely to be diverse.

2.1 Expectations from LLs

A longitudinal literature search suggests that the expectations surrounding LLs have extended over time from solely having technological and commercial benefits for the private sector (e.g. Almirall & Wareham, 2011; De Moor et al., 2010) to also offering public and social value for the public and civic sector (Bulkeley et al., 2019; Kronsell & Mukhtar-Landgren, 2018). One plausible explanation for this broader expectation is a shift in the (European) RIS approach. The RIS concept has been used as a framework to analyse the differential innovativeness of regions (Asheim et al., 2019), inspiring regional innovation policy questioning ‘one size fits all’ policy solutions (Tödtling & Trippl, 2005). Several authors have called for more place-based and inclusive innovation processes where several agents collaborate towards regional development (Tödtling et al., 2021). Considering that LLs have become popular policy instruments, the more diverse participants in RISs there are, the more likely various expectations from LLs they hold.

Actually, LLs 'have been said to offer multiple benefits to businesses, society and users' (Hossain et al., 2019, p. 986). For example, LLs contribute to product development and the market expansion of *private companies* by matching products and consumer demands, providing ideas for new products/services and quickening the product's entry into the market (Almirall & Wareham, 2011). Their capacity in organising different stakeholders also assists *public authorities* in promoting entrepreneurial ecosystems (Rodrigues & Franco, 2018) or in responding to urban challenges through experimental governance (Bulkeley & Castán Broto, 2013; Voytenko et al., 2016). Regarding *universities*, they wish to join LLs to conduct research that addresses local challenges (Salomaa, 2019) and to transfer knowledge more effectively from the university to regional business (Van Geenhuizen, 2013). Lastly, *citizens* may expect both personal and social benefits when joining LLs or when doing co-creation to be more specific, depending on the purpose of the activities (Nesti, 2017a). Acquiring knowledge, achieving a sense of belonging to the network, and developing ideas independently have been identified as the citizens' main motivations (Gascó, 2017).

The extant literature offers some insight into specific stakeholders' expectations in terms of LL collaboration. We however contend that aligning these diverse needs is extremely complex in the local and regional context, where current research falls short in providing a holistic picture to address all of the participants' expectations (Benneworth et al., 2017; Gascó, 2017; Höglund & Linton, 2018).

2.2 From expectations to performance

Understanding the sources of stakeholder satisfaction is the basis for successful stakeholder engagement (Hietbrink et al., 2012). In a consumer or user context, satisfaction is commonly considered as *an outcome* of consumption, where quality of products and services from the supply side is the main external determinant towards recipients' evaluation (Cronin & Taylor, 1992; Vigoda, 2002). On the other side, satisfaction could be understood as *a process* where internal factors of consumers also play a role in their perception on results (Parker & Mathews, 2001). *Expectancy disconfirmation theory* (Oliver, 1980) is an effort of combining these two dimensions of satisfaction attributable to both external outcomes (supply side) and internal processes (consumption side).

From this approach, stakeholder satisfaction in innovation collaboration is partly related to the discrepancy between the perceived performance and the initial expectations about collaboration outcomes. This discrepancy of expectations can be negative if performance is below the expectations, or it can be positive if the performance exceeds the expectations (Oliver & Burke, 1999). Expectancy disconfirmation theory has been applied to several fields, initially in marketing for the private sector but then gradually expanding to public management in order to evaluate citizen satisfaction (e.g. Grimmelikhuijsen & Porumbescu, 2017; Van Ryzin, 2004). This theory, though, has not been explored in regional innovation collaboration research despite its advantage in recognising how expectations, implementation performance, and the gap between them influence stakeholders' satisfaction and participation.

Once LLs are established and functioning, stakeholders will interact with them to supply some types of assets or capital (e.g. financial, human, physical, social) and receive in turn outcomes, with similar or different nature. Most likely, the perceived outcomes are not going to perfectly match the original expectations of the collaboration. While the anticipated advantages of LLs are undeniable, especially with its participatory innovation approach focusing on connecting users and other actors in a real-life environment, concerns over LL implementation are also visible (Hyysalo & Hakkarainen, 2014; Von Wirth et al., 2019; Voytenko et al., 2016). For one, simultaneously addressing societal, economic and environmental issues, which is expected by various stakeholders, is evidently challenging in practice (Mastelic et al., 2015).

3 Methodology and Case Overview

3.1 Methodology

We adopt an exploratory qualitative approach to address the under-investigated research question in order to develop new insights about this complex topic (Creswell, 2013). An in-depth single case study has been chosen for three main reasons. First, it is useful in investigating the dynamics in single settings or examining complicated phenomena evolving over time (Eisenhardt, 1989; Yin, 2003), which is the case of the expectations and satisfaction of stakeholders in LL collaborations. Second, it is highly recommended for understanding

behaviours in inter-sectional relationships in network studies (Halinen & Törnroos, 2005). Finally, it is consistent with the call for micro-level and place-based analysis in Quadruple Helix collaborations (McAdam et al., 2018).

Data were collected from the end of 2017 to early 2019, a period when most activities of the chosen case (Library Living Lab, hereafter referred as L3) were limited to permanent working group discussing to re-define its governance and (financial) sustainability model. This seemed to be a difficult transition moment for L3, yet was an ideal time to look back to what was achieved and learnt after approximately four years of planning and three years of implementation. Primary data comprise 12 semi-structured interviews (on average 65 minutes each) with 17 key stakeholders: academics at both management and research levels (identified as Aca1 to 6); five authorities at local, provincial and regional management levels in charge of innovation and public services (Gov1 to 5); four local residents (User1 to 4); and two innovation managers in large companies (Ind1 and 2). Interviewees were recruited based on a snow-ball technique, in which active participants in the LL recommended the partners for interviewing. Thanks to this snow-ball technique, we are confident that the research has included the majority of significant stakeholders and the number of interviewees revealed quite properly the engagement level of the four helices in the LL activities.

All interviews, except for two upon request of the interviewed, were recorded and transcribed. We adopted a thematic analysis technique, a foundation of qualitative analysis, due to its flexibility in categorising themes (Braun & Clarke, 2006). Nvivo12 software was used to assist in data organisation and analysis. Accordingly, narratives of interviewees were coded chronologically following three main themes: initial expectations, achieved benefits and identified challenges. We synthesised and compared for all helices repeatedly. Furthermore, we triangulated the empirical data with secondary documents and through several visits to the premise, including observation and participation in some L3 activities (Table 1). Secondary data, especially documents at the early stage of LL operation and its webpage, were also valuable in understanding the communication that partially set the stakeholders' expectations.

Table 1. Complementary data sources (to interviews).

Observation and participation	
2018 & 2019	Conversations with participants of user activities (averaging 15 minutes each)
2018	Observations of preparation for L3's robotics training and artificial intelligence (AI) course
	Participation in robotics trainings with other users
	Participation in an introduction session about L3 to the public in an innovation tour organised by the UAB
2019	Participation in an AI public debate
Secondary sources	
Membership application to ENoLL - 9th wave and L3's profile in ENoLL	
L3 leaflet and poster	
L3 webpage	
L3 case studies (two documents)	
Presentations of L3, municipal innovation strategy, provincial library programme and regional digital social innovation updates (six documents)	
Catalonia Innovation Triangle Report: Cerdanyola, Rubí, Sant Cugat	

3.2 Case overview

Our chosen case study is L3, which makes part of a public library in Volpelleres, the neighbourhood of Sant Cugat del Vallès, in a close radius of Barcelona, Catalonia (Spain). L3 describes itself as 'an open, participatory, experimentation and co-creation space' aiming to create links among culture, technology, and society. The initiative seeks to explore how technology can transform users' experience into new services and applications, thereby fostering research and innovation in the cultural domain. L3 is relevant in a broad context (Figure 1). It is an outstanding case of multi-stakeholder collaboration with a Quadruple Helix approach and has been presented as a successful and promising project of being citizen-rooted. Yet L3 is also an example of the struggles involved in individual and inter-institutional collaboration (Vilariño et al., 2018).

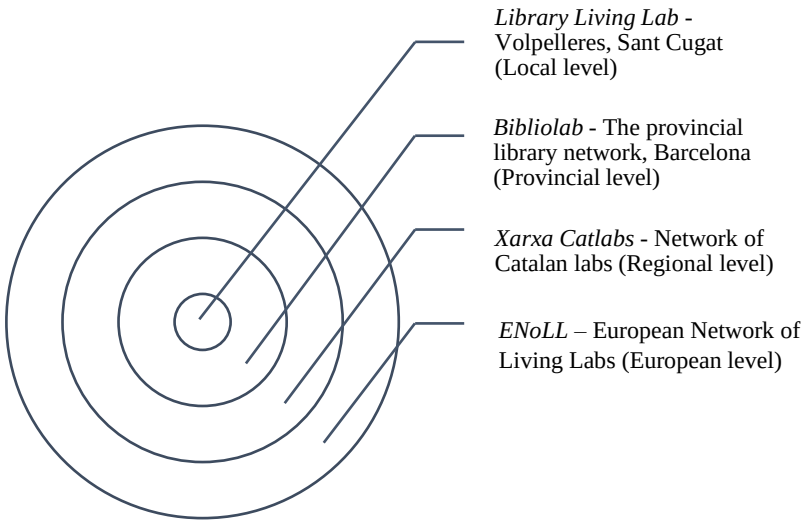

Figure 1. L3's relevance.

Source: Authors' design based on L3's profile.

The idea of setting up the L3 was born in the context of the neighbourhood construction stagnation in early 2010s, following 2008–09 financial crisis. At that moment, many promising projects got frozen and there was almost no activity offered to citizens in the area. A group of active residents was passionate about making the neighbourhood more innovative. They mobilised themselves under the Association of Residents of Volpelleres Neighbourhood (AVBV) and sought consultation from several academics ofthe Computer Vision Centre (CVC), located nearby in the Universitat Autònoma de Barcelona (UAB) campus. Coincidentally, this research centre was looking for a model to realise their institutional strategy of transferring some research outcomes faster to the real world. These two collectives worked together on the proposal of L3, which was positively supported by the municipality of Sant Cugat. This initiative later gained attention from the Barcelona province aiming to promote its library network, and the UAB in the efforts to enhance their territorial impacts. These five stakeholders were committed enough to serve in the governance board of L3.

The LL welcomed users in October 2015, after the opening of the public library in May of the same year. 2016 was the most productive year of L3, while its activities visibly decreased in 2017 but then rebounded at the end of 2018. Table 2 presents details of the LL stakeholders.

Table 2. Main Quadruple Helix stakeholders in L3.

Stakeholders	**Library Living Lab** *The permanent working group includes the listed governments, academia, and first-tier civil society.*
Government	▪ Municipality of Sant Cugat del Vallès: allocates human resources, funds and infrastructure ▪ Provincial council of Barcelona: manages the network of libraries and provides services
Academia	▪ CVC – UAB's research centre, catalyst and project manager: provides knowledge, funds and other resources ▪ UAB: Provides knowledge and funds
Civil society	▪ First tier: AVBV, instigator of the initiative, final recipient of services ▪ Second tier: Library users and other local residents, some participate in executive meetings and lead projects
Industry	▪ Some companies: provided kind contributions and physical equipment

Source: Authors' elaboration based on interviews and Vilariño et al. 2018.

4 Findings

This section presents the main findings regarding expectations from the LL collaboration, perceived benefits and challenges, according to the views of all four helices.

4.1 Expectations

The establishment and operation of L3 were facilitated by the initial positive expectations about its mutual benefits (Table 3). L3 represented a collective effort, in which local stakeholders voluntarily worked together to seek to address social challenges and further innovate the city. Most interviewees expected that the unique collaboration among stakeholders, who were 'normally difficult to engage in the same consortium' (Aca3) and supported by the novel participatory and experimental methodologies of LLs, would lead to a number of innovation projects. This collaboration also expectedly assisted each stakeholder in fulfilling their institutional missions as well as addressing their interrelated needs.

Table 3. Stakeholders' expectations from the collaboration.

Governments	Civil society	Academia	Industry
To address social challenges and to innovate the city via collaborative innovation projects with a close connection with citizens			
• To experiment with new public services • To promote an entrepreneurial ecosystem	• To improve local living quality • To pursue personal interests with public services • To support local entrepreneurial initiatives	• To enhance the relevance of research and innovation • To better transfer technology and diffuse knowledge	• To be directly close to end users for product development • To capture value from supporting entrepreneurs' ideas

Initially, the municipality supported the initiative in accordance with the current norms on the democratisation of knowledge and under the pressure of external stakeholders: 'This library and the LL within the library were the demands from the neighbourhood. Any demand of the citizenship must be at least heard. And if it is reasonable, why don't we promote this initiative?' (Gov1). Local, provincial and regional governments then quickly realised that the LL could be a pilot initiative and an experimental place to improve public services, including museums and libraries, in the midst of 'digital and technological changes leading to a decrease in number of users' (Gov2). In the meantime, the city hall desired to 'promote innovation projects transversally around the city' (Gov1), and it was believed that the LL could support the creativity and entrepreneurship of citizens in the long term.

Concerned with improving the neighbourhood's well-being, the CSO instigator of L3 shared some expectations with the governments and felt strongly entitled to influence local decisions in providing its residents with public innovative places. Upon L3's opening, the dominant group of users were local residents, mostly employees of surrounding companies. They expected to pursue their personal interests by accessing physical resources (e.g. a 3D printer) and networking with people (e.g. sharing information among peers with the same hobbies and/or complementary skills) via various LL activities:

> One day, I was bringing my kids to do homework here, and then I just walked by and saw people with a 3D printer. I thought: 'Oh, what is this? I like this hobby'. Later I came and found out this is the place to build car models and to talk about these things. (User4)

In addition, citizens were aware of the possibility of entrepreneurship development with L3's resources and conveyed their willingness to support them: 'Young people starting businesses need a physical place [...] they can share the LL; they can build their prototypes and test products with users here.' (User1).

From the academia side, supporting LL was driven by an institutional strategy of both the research centre and university. As proposers of the LL idea, they conveyed its prospect as a 'vehicle' to efficiently transfer technology and create impacts through developing innovation with different stakeholders. The idea derived from the need of having different transfer activities, particularly in the challenging cultural domain:

> We are very very [*emphasising voice*] close to industry, and we are doing a lot of technology transfer. […] The reasonable and easy ways to do technology transfer are license, contracts for research and contracts for companies. But there are different areas where creating impacts and transferring the results of our research are not so straightforward. One of them is culture. (Aca4)

Conducting research in a real-life context rather than a technical lab would also possibly improve the outcomes because 'it is better if you try to do innovation directly where the need exists and where the people will use the solution or participate in this innovation process' (Aca4). Furthermore, engaging with citizens and surrounding society was 'one of the main goals of the university management' (Aca2), as confirmed by another interviewee: 'it is our duty to open our knowledge, our research production, to the society' (Aca1).

Finally, both interviewees from industry wished to approach end-users and customers directly for product development in the context of fast-changing buying habits and technological progress. The LL had potential in facilitating this access because it was typically challenging for the companies, as producers, to understand the customers' needs through the perspectives of the distributors or retailers in their value chain, whose analysis was 'not always with the same level of deepness that we [producers] would like' (Ind2). In addition, one of the interviewees expected to capture value from the exploration side of innovation by means of giving supports to entrepreneurs' new ideas. Nevertheless, the latter expectation was quite low based on a previous negative experience in another initiative,

where they did not get any value and thus looked for more proactive behaviours from other partners: ‘We can place a 3D printer there, but then they [lab managers and users] have to manage and explore its application’ (Ind2).

4.2 Benefits

L3 brought several benefits to each partner, with the lowest positive level perceived by industry (Table 4). The first year of LL operation sought to create projects in which they ‘basically tested out different ways to do the idea of Quadruple Helix because everybody speaks about it, but not many people have actually implemented it’ (Aca4). Accordingly, most of interviewees appreciated L3’s advantage in terms of the institutional learning regarding the needs and working dynamics of other sectors thanks to the proximity with them: ‘It is mainly mutual learning […] we learnt to understand each other’ (Gov4). This learning process also helped participants, especially knowledge institutes, to better communicate and explain themselves to the community, following the encouragement of European Union’s research and innovation programmes (e.g. Horizon 2020):

> With the interactions with other actors in the LL, we are improving our communication and our how-to. We are getting close to doing something together; so for me, that’s something that we are gaining; we are learning. It’s very important for us to do work with other helices. (Aca1)

Table 4. Collaboration benefits.

Governments	Civil society	Academia	Industry
Institutional learning with a better understanding of local stakeholders via proximity with them			
Innovated public services: • Increased users • Increased utilisation of public infrastructure	Improved local living conditions: • Fulfilled personal interests with public services • Enhanced local sociability	• Data collection and research outcomes • Approached local residents and impacted community	• Reputational benefits: Branch name recognition

Governments achieved optimistic results of innovating public services with L3: ‘There are challenges but examining the results, in terms of developing the process and developing the website, the benefits outweigh the challenges’ (Gov5). The number of library users had

increased: ‘We have new users with the LL’s presence. At the beginning, when L3 took off, many people that had never set foot in the library before came to see this’ (Gov3). The creation of the LL was also somewhat economically efficient because it was integrated into the same space of a traditional public library, and as one authority indicated, ‘our investment nowadays is more in kind of efforts than in money’ (Gov1).

Citizens reaffirmed the accomplishments: ‘I didn’t remember the last time I came to a library. If it wasn’t for the LL, maybe I wouldn’t be here’ (User1), and ‘it’s a nice use of the library’ (User3). All interviewees agreed that the LL fulfilled their interests and further reinforced the connection of the local community. They were able to produce their own products using the available equipment with course instructors, share activities with their family members and get closer to other local residents through courses and other events. It was ‘more useful coming here [to L3] for an hour than spending one day at home’ (User1). The presence of L3 appeared to improve the local living conditions.

From the academia side, the mentioned benefits from L3 included data collection, research outputs (e.g. doctoral theses) and other academic activities (e.g. seminars). Researchers were better enabled to spread their knowledge and to review the research implication through gaining outsider opinion in LL activities (e.g. public debates). The participating researchers explained: ‘The community has more knowledge and are more accepting of what we do, and they encourage it; it’s a kind of benefit’ (Aca6). According to them, participating in these public engagement sessions also brought ‘satisfaction of helping’ or ‘self-fulfilment in impacting the community’. With the assistance of a facilitator from their institution, researchers expressed that it was feasible for them to participate in these public engagement activities.

Industry in turn found it difficult to obtain relevant benefits under the current form of the LL. However, since the companies’ branch name was recognised by users, participating in the LL was reputationally positive.

4.3 Challenges

Despite the perceived benefits, respondents indicated that expectations on entrepreneurship growth and industry engagement via experiments and testing had yet to be realised. Industry engagement had been inconsistent and the lowest among all stakeholders. Ongoing activities were also subject to several challenges. Table 5 outlines the stakeholders' concerns.

Table 5. Collaboration challenges.

Government	Civil society	Academia	Industry
Internal structuring and human resource development	Timely receipt of support and responses	Researchers' priority setting of activity participation	• Intellectual property (IP) protection and confidentiality • Scalability of the collaboration
Challenges shared by most stakeholders			
• Difficulty in initiating collaborative projects and activities due to: o Lack of guidelines and of a shared understanding of the LL methodology and its potential o Different languages among disciplines o Different interests and working dynamics among helices • Weak strategy and legal framework leading to: o Lack of clear indicators o Role confusion o Slow decision-making process and stakeholders' hesitation to participate • Lack of effective communication			

Each stakeholder faced their own challenges. Participating public authorities referred to their internal challenge of fitting L3 activities into their organisational activities or their regular responsibilities of their staff: 'Someone in the staff has to learn that; it's a new task, a new program for a member of our team. And yes, it's a complicated issue because we have a lot of work' (Gov5). Citizens, as the daily users, struggled in receiving timely support and responses related to the utilisation of the LL resources. According to them, 'every party focuses on their part' (User3), and 'there are a lot of interests […] nobody has dedicated to our problems' (User2). Regarding individual researchers, one of their challenges appeared to be how to prioritise upcoming activities. Their presence in L3's public engagement sessions depended on whether they 'would have time to join or not' (Aca5), considering these sessions brought 'more personal benefit than professional one' (Aca6). One of concerns from industry was the replication and scalability of the LL model, as a regional initiative to a more global practice: 'We want something that can be scaled up globally; we don't want to limit ourselves to the people here' (Ind2).

Regarding shared concerns, they referred mainly to the difficulty in initiating LL activities, the weak strategy and legal framework, and a lack of effective communication, which will be analysed in the following sections.

4.3.1 Difficulty in activity initiation

Most of interviewees pointed out how they struggled to initiate L3 collaborative projects proven by an interrupted time without activities just one year after their opening. Although the activities started again later, the discontinuity undermined the interests of both current and potential partners. Some interviewees emphasised the need of having 'different activities, not more [typical] activities' (Gov3) because there was 'not enough input to make people want to do more' (User2). One representative from academia summarised the situation:

> I think that in the beginning, we were a little bit naive because we expected a lot of things [...] that it could be very easy to create a new project and to interact with the citizens, with the users of the library. But it is very difficult because it's a process where we are learning about how to explain ourselves, how to explain to create a new model of education. (Aca1)

This situation can be explained by several reasons. First, the absence of an official guideline of LL methodology led to a lack of shared understandings on its operation and potential:

> It is very difficult because we don't have a white paper on this methodology. (Aca4)

> From our sector, it is very difficult to understand this [the LL], and until this day, it is still not clear for us because we do not see it ... It has been a year and a half since I was told this, and I do not really see what's happening. (Gov3)

Second, it was difficult to align individual and institutional partners with diverse languages, structures and working dynamics.

> Coming from the history and art worlds, it was very difficult to understand the potential of a LL for us […] to define a project. Because it was like speaking in different languages. (Gov5)

> It is difficult to collaborate with the university, because some departments or groups […] are too dynamic. They want to change the strategy too quickly […] Also, students and professors

> are changing all the time. So it's difficult for those departments to have a continuity in their team and their lines of research. (Gov5)

> The dynamics of how the LL like this was created is difficult to co-align with the dynamic of companies. The companies don't want things that happen in five years; they want things would be much faster. (Aca3)

Although collaborative governance brought the advantages of building a common awareness about the L3's direction, it was perceived difficult to reach an agreement among heterogeneous partners:

> We have seen that we need to foster this [citizenship] participation, it's not a spontaneous collaboration […] And this is the difficulty of managing this LL: defining the point of interest of these four stakeholders with their own languages and interests. It's possible but it's not easy. And we are here still nowadays working on it. (Gov1)

4.3.2 Weak strategy and legal framework

The lack of a clear strategy was the probable cause for some interviewees finding it problematic to measure the LL performance to continue engagement:

> Nowadays, our concern is just to explain it was a good investment, but it's difficult to explain […] It's more difficult to evaluate the return. And perhaps the long-term goal is to explain to our colleagues, to the citizens, the importance of a resource like this [LL]. (Gov1)

> Since I invest money, I need some types of monitoring, some type of indicator to evaluate how this project is performing. And I am always asking what's the number of users […] of projects […] of companies. (Aca1)

Second, there was difficulty in timely identifying the responsibility of partners. There was confusion around who should be in charge of L3's operation, whether it should be the library staff because the LL was inside the library *or* whether it should be the academics because they were the current managers of this initiative: 'There is an initial agreement that has expired, which now has to be renewed, but there is no established framework for what happens at any time, or who is responsible for what. It is a great lack.' (Gov3)

Finally, the absence of an official contract or 'a legal document' could also explain the low level of industry participation, considering their concerns about finance, confidentiality, and IP protection.

> They [large companies] were here, but we didn't have the chance to tight them because we didn't have the contract. (Aca4)

> Especially with new ventures with many partners, everyone is worried about who is going to own the patent… It can take ages. (Ind1)

> The company has always been working on protecting intellectual property […] We try to keep the IP inside and sometimes limit the collaboration. (Ind2).

The slow decision-making in this issue also affected the willingness of industry in participating, as perceived by one interviewee: 'What they don't want is to join in endless meetings and long-time decision at political level; they want to be part of it, but they want a more agile way of doing so.' (Aca3).

4.3.3 Lack of effective communication

Citizens expressed their concern about the L3's insufficient communication to both current and potential users: 'I'm not sure if people know this place exists, because there is not a lot of news, advertising' (User1). Information on LL activities was mainly circulating informally among users: 'If it were not to be WhatsApp group [among users], I could hardly know what is going on, hardly' (User3).

The lack of a proper communication might also be the reason why some activities did not reach sufficient audience or the desired citizens:

> I am a bit disappointed to see that a big part of the people that went there were already part of research community and that there were only a few people who were not actually from our field […] I hope that this spreads the word, and people start coming because that would be useful for us. (Aca5)

To address some challenges, one of the solutions learnt was that L3 needed a coordinator encouraging stakeholder engagement and 'working in the interest of the four stakeholders'

(Gov1). This coordinator could also serve as ‘a technician in the lab the whole time’ (Aca2) to take care of users’ daily needs. Again, although the profile of this coordinator was sketched, the position had not been realised by the time this research was conducted: ‘we always say [to citizens] that we are in a governance process to look for a manager, but we’ve been saying the same thing for a year’ (Gov3).

5 Discussion and Conclusions

Our findings suggest that expectations reasonably explain the engagement of stakeholders in the mobilisation phase. These expectations are shaped by three main premises: LL concept perception, context evaluation (Clarke & Fuller, 2010) and prior experience (Oliver, 1980). In this case, partners with high expectations (i.e. civil society, academia, and governments) joined with greater apparent commitment. Their enthusiasm derived from the first two premises. First, these partners were persuaded by the theoretical promises of Quadruple Helix in general, and LLs as the particular instrument, in producing regional development and innovation while fulfilling individual partner needs. Second, they perceived the geographical context with the right preconditions to implement the LL collaboration; counting with pioneering public institutions, engaged knowledge institutes, an exceptional community of active and well-educated residents, and a large number of technological companies nearby. The remaining helix, industry, was the stakeholder with weaker engagement in the LL, a finding which is consistent with previous research (Gascó, 2017; Voytenko et al., 2016). But our research offers a deeper explanation for this finding, which is industry’s lower expectations of the collaboration, based on negative previous experiences. As a compromise to reduce their concern, industry wished for a formal collaboration and asked for official contracts right from the beginning. Industry was also oriented to outputs more than processes of understandings and dialogue (Rizzo et al., 2021).

When it comes to continuing LL collaboration, stakeholders assessed their actual outcomes in the realisation phase. We called benefits to the realised expectations, which are incentives for further stakeholder engagement, and unrealised expectations were analysed as challenges. The logic and main findings of this research can be represented as the cognitive and decision process of stakeholders in Figure 2. The process includes a continuous cycle of

a first mobilising phase where expectations are determinants for stakeholder engagement, followed by an intervention phase of LL functioning where communication, coordination and evaluation are managed, and finally, a realising phase when stakeholders evaluate their experience including a comparison with expectations to decide their engagement continuation.

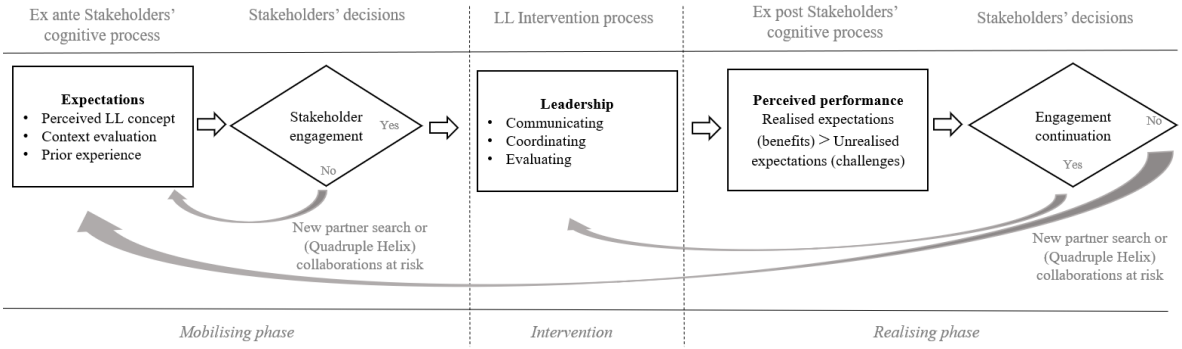

Figure 2. A model of stakeholders' decision processes for engagement.

In this case, the LL outcomes and performance were partly consistent with the stakeholders' expectations in the short term, but there were also relevant unachieved ones, such as entrepreneurship growth, which possibly caused dissatisfaction among the stakeholders that eroded their interest in continuing the collaboration. Most observed interactions in the LL were in the form of education and learning, while the core part of the LL concept as communicated, such as experimenting in real-life contexts, had not really been implemented. Accordingly, stakeholders perceived insufficient new and varied innovation projects. One explanation could be that 'experiment' remains a vague and broad concept leading to different interpretation among partners. Only recently has the literature begun to question LLs' purposes and implications, particularly their experimentation characteristic (Bulkeley et al., 2019; Rizzo et al., 2021; Von Wirth et al., 2019). Although learning could serve as the first step to building partners' capacity and identify citizens' interest, our findings suggest that there is a need to have further experimental and co-creation activities or necessary resources to stimulate the entrepreneurial spirit.

Despite some frustration, the data revealed that governments, academia, and civil society remained positive because they could obtain some benefits; at the same time, there was a shared understanding of the challenges facing stakeholders and a set of proposed solutions to

be implemented. The positiveness demonstrates the advantages of governance structures in form of collaborative leadership as proposed in the literature and policies (Foray et al., 2012; Menny et al., 2018). Nevertheless, the process has been time-consuming (and not always productive) in this case, considering the heterogeneity of stakeholders. Furthermore, representatives of these participants took the most important responsibilities in their home institutions, leaving citizens, as daily users, neglected. This situation requires 'honest brokers' or dedicated coordinators to accelerate the process of decision-making and user engagement activities (Palomo-Navarro & Navío-Marco, 2018; Von Schnurbein, 2010). We see here the importance of differentiating between steering and coordinating functions. While the governance board, as steering committee, has a role to play in navigating the partnerships, coordinators are responsible for smooth operations and building relationships with the stakeholders (Palomo-Navarro & Navío-Marco, 2018).

5.1 Theoretical and empirical contributions

This article contributes to the extant literature on RISs, particularly the debate about citizen engagement under the Quadruple Helix model and LLs (Arnkil et al., 2010; McAdam & Debackere, 2018). It is among the scarce number of studies offering a micro-level understanding of all four participants' view. The article proposes a cognitive and decision-making model that can have both a descriptive and analytic use for theory and can also be informative for the practice of LL management. Its main conceptual originality is the extension of expectancy disconfirmation framework (Oliver, 1980; Van Ryzin, 2004), with an emphasis on the intervention of partnership governance and management, as orchestrators, which communicates and further bridges the stakeholder expectation gap to sustain the collaboration.

Taking a macro-level view, this research underscores the significance of the civil society, including citizens and CSOs, in stimulating the relevance of research, innovation and entrepreneurial discovery in the region (Bunders et al., 1999; García-Terán & Skoglund, 2018). The access to final users or citizens was found attractive to all stakeholders. Nevertheless, the engagement from industry in the case was extremely low, despite previous contacts and closeness with academia. The complexity of interactions, with conflicting logics and priority, challenges the straightforward extension from the Triple to Quadruple Helix as

theoretically claimed, which ended not even in a functional Triple Helix collaboration. The transition to a Quadruple Helix does not function seamlessly in reality, as heroic efforts are required with a likely trade-off or compromise of value. Our empirical evidence resonates with a recent conceptual study, which argues that among the several ways to promote active citizenship, 'simply following the path of extending RIS by a further dimension, for instance, civil society, is not promising' (Terstriep et al., 2020, p. 17).

5.2 Policy implications

The study is highly relevant to the contemporary discussion, as the smart specialisation strategy, a keystone of European regional innovation policy since 2011, has been widely implemented and thus its practical evolution needs to be understood (Foray, 2020). The core feature of this strategy is the entrepreneurial discovery process, which embraces a Quadruple Helix approach in collaborative leadership and experimental platforms to give voice to underrepresented actors in innovation systems (Foray et al., 2012). This research identifies the challenge of a common understanding of the LL concept and of experimentation itself. Policy should consider that experimentation may be understood at different levels, such as science or technology, types and nature of collaborations, entrepreneurial business models or citizens' behaviour.

The article also highlights that institutional learning from place-based pilot projects may ease barriers of future collaborations. Yet one should be aware of the risk of stakeholders opting out in the next initiatives due to their sceptical attitudes towards the collaboration's incentives and transaction costs. This suggests that policy design should avoid being idealistic (Flanagan & Uyarra, 2016) whilst not lowering stakeholders' expectations (Filtenborg et al., 2017; Grimmelikhuijsen & Porumbescu, 2017). Overall, it is important to devise guidelines that assist regional actors in assessing and prioritising their focus, including a consideration of both the benefits and challenges, to narrow the expectation versus implementation gap. It is particularly significant in the policy context to seek a transition to a voluntary RIS with territorial development strategies that go beyond industry-focused ones (Capello & Kroll, 2016).

5.3 Limitations and future research

We realise that the small scale of our case study limits generalisability. However, the extant literature and practices call for more research on the micro-foundations of the Quadruple Helix, and in this article, we offer an exploration of the main sources that inform the stakeholders' decisions to commit to a regional collaboration, such as LLs. A slight under-representation of industry following the characteristic of our case restricts the investigation based on the perception of few large companies. This invites further research on citizens inclusion from the views of other types of businesses, such as small and medium enterprises, in collaborations. In addition, innovation and entrepreneurship are long processes where evaluating their performances and stakeholder satisfaction would benefit from a longitudinal observation.

We also acknowledge that stakeholders' durable engagement in a partnership requires their adaptable internal institutional arrangement (Vitale, 2010). Hence, this article poses important questions about how each Quadruple Helix partner seeks to embed inclusive collaboration into their institutional level and gain benefits accordingly. Future studies could also explore the model that we propose and test if the arguments raised hold for other (local and regional) collaborations, especially in other settings. Quantitative approaches would also be applicable when theoretical propositions have become better developed.

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References

Almirall, E., & Wareham, J. (2011). Living Labs: Arbiters of mid and ground-level innovation. *Technology Analysis and Strategic Management*, *23*(1), 87–102.

https://doi.org/10.1080/09537325.2011.537110

Arnkil, R., Järvensivu, A., Koski, P., & Piirainen, T. (2010). *Exploring Quadruple Helix: Outlining user-oriented innovation models* (University of Tampere: No. 85/2010).

Asheim, B. T., Isaksen, A., & Trippl, M. (2019). *Advanced Introduction to Regional Innovation Systems*. *Elgar Advanced Introductions series*. Edward Elgar Publishing Limited.

Ballon, P., & Schuurman, D. (2015). Living labs: concepts, tools and cases. *Info*, *17*(4), info-04-2015-0024. https://doi.org/10.1108/info-04-2015-0024

Benneworth, P., Pinheiro, R., & Karlsen, J. (2017). Strategic agency and institutional change: investigating the role of universities in regional innovation systems (RISs). *Regional Studies*, *51*(2), 235–248. https://doi.org/10.1080/00343404.2016.1215599

Benneworth, P., Smith, H. L., & Bagchi-Sen, S. (2015). Special Issue: Building Inter-Organizational Synergies in the Regional Triple Helix. *Industry and Higher Education*, *29*(1), 5–10. https://doi.org/10.5367/ihe.2015.0242

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Bulkeley, H., & Castán Broto, V. (2013). Government by experiment? Global cities and the governing of climate change. *Transactions of the Institute of British Geographers*, *38*(3), 361–375. https://doi.org/10.1111/j.1475-5661.2012.00535.x

Bulkeley, H., Marvin, S., Palgan, Y. V., McCormick, K., Breitfuss-Loidl, M., Mai, L., … Frantzeskaki, N. (2019). Urban living laboratories: Conducting the experimental city? *European Urban and Regional Studies*, *26*(4), 317–335. https://doi.org/10.1177/0969776418787222

Bunders, J. F. G., Broerse, J. E. W., & Zweekhorst, M. B. M. (1999). The Triple helix enriched with the user perspective: A view from Bangladesh. *Journal of Technology Transfer*, *24*(2–3), 235–246. https://doi.org/10.1023/A:1007811607384

Bylund, J., Riegler, J., & Wrangsten, C. (2020). Urban living labs as the new normal in co-creating place? In C. S. Costa, M. Mačiulienė, M. Menezes, & B. G. Marušić (Eds.), *Co-Creation of Public Open Places. Practice - Reflection - Learning*. Lisbon: Lusofona University Press. https://doi.org/10.24140/2020-sct-vol.4

Cai, Y. (2015). What contextual factors shape 'innovation in innovation'? Integration of insights from the Triple Helix and the institutional logics perspective. *Social Science Information*, *54*(3), 299–326. https://doi.org/10.1177/0539018415583527

Capello, R., & Kroll, H. (2016). From theory to practice in smart specialization strategy: emerging limits and possible future trajectories. *European Planning Studies*, *24*(8), 1393–1406. https://doi.org/10.1080/09654313.2016.1156058

Carayannis, E. G., & Campbell, D. F. J. (2012). *Mode 3 Knowledge Production in Quadruple Helix Innovation Systems*. SpringerBriefs in Business 7. https://doi.org/10.1007/978-1-4614-2062-0_1

Carayannis, E. G., Grigoroudis, E., Campbell, D. F. J., Meissner, D., & Stamati, D. (2018). The ecosystem as helix: an exploratory theory-building study of regional co-opetitive entrepreneurial ecosystems as Quadruple/Quintuple Helix Innovation Models. *R&D Management*, *48*(1), 148–162. https://doi.org/10.1111/radm.12300

Clarke, A., & Fuller, M. (2010). Collaborative Strategic Management: Strategy Formulation and Implementation by Multi-Organizational Cross-Sector Social Partnerships. *Journal of*

Business Ethics, *94*(1), 85–101. https://doi.org/10.1007/s10551-011-0781-5

Creswell, J. W. (2013). *Research design: Qualitative, quantitative and mix methods approaches* (4th ed.). SAGE.

Cronin, J. J., & Taylor, S. A. (1992). Measuring Service Quality: A Reexamination and Extension. *Journal of Marketing*, *56*(3), 55. https://doi.org/10.2307/1252296

Cunningham, J. A., Menter, M., & O'Kane, C. (2018). Value creation in the quadruple helix: a micro level conceptual model of principal investigators as value creators. *R&D Management*, *48*(1), 136–147. https://doi.org/10.1111/radm.12310

De Moor, K., Berte, K., De Marez, L., Joseph, W., Deryckere, T., & Martens, L. (2010). User-driven innovation? Challenges of user involvement in future technology analysis. *Science and Public Policy*, *37*(1), 51–61. https://doi.org/10.3152/030234210X484775

Eisenhardt, K. M. (1989). Building Theories from Case Study Research. *The Academy of Management Review*, *14*(4), 532. https://doi.org/10.2307/258557

Etzkowitz, H. (2003). Innovation in innovation : the Triple Helix of university - industry - government relations. *Social Science Information*, *42*(3), 293–337. https://doi.org/10.1023/A:1026276308287

Etzkowitz, H. (2008). *The Triple Helix: University–Industry–Government Innovation in Action*. New York: Taylor & Francis.

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "Mode 2" to Triple Helix of university-industry-government relations. *Research Policy*, *29*(2), 109–123. https://doi.org/10.22503/inftars.XVII.2017.4.2

Feurstein, K., Hesmer, A., Hribernik, K., Thoben, T., & Schumacher, J. (2008). Living lab: A new development strategy. In *European Living Labs - A new approach for human centric regional innovation* (pp. 1–14). Berlin: Wissenschaftlicher.

Filtenborg, A. F., Gaardboe, F., & Sigsgaard-Rasmussen, J. (2017). Experimental replication: an experimental test of the expectancy disconfirmation theory of citizen satisfaction. *Public Management Review*, *19*(9), 1235–1250. https://doi.org/10.1080/14719037.2017.1295099

Flanagan, K., & Uyarra, E. (2016). Four dangers in innovation policy studies – and how to avoid them. *Industry and Innovation*, *23*(2), 177–188. https://doi.org/10.1080/13662716.2016.1146126

Fogelberg, H., & Thorpenberg, S. (2012). Regional innovation policy and public-private partnership: The case of Triple Helix Arenas in Western Sweden. *Science and Public Policy*, *39*(3), 347–356. https://doi.org/10.1093/scipol/scs023

Foray, D. (2020). Six additional replies – one more chorus of the S3 ballad. *European Planning Studies*, *8*(9), 1685–1690. https://doi.org/10.1080/09654313.2020.1797307

Foray, D., Goddard, J., Beldarrain, X. G., Landabaso, M., McCann, P., Morgan, K., … Ortega-Argilés, R. (2012). *Guide to Research and Innovation Strategies for Smart Specialization (RIS3)*. Luxembourg. https://doi.org/10.2776/65746

Galvao, A., Mascarenhas, C., Marques, C., Ferreira, J., & Ratten, V. (2019). Triple helix and its evolution: a systematic literature review. *Journal of Science and Technology Policy Management*, 2053–4620. https://doi.org/10.1108/jstpm-10-2018-0103

García-Terán, J., & Skoglund, A. (2018). A Processual Approach for the Quadruple Helix Model: the Case of a Regional Project in Uppsala. *Journal of the Knowledge Economy*.

https://doi.org/10.1007/s13132-018-0521-5

Gascó, M. (2017). Living labs: Implementing open innovation in the public sector. *Government Information Quarterly*, *34*(1), 90–98. https://doi.org/10.1016/j.giq.2016.09.003

Grimmelikhuijsen, S., & Porumbescu, G. A. (2017). Reconsidering the expectancy disconfirmation model. Three experimental replications. *Public Management Review*, *19*(9), 1272–1292. https://doi.org/10.1080/14719037.2017.1282000

Grundel, I., & Dahlström, M. (2016). A Quadruple and Quintuple Helix Approach to Regional Innovation Systems in the Transformation to a Forestry-Based Bioeconomy. *Journal of the Knowledge Economy*, *7*(4), 963–983. https://doi.org/10.1007/s13132-016-0411-7

Halinen, A., & Törnroos, J.-Å. (2005). Using case methods in the study of contemporary business networks. *Journal of Business Ethics*, *58*(9), 1285–1297.

Hietbrink, M., Hartmann, A., & Dewulf, G. (2012). Stakeholder Expectation and Satisfaction in Road Maintenance. *Procedia - Social and Behavioral Sciences*, *48*, 266–275. https://doi.org/10.1016/j.sbspro.2012.06.1007

Höglund, L., & Linton, G. (2018). Smart specialization in regional innovation systems: a quadruple helix perspective. *R&D Management*, *48*(1), 60–72. https://doi.org/10.1111/radm.12306

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

Hyysalo, S., & Hakkarainen, L. (2014). What difference does a living lab make? Comparing two health technology innovation projects. *CoDesign*, *10*(3–4), 191–208. https://doi.org/10.1080/15710882.2014.983936

Kronsell, A., & Mukhtar-Landgren, D. (2018). Experimental governance: the role of municipalities in urban living labs. *European Planning Studies*, 1–20. https://doi.org/10.1080/09654313.2018.1435631

Leminen, S. (2015). What are living labs? *Technology Innovation Management Review*, *5*(9), 187–188.

Marušić, B. G., & Erjavec, I. Š. (2020). Understanding co-creation within open space development process. In C. S. Costa, M. Mačiulienė, M. Menezes, & B. G. Marušić (Eds.), *Co-Creation of Public Open Places. Practice - Reflection - Learning* (pp. 17–21). Lisbon: Lusofona University Press. https://doi.org/10.24140/2020-sct-vol.4

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

McAdam, M., & Debackere, K. (2018). Beyond "triple helix" toward "quadruple helix" models in regional innovation systems: implications for theory and practice. *R&D Management*, *48*(1), 3–6. https://doi.org/10.1111/radm.12309

McAdam, M., Miller, K., & McAdam, R. (2018). Understanding Quadruple Helix relationships of university technology commercialisation: a micro-level approach. *Studies in Higher Education*, *43*(6), 1058–1073. https://doi.org/10.1080/03075079.2016.1212328

Menny, M., Voytenko Palgan, Y., & McCormick, K. (2018). Urban living labs and the role of users in co-creation. *GAIA*, *27*, 68–77. https://doi.org/10.14512/gaia.27.S1.14

Miller, K., McAdam, R., & McAdam, M. (2018). A systematic literature review of university technology transfer from a quadruple helix perspective: toward a research agenda. *R&D Management*, *48*(1), 7–24. https://doi.org/10.1111/radm.12228

Nesti, G. (2017a). Co-production for innovation: the urban living lab experience. *Policy and Society*, 1–16. https://doi.org/10.1080/14494035.2017.1374692

Nesti, G. (2017b). Living Labs: A New Tool for Co-production? In A. Bisello, D. Vettorato, R. Stephens, & P. Elisei (Eds.), *Smart and Sustainable Planning for Cities and Regions* (pp. 267–281). Springer.

Nordberg, K. (2015). Enabling regional growth in peripheral non-university regions—The impact of a quadruple helix intermediate organisation. *Journal of the Knowledge Economy*, *6*(2), 334–356. https://doi.org/10.1007/s13132-015-0241-z

Oliver, R. L. (1980). A Cognitive Model of the Antecedents and Consequences of Satisfaction Decisions. *Journal of Marketing Research*, *17*(4), 460–469.

Oliver, R. L., & Burke, R. R. (1999). Expectation processes in satisfaction formation: A field study. *Journal of Service Research*, *1*(3), 196–214. https://doi.org/10.1177/109467059913002

Palomo-Navarro, Á., & Navío-Marco, J. (2018). Smart city networks' governance: The Spanish smart city network case study. *Telecommunications Policy*, *42*(10), 872–880. https://doi.org/10.1016/j.telpol.2017.10.002

Parker, C., & Mathews, B. P. (2001). Customer satisfaction: Contrasting academic and consumers' interpretations. *Marketing Intelligence & Planning*, *19*(1), 38–44. https://doi.org/10.1108/02634500110363790

Puerari, E., De Koning, J. I. J. C., Von Wirth, T., Karré, P. M., Mulder, I. J., & Loorbach, D. A. (2018). Co-creation dynamics in Urban Living Labs. *Sustainability*, *10*(6). https://doi.org/10.3390/su10061893

Rizzo, A., Habibipour, A., & Ståhlbröst, A. (2021). Transformative thinking and urban living labs in planning practice: a critical review and ongoing case studies in Europe. *European Planning Studies*. https://doi.org/10.1080/09654313.2021.1911955

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

Salomaa, M. (2019). Third mission and regional context: assessing universities' entrepreneurial architecture in rural regions. *Regional Studies, Regional Science*, *6*(1), 233–249. https://doi.org/10.1080/21681376.2019.1586574

Schuurman, D. (2015). *Bridging the gap between Open and User Innovation? Exploring the value of Living Labs as a means to structure user contribution and manage distributed innovation*. Ghent University & Vrije Universiteit Brussel. Retrieved from https://biblio.ugent.be/publication/5931264/file/5931265.pdf

Terstriep, J., Rehfeld, D., & Kleverbeck, M. (2020). Favourable social innovation ecosystem(s)?–An explorative approach. *European Planning Studies*. https://doi.org/10.1080/09654313.2019.1708868

Tödtling, F., & Trippl, M. (2005). One size fits all?: Towards a differentiated regional innovation policy approach. *Research Policy*, *34*(8), 1203–1219. https://doi.org/10.1016/j.respol.2005.01.018

Tödtling, F., Trippl, M., & Desch, V. (2021). New directions for RIS studies and policies in the face of grand societal challenges. https://doi.org/10.1080/09654313.2021.1951177

Vallance, P., Tewdwr-Jones, M., & Kempton, L. (2020). Building collaborative platforms for urban innovation: Newcastle City Futures as a quadruple helix intermediary. *European Urban and*

Regional Studies, 1–17. https://doi.org/10.1177/0969776420905630

Van Geenhuizen, M. (2013). From ivory tower to living lab: Accelerating the use of university knowledge. *Environment and Planning C: Government and Policy*, *31*(6), 1115–1132. https://doi.org/10.1068/c1175b

Van Ryzin, G. G. (2004). Expectations, performance, and citizen satisfaction with urban services. *Journal of Policy Analysis and Management*, *23*(3), 433–448. https://doi.org/10.1002/pam.20020

Vigoda, E. (2002). From responsiveness to collaboration: Governance, citizens, and the next generation of public administration. *Public Administration Review*, *62*(5), 527–540. https://doi.org/10.1111/1540-6210.00235

Vilariño, F., Karatzas, D., & Valcarce, A. (2018). The Library Living Lab: A Collaborative Innovation Model for Public Libraries. *Technology Innovation Management Review*, *8*(12), 17–25. https://doi.org/10.22215/timreview/1202

Vitale, T. (2010). Building a shared interest. Olinda, Milan: social innovation between strategy and organisational learning. In F. Moulaert, F. Martinelli, E. Swyngedouw, & S. González (Eds.), *Can Neighbourhoods Save the City? Community Development and Social Innovation* (pp. 81–92). Routledge.

Von Schnurbein, G. (2010). Foundations as honest brokers between market, state and nonprofits through building social capital. *European Management Journal*, *28*(6), 413–420. https://doi.org/10.1016/j.emj.2010.06.008

Von Wirth, T., Fuenfschilling, L., Frantzeskaki, N., & Coenen, L. (2019). Impacts of urban living labs on sustainability transitions: mechanisms and strategies for systemic change through experimentation. *European Planning Studies*, *27*(2), 229–257. https://doi.org/10.1080/09654313.2018.1504895

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. https://doi.org/10.1016/j.jclepro.2015.08.053

Yin, R. K. (2003). *Case Study Research. Design and Methods* (Third). SAGE Publications.

Paper 3. Collaborative Public Sector Innovation as a Quadruple Helix Model? Insights from Denmark

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Abstract

This paper connects the related yet currently separate debates on collaborative public sector innovation and helix models of innovation systems regarding actors and their interdependencies to stimulate innovation. In particular, it explores to what extent the Quadruple Helix model (government-university-industry-civil society) is applicable to public sector innovation. The findings draw from mixed data sources, including a survey and interviews in Danish municipal workplaces. Overall, there were more municipalities that considered all the Quadruple Helix actors in the innovation process than only the Triple Helix (i.e. excluding civil society as actors or factors). Nevertheless, including citizens in ways that allow them to meaningfully influence decision-making remains complex, with several changes and challenges involved.

Keywords: citizen engagement; collaborative innovation; local governments; public sector innovation; Quadruple Helix

1 Introduction

Governments across the globe have been under pressure to effectively respond to socioeconomic challenges and better delivery of public services whilst improving resource efficiency, especially in turbulent times (Lewis et al., 2018; Szkuta et al., 2014). To this end, policy interest in stimulating innovation in the public sector is increasing (Arundel et al., 2019). Innovation, which is understood to comprise new or significantly changed practices of organisations, has been growing substantially as a research field in the public sector since the late 1990s (De Vries et al., 2016; Hartley, 2005).

In the wake of the 'new public governance' approach, it is widely acknowledged nowadays that multi-actor interaction is a key driver of public sector innovation (Lopes & Farias, 2020; Osborne, 2010). This notion is at the core of 'collaborative innovation', a promising research agenda to enhance public management performance and theories (Bekkers & Tummers, 2018; Sørensen & Torfing, 2011). In contrast to the conventional practice and view, the collaborative strategy argues that the participation of different actors, who (i) have the expertise and/or (ii) are influenced by the problems/solutions, is pertinent to understanding and addressing increasingly complex matters (Hartley et al., 2013; Torfing, 2019). Dealing with the 2019 Coronavirus pandemic is the most recent example.

Despite a growing number of studies on collaborative innovation in the public sector (e.g. Special Issue by Bekkers & Tummers, 2018), Wegrich (2019, p. 7) contended the concept to be 'too broad' to benefit public organisations. Public sector innovation and its sources remain under-theorised (Clausen et al., 2020; De Vries et al., 2016). In particular, it continues to be unclear which actors could assist public organisations in improving their performances and dealing with complex challenges (Clausen et al., 2020; Torfing, 2019). This resonates with the constant suggestions that insights from different literature strands are essential to shaping the theoretical progress of public sector innovation (Bekkers & Tummers, 2018; Bloch & Bugge, 2013; Bryson et al., 2015).

From this perspective, the innovation system theory is beneficial considering its advantages in exploring actors and their interdependencies for innovation purposes (Edquist & Hommen, 1999; Lundvall, 2010). Since the mid-1990s, the Triple Helix model has become

a popular heuristic that guides empirical research in innovation systems (Etzkowitz & Leydesdorff, 2000; Leydesdorff & Etzkowitz, 1996). It indicates the non-linear interactions among three key actors, namely, government, industry and university, in the knowledge economy. Much has been written seeking to advance the theory and applicability of the Triple Helix. To address some criticisms of the Triple Helix approach, there has been a recent request to facilitate the former's evolution into a Quadruple Helix approach, urging for civil society participation in the knowledge creation and innovation process (Carayannis & Campbell, 2012; MacGregor et al., 2010). The presence of societal groups is expected to offer various types of innovation with broad public value beyond technological focus (European Commission, 2010; Nordberg, 2015), especially for governments, which are supposed to serve their corresponding civil society.

Although the idea of the Quadruple Helix was posited as early as 2003 (Leydesdorff, 2012; Leydesdorff & Etzkowitz, 2003), it is remarkably difficult to identify empirical cases where citizens and civil society organisations (CSOs) have been institutionally weaved into innovation activities of both public and private organisations. Citizens and CSOs, as a new type of actors considered in an innovation context, are likely to bring distinct interests and new dynamics, either positively or negatively, to existing partnerships and organisational structures. Their impact should be subjected to close scrutiny, critically starting with the consideration of each initial helix's nature (Benneworth et al., 2020).

This paper presents the first investigation that brings together the two currently separated-yet-related research lines, namely, (i) collaborative innovation in the public sector and (ii) the evolution from the Triple to Quadruple Helix model in innovation systems. It seeks to address the following exploratory research question: 'To what extent is the Quadruple Helix model applicable to public sector innovation?' This question is approached in two parts:

- Sub-question 1: With whom and in which helix models do public organisations interact in the innovation process?

- Sub-question 2: How do public organisations organise citizen engagement in their innovation activities?

The questions were explored with mixed methods in a Danish context. The survey results suggest that citizens and CSOs played significant roles in public sector innovation processes. Among the respondents, a considerable number of innovative municipal workplaces considered all four actors (i.e. a broad Quadruple Helix approach) and not only three (i.e. a broad Triple Helix approach) in initiating, co-developing and promoting innovation. Interviews relating to a specific municipality further identified key external and internal factors that influenced the municipality's efforts in engaging citizens. The paper concludes with a discussion of the changes and challenges public organisations are likely to face when incorporating citizens into their innovation activities.

2 Theoretical Background

2.1 From the Triple to Quadruple Helix model: The emerging debate in innovation theory and policy

The discussion on the Quadruple Helix originated from the Triple Helix of university-industry-government relations (Etzkowitz & Leydesdorff, 2000; Leydesdorff, 2012). In the initial model, each partner may contribute differently: the university offers new knowledge sources, the industry is the main focus for production, and, finally, the government provides regulatory support for collaborations (Etzkowitz, 2008). The potential sources of innovation lie in the hybridisation of activities where actors do not only play their traditional roles but also take on new roles or 'take the role of the other' (Etzkowitz, 2008, p. 9). Equally important, a third helix presumably serves as a *tertius gaudens* that mediates the relationship by easing the likely tensions in a bilateral interaction because of either 'hype-agreement' or 'excessive conflict' (Etzkowitz, 2008, p. 25). The Triple Helix has been used to intensively improve knowledge production and innovation generation in the science and technology development of the knowledge economy (Etzkowitz & Leydesdorff, 2000; Trousset, 2014).

Several scholars argue that the Triple Helix model overlooks the roles of other actors who might be the driving forces in the innovation systems (Bunders et al., 1999; Jensen & Trägårdh, 2004). Accordingly, a line of research has extended the model to the Quadruple Helix by subsuming the *fourth helix* in the knowledge creation and innovation process (Höglund & Linton, 2018; Leydesdorff, 2012). Among various candidates, most studies urge

the inclusion of civil society, such as citizens and CSOs, to promote knowledge democracy (Carayannis & Campbell, 2012) and bring societal needs into the innovation system (Jensen & Trägårdh, 2004; MacGregor et al., 2010). While civil society may not be absolutely disregarded in the Triple Helix model, 'society' or 'the public' is supposed to serve as the foundation of innovation, which the Triple Helix emerges from and operates within, rather than being an independent helix (Leydesdorff & Etzkowitz, 2003). In this sense, the role of civil society in innovation has been abstract and not explicit under the Triple Helix model. Transforming to the Quadruple Helix requires a meaningful engagement of civil society in the innovation process, which may require the acknowledgement of civil society as an explicit helix.

There has been a noticeable extension from the Triple to Quadruple Helix in European innovation policy discourse (Foray et al., 2012) that targets sustainable and inclusive place-based growth (European Commission, 2010), going beyond the industry and technology focus. Nevertheless, the Quadruple Helix remains a normative model and policy rhetoric. It is not yet known whether a shift to the Quadruple Helix would help deal with the major concerns of the Triple Helix: addressing partnerships' tensions and applying the model to the wide-ranging development of different contexts (Benneworth et al., 2015; Jensen & Trägårdh, 2004). In practice, although the role of civil society in innovation and local development is perceived to be important, this system change has proven to be quite challenging (Nguyen & Marques, 2021). In any case, it requires a better understanding of how each original helix with distinct institutional logics and nature deals with and shapes this enlarged collaboration (Benneworth et al., 2020). From this perspective, examining the Quadruple Helix's relevance to public organisations and public sector innovation is crucial yet under-investigated.

2.2 Collaborative innovation in the public sector

Collaborative innovation in the public sector is defined to be 'a process of creative problem solving through which relevant and affected actors work across formal institutional boundaries to develop and implement innovative solutions to urgent problems' (Sørensen & Torfing, 2018, p. 394). Some of the critical questions posed to public organisations are who these *relevant and affected actors* could be and how they should interact. These actors and

their interactions are certainly diverse. For instance, Barrutia and Echebarria (2019) categorised external actors of municipalities into three main groups: (i) higher tiers of government (e.g. regional and national governments), (ii) peers (e.g. other municipalities), and (iii) local stakeholders (e.g. businesses, civil society).

Among those, the discussion on civil society participation, as addressed under the Quadruple Helix discourse and in innovation studies generally, is not fundamentally new. Citizens have long been at the centre of public administration, and their roles are far more complex than being pure users of innovation (Siebers & Torfing, 2018; Strokosch & Osborne, 2020). Primarily, democracy and politics are ineluctable aspects when studying the relations between citizens and governments. In a liberal representative democracy, the citizens are voters who exercise a controlling function through regular elections (Røste, 2005; Vigoda, 2002). Legitimately, the elected representatives (i.e. politicians) formulate public policies, which are the choices made on behalf of citizens; thereafter, civil servants implement them (Bach et al., 2012; Mintrom, 2012). Furthermore, citizens as taxpayers could also put further pressure to enjoy better public services. However, it has been observed that this representative model of democracy is facing a crisis nowadays, as political parties often fail to satisfy citizens' demands (Sønderskov, 2020). This concern has raised interest in enabling more direct citizen participation in policy-making and decision-making processes.

From an administrative perspective, the ethos of citizens' roles and inclusion has changed substantially. Together with this change, the interactions towards the innovation of governments and other stakeholders also vary (Hartley, 2005; Siebers & Torfing, 2018). Public organisations have experienced three main paradigms: classical public administration, new public management (NPM) and new public governance (NPG) (Table 1). These paradigms are contested by scholars and practitioners in the public sector, with each paradigm possessing different advantages and disadvantages (Osborne, 2010).

Table 1. Citizens and helix collaboration in public management paradigms.

Paradigms	**I. Classical Public Administration**	**II. New Public Management**	**III. New Public Governance**
Role of citizens	Clients	Customers	Partners/Co-creators
Role of governments	Legal authorities	Service providers	Promoters of the co-creation arena
Governmental strategy	Authoritative: State- and producer-centred	Competitive: Market- and customer-centred	Collaborative: Civil society-driven
Types of interactions	Intra-organisations	Inter-organisations: partnerships, networks, etc.	
		• Contracting and tendering • Public-private partnership	• Public-private-people partnership
Helix collaborative approach	None	Triple Helix	Quadruple Helix

Source: Author's elaboration based on Hartley (2005), Sorrentino et al. (2018) and Torfing et al. (2019)

In the first paradigm, which was popular up to the early 1980s, the public is considered 'fairly homogenous' and passive as the client of public services (Hartley, 2005). Meanwhile, governments are originally regarded as (Weberian) bureaucratic organisations that operate with formal jurisdictional competencies (Kornberger et al., 2017; Weber, 2019). Accordingly, governments are legal authorities that regulate people's behaviours and other mandating areas to spur economic growth and maintain social order (Torfing et al., 2019). Given such central roles of the bureaucracy in policy making and implementation as per the classical public administration (Osborne, 2010), a close intra-organisational hierarchical system is advocated rather than interacting with external actors (Agger & Sørensen, 2018).

Since the 1980s, public organisations have undergone massive reforms with a common emphasis on opening to the external world, following NPM and NPG approaches. NPM originally emerged under the influence of business-inspired management techniques and neo-liberal economics (Hartley, 2005; Siebers & Torfing, 2018). In this context, citizens are considered customers with specific needs, and they should have more choices of using public or private service providers. Thus, public organisations are expected to be competitive and responsive, seeking to improve efficiency and, ultimately, citizen satisfaction. Practices such

as contracting, outsourcing and tendering started being considered, with the aim of inviting private suppliers to participate in supplying public services.

During the 2000s, several authors raised two main concerns about the ways that NPM shaped the roles of citizens (Pestoff, 2006; Vigoda, 2002). First, the market-driven approach in NPM overlooked the value of 'citizenship' because citizens as voters and taxpayers should be able to exert their influence on governments to improve public service quality. Second, being customers under the NPM, citizen contribution remained limited, such as only evaluating the performance of public services/infrastructures. Accordingly, the NPG approach that has been predominant since the 2010s proposes that citizens are not only actors with voices that need to be heard and with interests to be met but also partners or co-creators who possess critical resources to be mobilised (Osborne, 2010; Siebers & Torfing, 2018). Therefore, public organisations should be collaborative (Vigoda, 2002) and promote an arena of co-creation that facilitates multi-actor collaborations (Torfing et al., 2019). This approach is notably relevant in dealing with increasingly complex issues.

From the above, NPM and NPG are derived from different underlying rationales, wherein collaborative innovation is typical under the latter approach. Nevertheless, there is not always a clear-cut difference between these two paradigms since many collaborations in the form of partnerships and networks theoretically and practically appear to maintain strong market logics, as per NPM. The emergence of multilateral public-private-people partnerships (e.g. Maraña et al., 2020) acknowledging the increasing importance of citizen engagement can be the manifestation of helix models.

In any case, the bilateral public-private partnerships between governments and businesses have been well-investigated in extant public management literature (Brogaard, 2019; Pestoff, 2006). Yet, the helix models are largely underexplored in general, particularly in relation to collaborative public sector innovation. One of the plausible explanations for this deficit is the limited understanding of universities' contributions to public sector innovation, with few articles such as Demircioglu and Audretsch (2019). At the same time, citizen engagement also faces many challenges (Strokosch & Osborne, 2020).

2.3 Citizen engagement: The key challenge of governments

Collaboration is a viable strategy to generate holistic solutions from the pool of diverse information and knowledge (Hofstad & Torfing, 2015). Promoting collaboration is potentially beneficial for public organisations in several ways, such as sharing risks and overcoming institutional attention biases (Huxham & Vangen, 2005; Sørensen & Torfing, 2011; Wegrich, 2019). Nevertheless, collaborations among multi-actors are extremely complex, with a high rate of failure. This raises the question of the serendipitous effectiveness of collaboration in promoting public sector innovation (Godenhjelm & Johanson, 2018; Vangen et al., 2015). Cinar et al. (2019) revealed that in undertaking public sector innovation processes, interactions with different partners, especially with citizens, are the most frequent challenges reported by public organisations.

The practice of citizen engagement, a common interest under the collaborative innovation and the Quadruple Helix, is hitherto challenging for several reasons (Strokosch & Osborne, 2020). First, a linear model of service production remains prevalent in the innovation process. Actors from the production and consumption sides are perceived to play different roles, wherein citizens, as consumers, are rarely engaged in initiating and developing solutions. Second, and in relation to this point, power asymmetries between (Triple Helix) organisations and citizens exist, which may prevent citizens from participating in the collaboration (Vigoda, 2002). Third, changes in structure, such as partnerships and networks, have failed to embed citizen participation. Lastly, although increased participation of citizens under the NPG has recently been called for (Torfing et al., 2019), its efficacy is subject to further investigation. Recent analyses point out that while local politicians support citizen participation in policy and service processes, 'they are uncertain about the extent to which it is feasible or desirable to collaborate more directly with citizens in such processes [… considering] the costs and risks are too high compared to possible gains' (Sønderskov, 2020, p. 15).

New innovation sources and/or their new combinations require adaptable working mechanisms (von Hippel, 1988; Waardenburg et al., 2020), which is likely the case for the Quadruple Helix. The shift from viewing citizens as pure users to partners in innovation processes demands a more systematic approach from public sector organisations, such as

new structures and instruments, to build innovation and leadership capabilities for engagement success (Szkuta et al., 2014; Torfing et al., 2019). This task is particularly challenging for public organisations because of the competing managing logics between public bureaucracies conventionally based on hierarchical relationships and collaborative innovations seeking a horizontal distribution of authorities among stakeholders (Agger & Sørensen, 2018).

3 Research Context and Methodology

This paper is designed as an exploratory research using parallel mixed-data sources, namely, a survey and interviews (Mele & Belardinelli, 2019), in a Danish context to explore the research domains discussed above.

3.1 Research context: Denmark

Denmark has expressed a strong commitment to innovate and make the administrative system accessible to and collaborative with the public (Bouckaert & Kuhlmann, 2016). The country holds a decentralised welfare state, a well-organised civil society and traditionally autonomous citizens. Thus, a close relationship between governments and citizens is expected (OECD, 2000), and citizens tend to find it worthwhile to engage with local decision-makers to influence outcomes (Siebers & Torfing, 2018). By contrast, some pieces of empirical evidence suggest that Denmark has a relatively low rate of co-creation with citizens compared with other studied countries, as exemplified by a high satisfaction rate of citizens towards public services (Ongaro & van Thiel, 2018).

Local governments (municipalities) are selected to be the unit of analysis of the research for three main reasons. First, they are the closest level of government to the citizenry, making them a likely site for collaborative innovation (Lewis et al., 2018). In 2007, Denmark experienced a national administrative reform, which reduced 271 municipalities in 14 counties *to* 98 municipalities in five regions (Ministry for Economic Affairs and the Interior, 2014). Following this reform and the 2012–2013 reform evaluation, Danish municipalities, like those in several countries, are now in charge of most citizen-related service delivery tasks, such as eldercare, education and environmental care. Second, although Denmark has

traditionally been a slow-moving country in establishing partnerships with the private sector, the number of those partnerships is rising at the local government level (Warsen et al., 2020). The tendency of local governments to collaborate with citizens has increased substantially since 2013 (Reiermann, 2017). This suggests that local governments tend to become more flexible and/or there is a real need for them to collaborate with external partners. Third, the role of municipalities has been proven significant in orchestrating collective efforts from different stakeholders (Kronsell & Mukhtar-Landgren, 2018). Yet, local governments are not always familiar with their governance position, a fact that has raised calls for further research (Span et al., 2012).

3.2 Validity, reliability and generalisability

The mixed-data source collection in this research allows the triangulation of evidence and reinforcement of the validity and reliability of findings. Primary and secondary data include interviews, surveys and other public communication that produce a holistic examination of the Quadruple Helix's applicability in public sector innovations in Denmark.

The role of civil society and other interest groups in public administration differs among countries where political systems should be considered (Brandsen et al., 2017). Denmark traditionally follows a corporatist democracy model, in which 'interest groups are integrated into the preparation and/or implementation of public policies' (Christiansen et al., 2010, p. 22). As the interest groups' involvement is institutionalised, the interaction between the privileged interest groups and governments may be greater in corporatist countries than in pluralist ones (Fisker, 2015). However, on the one hand, citizen groups do not necessarily belong to such privileged groups in corporatist systems (Christiansen et al., 2018). On the other hand, other privileged inclusion ways are found in almost all political systems, including pluralist ones (Fisker, 2015). These arguments support that although the differences among countries remain, the public administration changes have seen some convergence between previously distinct systems of corporatist and pluralist (Hunold, 2001).

Thus, the research concerns and results in this study are potentially generalisable to other countries, not only to corporatist ones such as Scandinavia but also to pluralist ones such as Spain. It is especially relevant in Europe, where the contemporary innovation policies largely

share a system perspective that promotes a wide range of actors and interactions in place-based innovation systems. Nevertheless, one should note that this research was conducted before the latest Danish policy reform in 2019 that was 'shaped by a return to a more neo-classically inspired market failure perspective' (Drejer & Christensen, 2021, p. 70). This change may affect the actors and their interactions in innovation systems. At the same time, decentralised structure and localised responsibility indicate that municipalities innovate and respond to public reforms in different ways (OECD, 2000). Taking into consideration the differences among regions and cities is advised.

3.3 Quantitative data source and analysis

To quantify the proportion of organisations that considered the Quadruple Helix actors during their innovation process, a quantitative data source was utilised. Thus, the quantitative results[11] draw on the 2015–2016 public sector innovation survey in Denmark, namely, the Innovation Barometer conducted by Statistics Denmark and The National Centre for Public Innovation (*Center for Offentlig Innovation* – COI[12]). The respondents were mostly managers from 2,363 (out of a sample size of 4,765) public administration and service workplaces covering all governmental levels (i.e. national, regional and local). The survey was self-reported with a superior response rate of 50 percent compared with other similar research (Thøgersen et al., 2020).

In the survey conducted in 2017, innovation was defined as 'a new or significantly changed way to improve the workplace's activities and results' (COI & Statistics Denmark, 2019, p. 6), inspired by the 'Oslo Manual' guideline (2005) by the Organisation for Economic Cooperation and Development (OECD) and European Statistical Office (Eurostat). The innovations should be new to the workplace but could already be implemented elsewhere or developed by others. Below, the four types of innovation considered in the survey are presented, with added examples of innovation for each type (COI, 2018):

[11] The tables (2–4) based on the survey, which are shown in the following section, are generated by Ina Drejer from Aalborg University as part of a collaboration during the author's time as a visiting researcher at Aalborg University.
[12] Since 2022, COI has been called The National Centre for Public-Private Innovation (*Center for Offentlig-Privat Innovation* – CO-PI).

- Products: for example, diapers with a sensor to improve the quality of life of citizens with urinary incontinence;
- Services: for example, digital services to help reduce citizens' tax arrears;
- Processes or organisations (ways of organising work): for example, adopting a design process of medication administration in nursing homes; setting up a cross-disciplinary youth centre to support vulnerable young people get an education; and
- Communication (ways of communicating with the outside world): for example, using text messages to ask citizens to call and book dental appointments (as opposed to the standard system where citizens are just allocated an appointment); this is a means of reducing patient non-appearance and, hence, saving costs.

The present paper focuses on the dataset of 1,771 municipal workplaces representing 57 Danish municipalities. The research is primarily concerned with descriptive inference to provide an overview of collaborative innovation in local governments, considering the normative nature of the Quadruple Helix model. It seeks to offer a foundation for further investigation in both qualitative and quantitative approaches.

3.4 Qualitative data source and analysis

As citizen engagement is the key element of the Quadruple Helix model, understanding how to organise citizen engagement is crucial for the potential Quadruple Helix functioning. In addition to the analysis of survey data, an in-depth case study of Aalborg municipality has been conducted to gain insights on organising citizen engagement for public sector innovation. Aalborg is the main city in North Denmark, the least populous region among the five Danish ones. With 217,075 inhabitants as of 2020, Aalborg municipality accounts for more than one-third of the population in its region and is among the three largest municipalities in Denmark (Statistics Denmark, n.d.). More than half of the municipality's population lives in the city of Aalborg. Aalborg municipality is known among European cities for its sustainability commitment, with two international agreements holding its name: the Aalborg Charter (1994) and Aalborg Commitments (2004).

Aalborg municipality is selected because of its serious efforts in 'co-creating' with different actors to build a smart and sustainable city (Aalborg Kommune, 2016). Citizens

have been designated as the focus of the 2016–2020 sustainability strategy, in which the city development is intended to be not only *for* citizens but also *with* them. Other helices in Aalborg are strongly visible, comprising Aalborg University (AAU), University College Nordjylland and industry, including 9,523 companies with at least one employee by the end of 2019 (Aalborg Kommune, 2020). The local industry is dominated by small and medium-sized enterprises. The largest sector is the wholesale/retail trade and transport sector.

The primary qualitative data included 17 semi-structured interviews conducted in the spring of 2018 and 2019, with a total of 21 actors who understood or were actively engaged in collaborative innovations between the municipality and any other helix actors. The interviewees were identified in two rounds. The first round of sampling involved the reference from public information (e.g. municipal webpage) and the author's relationship. Next, a snowball technique was employed to contact potential interviewees recommended by the previous respondents. Thus, several interviewees were involved in the same collaboration, allowing for the triangulation of some of their responses. Among those, nine interviews were with 11 municipal employees (coded as Gov1–Gov11), covering six out of seven administrative departments (Figure 1). Among these departments, the mayor's department oversees general issues, such as business development, smart city and international relations. Eight remaining interviews were with 10 external stakeholders: seven academics from AAU (Aca1–7), two intermediary organisations, including a cluster organisation and a co-creation centre (IO1 & IO2), and, lastly, one CSO. Two companies were recommended by the interviewees and contacted. Despite initial positive responses, it turned out to be unachievable to arrange interviews with these actors.

All interviews were face-to-face at the interviewees' workplaces, except for one, which was conducted in the form of correspondence as requested by the respondent. The interviews were an average of 54 minutes each, and they were recorded and transcribed verbatim. Secondary data included available information on the municipality's web pages, public videos and leaflets.

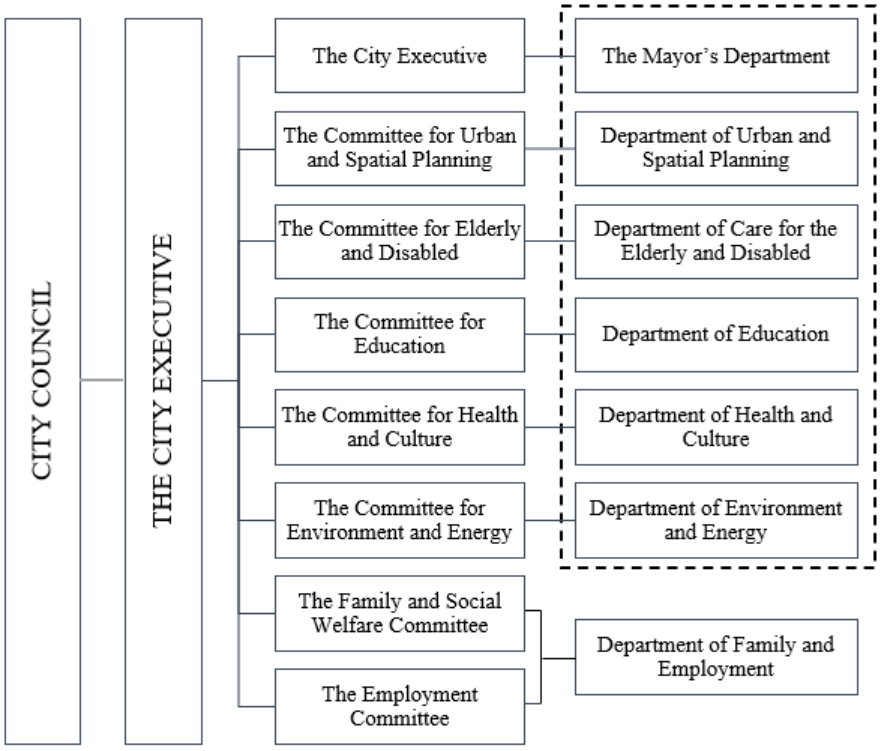

Figure 1. Political and administrative organisation of Aalborg Kommune.

Source: Adapted from Aalborg Kommune (2018). Legend: - - - - Interviewed workplaces.

The interview protocol included the following questions: *(i)* Why did the municipality initiate a collaborative innovation process with external stakeholders and what were the main strengths of the municipality in engaging in such collaborative processes? *(ii)* How and with whom did the municipality organise the collaborations, and were there any necessary changes in structures and human resources? *(iii)* Were the citizens engaged? If yes, which types of citizens and what promoted their engagement? If not, why?

Municipalities were the central investigation unit. Data analysis was iteratively conducted in sets starting with the municipal interviewees, followed by the collaborators in other helices (if any). The data structure was explored using a thematic technique (Braun & Clarke, 2006) and visualised accordingly (Gioia et al., 2012), as presented in Figure 2. In each interview, the respondents' relevant narratives were inductively coded and assigned into themes, which were finally related to aggregate dimensions that provided the main elements to answer the research question. While the codes were close to the interviewees' terms and expressions, the themes were adjusted from the semi-structured interview guideline.

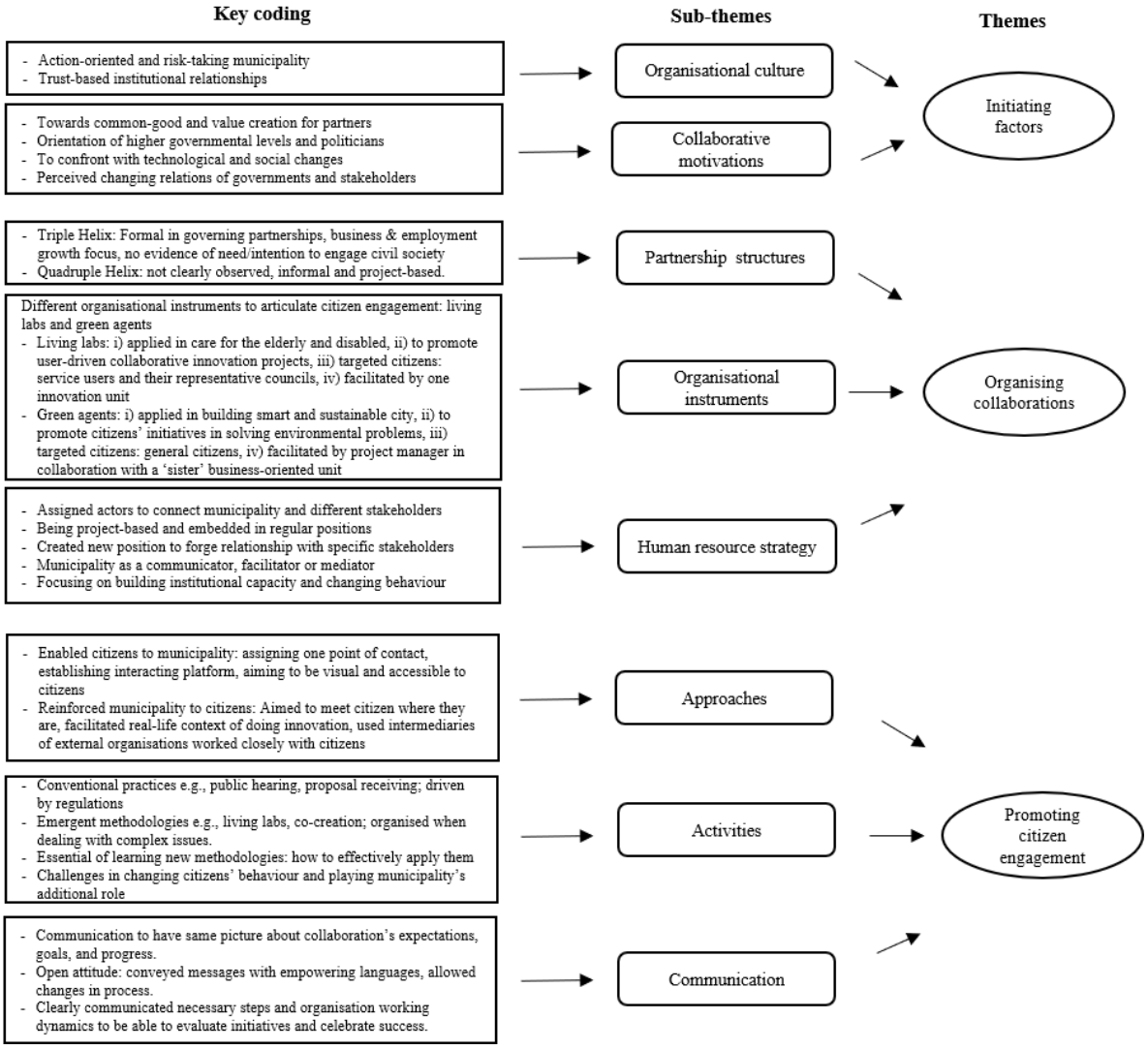

Figure 2. Data structure for exploring changes in a municipality's collaborative innovation practices.

4 Findings

4.1 Interacting actors in public sector innovation processes of Danish local governments

The degree of innovativeness was high among Danish municipalities because 1,436 out of 1,771 municipal respondents, equivalent to 81.1%, reported that their workplaces introduced at least one innovation during 2015–2016. Most workplaces reported more than one type of innovation. Among the introduced innovations, new or significantly improved processes/ways of organising work were the predominant type reported by 72.7% of the innovative municipal workplaces. Meanwhile, product innovation was the least frequent type

(24%). The percentages of innovations in service and communication were equal at 35.7% for both types.

Table 2 presents the frequencies of the innovative municipal workplaces that interacted with other Quadruple Helix actors on their latest innovation. The Quadruple Helix actors in the survey are categorised as: (i) *initiating (f)actors*; (ii) *collaborating/co-developing actors*; and (iii) *promoting factors* (or innovation drivers - another interpretation recommended by COI) if the actors, to a great or some extent, promoted the innovation (as opposed to hindering it).

Table 2. Interacting actors by Danish innovative municipal workplaces (obs.=1,436), 2015–2016.

Other Quadruple Helix actors	**Selected from the survey**	**Initiating (f)actors**		**Collaborating/Co-developing actors**		**Promoting factors**	
		n	*%*	*n*	*%*	*n*	*%*
Business	Private companies (e.g. consultants, suppliers, other private partners)	23	1.6%	328	22.8%	274	19.1%
Academia	Higher education and research institutions	78	5.4%	201	14.0%	461	32.1%
Civil society	(i) Citizens (ii) Voluntary associations/organisations	137	9.5%	390	27.2%	863	60.1%

Among the Quadruple Helix actors, civil society was the most frequent actor or factor in relation to the municipality's latest innovation. Civil society actors were the most frequent type of helix as collaborating partners in the latest innovation development (27.2%), the most frequent actors or factors leading to innovation initiation (9.5%) and the most frequent promoting factors of innovation perceived by respondents (60.1%). Academia was the least frequent collaborating partner of innovative workplaces, as revealed by 14% of the respondents, while being the second most frequent type of helix perceived as initiating and promoting factors of innovation (5.4% and 32.1%, respectively). By contrast, business was the least frequent helix actor type identified as initiating and promoting factors of innovation (1.6% and 19.1%, respectively). Yet, the percentage of innovation processes where businesses collaborated with municipalities on developing innovations was relatively high (22.8%) and only 4.4 percentage points lower than civil society.

The survey data allowed the quantification of the proportion of public organisations that interacted in the helix models during the process of the latest innovation (Table 3). Triple Helix cases referred to municipal workplaces that worked with businesses and academia and *without* civil society. In addition, Quadruple Helix cases also referred to municipal workplaces that worked with businesses and academia and *with* civil society.

Table 3. Frequencies of Triple Helix and Quadruple Helix cases.

	Innovative municipal workplaces (obs. = 1.436)	
	No.	*%*
Narrow Triple Helix (excluding civil society)	27	1.9%
Narrow Quadruple Helix	25	1.7%
Broad Triple Helix (excluding civil society)	45	3.1%
Broad Quadruple Helix	154	10.7%

Based on the formulated survey questions, among the three categories of initiating, developing and promoting innovation, there was a high possibility that stakeholders as collaborating *actors* during innovation development contributed actively. The extent of stakeholders' active contribution was unclear in the two remaining categories of initiating and promoting innovation because stakeholders were only considered as *factors*. Thus, a narrow approach to helix models would strictly refer to the collaboration of all stakeholders in the actual development of the innovation. This approach generated a small number of observed collaborations, and there was no statistically significant difference between the occurrence of narrow Triple Helix and Quadruple Helix collaborations (less than 2% for each model).

Nevertheless, one may argue that if an actor is perceived to be one of the factors that initiated and promoted the workplace's innovation, this actor has an influence, either actively or passively, on the organisation's innovation practices. From this perspective, a broad approach to helix models involves taking into consideration the actors in the whole process, whether as collaborators or initiating/promoting factors of innovation. This broad approach yielded 45 Triple Helix and 154 Quadruple Helix cases, equivalent to 3.1% and 10.7% of innovative workplaces, respectively.

The literature suggests that the presence of social actors in Quadruple Helix settings might aim to produce different types and values of innovation beyond technological and commercial advantages, which are considered more likely to be associated with the Triple Helix set-up. Accordingly, a chi-square test was used to explore if the interaction approaches adopted by municipal workplaces might be statistically significant to the innovation characteristics (Table 4). The results showed that there was only a statistically significant difference between workplaces that embraced a broad Triple or Quadruple Helix in terms of the proportion that reported that citizens had obtained a greater influence on or insight into municipal tasks[13]. It indicated that innovations from municipal workplaces interacted in the broad Quadruple Helix settings are more likely to be associated with the citizens' greater influence on and insight into municipal tasks compared with innovations from municipal workplaces in the broad Triple Helix settings. This is coherent with the broad Triple Helix approach implying that citizens were excluded from the entire innovation process. One could reasonably conclude that if a workplace tends to ignore citizen (f)actors throughout the innovation process, the citizens will be less likely to have an influence on or be aware of the organisational tasks.

The cross-sectional survey data may raise concerns about selection bias in frequencies to participate in the survey across different types of public sector organisations, such as organisational size and subsector. The sample source was derived from Statistics Denmark's registries (Thøgersen et al., 2020) and the ways of generating weights were unknown. A bias check showed no significant difference between the weighted and unweighted responses on interacting partners of workplaces. However, it appeared to have a considerable difference in the perception of Triple Helix cases towards innovation types and partial innovation outcomes (i.e. 'improved quality' category). One explanation could be that the difference in data weight is larger when the sample size is small, which is the case of Triple Helix.

[13]A binary logistic regression [that considers describing the actual model] confirmed the results, with the exception that the broad Quadruple Helix is more likely to be associated with 'increased efficiency' compared with the broad Triple Helix, although this finding is only statistically significance at the 10% level.

Table 4. Types and outcomes of innovation between broad Triple Helix vs. Quadruple Helix cases.

	Broad Triple Helix (obs.=45)		**Broad Quadruple Helix** (obs.=154)		**Chi-square test** (*p*-value)
Types of innovation	***n***	***%***	***n***	***%***	
Products	18	40.0%	55	35.7%	0.600
Services	16	35.6%	71	46.1%	0.210
Processes	35	77.8%	119	77.3%	0.943
Communication	21	46.7%	61	39.6%	0.398
Outcomes of innovation	***n***	***%***	***n***	***%***	
Improved quality	37	82.2%	116	75.3%	0.334
Increased efficiency	18	40.0%	81	52.6%	0.137
Increased employee satisfaction	26	57.8%	86	55.8%	0.818
Citizens have obtained greater influence on or insight into the tasks we do	6	13.3%	78	50.7%	0.000***

Notes: ***p<0.001

4.2 Collaborative innovation: An in-depth municipal case

4.2.1 Initiating factors

The following section provides insights from the case of Aalborg municipality with an emphasis on the municipality's organisational culture and its motivations to initiate a collaboration with other Quadruple Helix actors.

4.2.1.1 Organisational culture

The interviewees indicated the favourable characteristics of the municipality to collaborate with on innovations. First, the municipality representatives described Aalborg as 'very action-oriented' in adopting new ideas and projects (Gov9). This characteristic implied both strength and weakness. As clarified by one of the respondents:

> [Being action-oriented] can be a good thing because we can easily and quickly see opportunities, but it can also be a weakness because sometimes, if we have not looked at all the details […], it can turn out not to be such a good idea or that we entered a cooperation too quickly.

In relation to this point, a tolerant attitude to risks and failures of the municipality was persistently acknowledged: ‘I think, generally, with the administration, we have a culture where [it is fine] to have some failures because you learn from them. That’s a very innovative approach’. (Gov10)

In addition, most interviewees emphasised the prevailing trust-based relationships among the municipality and stakeholders, reinforced by the diversity and proximity of local organisations. The Triple Helix approach was generally considered strong in Aalborg, as pointed out by a person working on the smart city framing: ‘One of our strengths is that we have very good relations and networks with the university and businesses. We have good networks locally and regionally’ (Gov9). The remark was reiterated and elaborated by others:

> I think we are very good at [collaboration] in Aalborg because we have a [suitable] size. We are big enough to have a university, a lot of companies and a rather large, strong municipality but small enough to be secure in the knowledge that we know each other because we meet each other on a lot of different occasions. (Gov6)

> [Building up trust] is one of our strengths because we are a small town. If we have a problem, [if] we have a lack of trust, we pick up the phone and call the one we have a problem with. […] So, we are quite close. (Gov7)

4.2.1.2 Collaborative motivations

There was a strong belief among interviewees in collaborating for the ‘common good’, which was local development and value creation for all partners. Collaborations between the municipality and other Quadruple Helix actors were thus often derived from the interests of both sides. A respondent summarised the vision and efforts of the municipality as follows:

> We could see more and more that it was important to try to put the right partners together for the benefit not only of the citizens we try to serve but also ours as an organisation and of the companies. Then, we also saw the need to try to cover it with universities and other knowledge institutions. (Gov2)

The collaborative strategy was aligned with the scheme of higher governmental levels and the orientation of politicians. The latter was particularly driven by a local contextualisation

to improve the competitiveness of the city:

> We facilitate those kinds of projects in 'open school', which is part of the school reform decided here in Denmark in 2014. […] As a school, you are supposed to, or you are demanded to, open up more towards the surrounding community and work together. (Gov10)

> The politicians think it's very important that in a small town like Aalborg, we should be very, very [*emphasising*] good at collaborating with the university, companies, municipality, and everybody in the city. (Gov6)

Furthermore, collaboration with different stakeholders was perceived as crucial to addressing the technological and administrative changes in the operating fields. These changes could be, for instance, digital development in the cultural domain or local specialisation demands in healthcare, health promotion and disease prevention:

> We formulated a strategy for developing the music scene in Aalborg from mid-2017. […] Young musicians said they needed a place or a helping hand […] because of the changes that the music industry has had over the last 20 years in streaming and so forth. (Gov5)

> The health system is changing, as it is in the world, I think, with more specialisation. Therefore, more tasks go to municipalities and local practitioners or whatever system you have […]. We need more knowledge. […] Municipalities have an interest in strengthening collaboration to draw more research into the municipal health service area. (Gov11)

Lastly, a changing perception of the relations between governments and external stakeholders led to a 'paradigm shift' in the way the municipality interacts with the stakeholders. In particular, companies and citizens were considered the municipality's partners who possessed the resources critical to addressing several public issues, such as sustainability. The 'partnership' set-up was partially propelled by the 2007 national administrative reform, which enabled changes in terms of human resources and organisational structure.

> During that event [the 2007 reform], I came here from a small municipality […]. We had a new head of environmental management who had a vision, and I could see this vision right away: that we should try to establish a whole new way of cooperating with our local companies, like a partnership. (Gov8)

> This is a new development of the welfare state. […] Now citizens have a new role where they are no longer clients or customers. They are partners, you can say. They are on equal terms [with the municipality]. (Gov1)

4.2.2 Organising collaborations

According to several interviewees, there were a variety of projects that engaged different actors, yet 'not necessarily in the nice way [Triple/Quadruple Helix literature described that] you have them all together' (Aca3). One person pointed out: 'I think things get better when we have all four actors involved, but only when it is necessary. Sometimes, it can be easier and faster if you leave out some partners' (Gov1).

This section specifically focuses on the potential of the Quadruple Helix system embraced by the organisation. It explores how the municipality structured its partnerships, designed the internal organisation and designated staff to organise their collaborations.

4.2.2.1 Partnership structure

The Triple Helix model was adopted formally, such as when forming steering committees, in most partnerships that promoted business and employment growth. The person in charge of business issues in Aalborg explained: 'We have different clusters where we have a joint secretariat […] and different kinds of networks. […] Almost everything we do is like a Triple Helix. We work a lot in triangle-mixing businesses, the university or university college, and the public sector' (Gov7). The approach was appealing considering the local history of being an industrial city with 'a very good university, especially on the technical side, that is also actually very collaborative' and keen on 'working with the business sector […] and with the city' (Gov7). Likewise, the municipality considered the local university as its important partner in these networks: 'We thought: "Well, we can't do it all by ourselves. We need some partners". The most obvious is, of course, the local university, AAU' (Gov8).

There was no evidence indicating the necessity and intention to shift from the Triple to the Quadruple Helix in such partnerships. The interviews revealed that they operated with a strong business focus regardless of the economic, environmental or social targets. Thus, the 'formal involvement of civil society is lesser' (Aca1). As confirmed by another academic,

‘We don’t interact much with NGOs’ (Aca6). Citizens were perceived as important here, yet appeared to be end-users who ‘benefit[ed] at the end’ (Aca5), ‘ambassadors of the city’ (Gov7) that attracted businesses or the essential elements of the business environment:

> Probably for all kinds of companies, if you want to operate in the local area, it’s a very good idea to be open to the local citizens, to hear what they have to say, maybe sponsor some events [etc.]. Therefore, we encourage them to try and at least consider what to do to build good relationships with the local citizens in their area. (Gov8)

4.2.2.2 Organisational instruments

The Quadruple Helix model was not observed formally in the governance of municipal networks. Nevertheless, at the organisational level, it was possible to identify two key instruments that the municipality used to explicitly articulate the emerging necessity of active contribution from civil society along with other stakeholders: (i) living labs and (ii) ‘Green Agents’.

The living lab concept was initially applied in building the ‘Nursing Home of the Future’ in 2012–2013, after which it spread as a methodology onto the whole Department of Care for the Elderly and Disabled. The main purpose was to promote user-driven innovation projects that integrated research and development among different public and private partners. One interviewee explained: ‘It is really important to bring technology, or whatever it is, as close as possible to people who will be involved, who will be affected and who will use [the service]’ (Gov2). Accordingly, these projects emphasised the importance of engaging with ‘citizens using the services’, such as seniors and nursing home residents, and their representatives, such as the ‘council for disabled people and council for elderly people’ (Gov3). Their roles varied from participating in workshops and interviews to testing and evaluating initiatives (Gov2). In this sense, the leading solution development appeared to have mainly stayed with the Triple Helix actors. Nevertheless, it was ‘a new way to work better’ by ‘normally inviting [civil society] to give them the opportunity to be involved in projects’ (Gov3). An innovation unit established in 2015 was dedicated to the innovation projects of the department, especially facilitating these collaborative innovations.

Green Agents was established in 2015 as a programme that was part of the Department of Environment and Energy, particularly the Centre for Green Transition (CGO in Danish), with the aim of 'co-creating a smart and sustainable Aalborg'. The primary objective was to 'get in contact with people who like to solve [environmental] problems or come up with a green solution and then support them' (Gov1). The municipal supporting actions included, among others, 'giving knowledge about what's the law, what's possible to do, where [to] find funding, and creating the link between them [civil society] and other organisations also involved in this [topic]' (Gov1). By this, the municipality sought to develop local solutions to grand challenges especially initiated by civil society, including general citizens (even exchange students) and CSOs. Unlike the above approach, there was a specialisation of two units in charge of different actors, even though they were involved in the same topic of the same department. The first unit promoted (Triple Helix) the 'Network for Sustainable Business Development' (NBE in Danish, 2008) and focused on strengthening companies' competitiveness by pursuing sustainability. The second unit, namely 'Green Agents', was dedicated to citizens' green initiatives The two sister units 'had some common projects' (Gov1) and 'learn[t] from each other all the time' (Gov8).

4.2.2.3 Human resource strategy

What was common in all investigated departments was the existence of gatekeepers who connected the municipality with different stakeholders, typically with a given budget to do so. This role might be project-based and embedded in regular positions, such as culture officers and planners. It could also be played by innovation consultants of a specialised innovation unit found in only one department. In addition, the need to forge close relationships with a specific stakeholder led to the creation of several municipal positions considered as the first or the only of their type in Denmark. They might have included a project manager for 'Green Agents' who made it easier for *citizens* to initiate and engage in environmental projects, a 'business playmaker' who linked schools with *business* partners in the education field and a 'research director' who sought to improve *academics'* research interests in municipal health issues. In formal networks involving multiple actors such as the NBE, the municipality designated an increasing number of full-time staff who administrated the partnerships: 'Back in 2008, there was just [one]; now [2018], we are 14' (Gov8).

The role of these municipal staff members, in the words of some interviewees, was to be 'a communicator' (Gov3), 'a facilitator or a mediator' (Gov8) who linked and 'put people together' (Gov1). On one side, they 'open[ed] the right door at the right time' (Gov2), which assisted external partners in approaching the right persons and resources to cater to their needs. On the other side, they kept the internal teams cognisant of the collaboration purposes and then facilitated the involvement of relevant staff considering their intensive schedule. Interestingly, although some positions were project-based, the tasks focused more on building institutional capacity and changing behaviour from both the municipality and its partners rather than on targeting the results of individual projects:

> [The] success criteria are not really about the individual projects, but about building the capacity to use research in the municipality, to know how to collaborate for research and to build a researcher community that knows about municipal health services. Therefore, it's more about capacity building from both sides. (Gov11)

> In the beginning, it was we who had to come up with all the solutions. We had to contact people to say: 'We think this is a good idea. Would you like to be involved in it?' […] During the three years I have been here, things have changed. People are now coming to us. (Gov1)

4.2.3 Promoting citizen engagement

The section below elaborates on the municipality's changing practices, perceived as the foundation for fostering citizen engagement regarding approaches, activities and communication.

4.2.3.1 Approaches

The municipality employed a two-way interaction in approaching citizens. First, the municipality encouraged a volunteering flow of ideas from the citizens to the municipality by assigning one point of contact and establishing interfacing platforms. For instance, Green Agents sought to be 'visual and accessible' to citizens and CSOs in different sustainability activities via, *inter alia*, recruiting a dedicated project manager, connecting through social media and organising an annual Sustainability Festival (CGO, n.d.). To build 'a strong network', the festival's original objective was changed:

> In the beginning, the premise of the festival was to show off all the good initiatives that the municipality makes, but then we changed it. Instead, we made a platform for others, so they could show what they are doing to attain sustainability. (Gov1)

Second, the municipality also endeavoured to meet citizens 'where they are' (CGO, n.d.). In the departments that provided public services directly to citizens, such as care for the elderly and disabled, solution development following a living lab methodology was feasible in the real-life context with 'real users' (Gov2). In other areas, several interviewees emphasised the significance of intermediary organisations that worked closely with citizens. Examples of 'good collaborators' were the non-profit housing associations that were technically 'very strong and very agile' in Denmark (Gov6). Another interviewee added: 'Housing associations are very important to us because we can reach a lot of people through them. I think […] 30 percent of the citizens in Aalborg live [here]' (Gov1). In this vein, the municipality's partner from a co-creation centre who belonged to one housing association confirmed:

> What we want is to place these meetings in the area where [citizens] live, especially when we know they don't want to move all the way from X to Y, [even] it's just maybe five-six hundred meters […]. 'If the mountain will not come to Muhammad, then Muhammad must go to the mountain'. It's in this philosophy. (IO2)

4.2.3.2 Activities

The municipality hosted diverse citizen activities, from conventional practices (e.g. public hearing, proposal receiving) to emergent methodologies (e.g. interactive workshops led by experts, prototype testing of living lab, co-creation). The first was driven mainly by regulations to promote democratic influence on the system: 'When making a local plan in Denmark, we have to have a public hearing period of up to eight weeks. […] We get a stack of comments from citizens' (Gov6). The latter activities tended to be organised when the problems were 'more difficult to solve' (Gov6) or 'cannot be legislated' (Aca2), such as changing housing devices for environmental purposes (Aca3). The strategy was summarised by an urban planner:

> We have a lot of different tools […]. For some, we have to be very precise and do things by the book. Sometimes we have to listen to what [stakeholders] are saying and [look at] the overall goals. They are more adaptive, constructive and innovative in finding solutions because it is complex […] to build and develop the city. (Gov6)

Due to their newness and complexity, the need for learning emergent methodologies has become apparent. Several doubts were raised when a 'living lab' approach was applied in municipal activities despite its perceived benefits: 'It was obvious that we were trying to work in that direction, but the question was how are we doing it? What did it take? What is the living lab? Was the location found quite quickly or not? It's much more about the method, but what is the method, and how do we work with that?' (Gov2). The same concern was noted when organising co-creation. In addition, co-creation had its own challenges, emphasising citizens' behaviours and the municipality's changing role:

> We want [citizens] to be active, take responsibility for their solutions, put their energy into our projects, and so on. This can be difficult because they still think of us as a traditional municipality of traditional people coming to tell them what to do and what not to do or how things should be. However, it's not really what we want. (Gov1)

> When you [municipality] engage […] in co-creation, you wear another hat [as a facilitator], but citizens will tend to meet you as a 'policeman' or as the service person. There is a clash there, and I would say that is pretty general. (Aca3)

Finally, although many ideas could come up during co-creation, 'the problem was the implementation or the uptake of all those ideas, how to take the ideas and have someone somewhere in the municipality, among the citizens or other stakeholders, act on them' (Aca2). It raised the question of whether the whole system relying upon a project manager would be sufficient if these citizen initiatives were to be scaled up. There was also an opinion from a non-governmental interviewee that underscored the need for communicating in a timely manner or accelerating decision-making from the municipality to generate outcomes rather than only focusing on the process.

4.2.3.3 Communication

As per all of the interviewees, effective communication was the key component for

engagement success so that everyone 'had the same picture' (Gov1) in mind about the expectations, goals and progression of the collaborations. Each stakeholder might require various ways of interaction: 'It's very important that we know who we are directing our communication to: is it a resident, a company or the university?' (Gov3). In the case of citizens, the interviewed NGO summarised the experience best:

> It takes some time [for people] to see the aim and structure. However, what is important is having an open attitude when you invite people to take ownership and responsibility. […] The next thing is to keep an open and well-structured process: what are we doing next, and how do we communicate along the way? […] The last point is to celebrate success. This is very important.

First, an 'open attitude' was deemed crucial when communicating with citizens whose roles were perceived as changing. Hence, the municipality sought to convey messages with language that empowered the public in engaging and expressing their thoughts:

> When we go to meetings and presentations, we always say that it's very important that we all contribute and that we cannot achieve our goals alone. We want them to be engaged, we want to listen to use their knowledge, and so on. (Gov1)

> It's very good to try to involve elderly people because they also get the chance to speak their minds. Suddenly, someone directs attention to them and tells them: 'We take you very seriously. You are kind of an expert in this field.' (Gov2)

This open attitude also involved the flexibility to allow changes during the process because 'people may have better ideas than yourself' (NGO). Indeed, although the municipality might come up with a certain framework of reference, collaboration often requires 'a lot of negotiations and a lot of give and take' (Gov6), as well as transparent communication: 'We have to explain all the time why we are doing what we are doing' (Gov6).

Finally, communication was considered important for the different parties to be aware of the necessary steps and be able to 'celebrate the success' as success could mean different things to different stakeholders. One outstanding example observed was the electric bike loan, a new municipal service proposed by civil society to mitigate local car traffic. Although this was 'a really great project', different expectations on working dynamics led to tensions:

‘It took six months from the [idea] conceptualisation to the first electric bike [being] made available for loan. From a citizen’s perspective, that was a really long process. However, in the perspective of the municipality, six months was really fast’ (Gov1). A shared understanding was achieved once ‘we talked about this issue and explained the timeframe’, citing the series of actions required from the municipality to support the initiative (Gov1).

5 Discussion and Conclusions: To what extent is the Quadruple Helix model applicable to local public sector innovation?

This research offers valuable insights into collaborative innovation processes in the public sector and the helix models of innovation systems. In particular, it examines the applicability of the Quadruple Helix model (i.e. actors and their interactions) to public sector innovation at three levels: innovation process, partnership structure and organisational practice. The research is designed with mixed methods in the Danish local government context.

5.1 With whom and in which helix models do public organisations interact in innovation processes?

The results show that, to a certain extent, the Quadruple Helix actors were present in local public sector innovation processes. Compared with the two remaining helices of industry and academia, civil society (i.e. citizens and CSOs) was the most frequent actor and factor that collaborated with and influenced local governments in initiating, developing and promoting an innovation. This finding suggests that the roles of civil society are important in fostering public sector innovation and that their roles are likely to be undermined in the innovation literature (Leydesdorff & Etzkowitz, 2003). Nevertheless, it should be mentioned that the extent of the social actors’ active contributions was not clear in the survey and should be subject to further investigations.

Regarding the interactions among actors, the proportion of municipal workplaces that organised the innovation process into a Triple Helix or Quadruple Helix model was rather small. Specifically, only a few Danish municipalities collaborated with stakeholders from both industry and academia in innovation development. Among those, the numbers of cases that either excluded civil society (Triple Helix) or collaborated with civil society (Quadruple

Helix) were relatively equal. When exploring helix models that broadly considered all stakeholders in the whole innovation process as either collaborating/co-developing actors or initiating/promoting factors, the municipal workplaces that embraced Quadruple Helix considerably outnumbered those that adopted the Triple Helix.

These results imply that all helices rarely participate in the same stage of innovation development, and to some extent, they do not participate in the same innovation project. Interviews from the in-depth case study provided preliminary explanations for this phenomenon. The choice of actors depended on different factors, such as the purposes of the projects, availability of existing resources and efficiency of actor participation. The findings carry important theoretical and empirical implications for the development of helix models. The Triple Helix model refers to university-industry-government relations, whereas the Quadruple Helix counts on the additional presence of civil society in innovation processes. However, there is a lack of research to guide the organisation of such relations in practice. Some authors argue that most previous research analysed such relations at an innovation system level in the forms of networks and partnerships, while empirical research at the project-based micro-level is substantially lesser and, therefore, urgently needed (Höglund & Linton, 2018; Miller et al., 2018). This research proposes that although all the Quadruple Helix actors might be important for the implementation of innovation projects, organising actors' interactions is often pragmatic given the context rather than embedding in theoretical models.

Lastly, the extant innovation literature and policy propose that the integration of civil society into the Triple Helix model might produce different innovation types and outcomes (Foray et al., 2012; Nordberg, 2015). The findings confirm that innovations produced from a broad Quadruple Helix set-up are likely to be associated with a greater citizen influence compared with the innovations produced from a broad Triple Helix set-up. Except for this, there was not enough empirical evidence to conclude whether a statistical difference exists in the innovation types and outcomes between the Quadruple Helix and Triple Helix.

5.2 How do public organisations organise citizen engagement in their innovation activities?

The research affirms that active citizen engagement is acknowledged as important to develop public services and solve complex public problems, as per NPM and NPG literature. Two outstanding modes of direct engagement have been observed with the different latitudes of citizens to influence the innovation process. The first mode relates to a consultative nature in a living lab context. It is related to providing users with opportunities to participate in planning infrastructures and prototyping healthcare products. The second mode expects to create a co-creative landscape, where general citizens are considered equal partners who detect environmental problems and get support to realise local solutions. These modes are applied to different groups of citizens in different fields with various levels of relations among existing stakeholders.

The overall findings regarding external and internal conditions for local governments to organise citizen engagement for public segctor innovation are illustrated in Figure 3. Local governments may already engage with academia and industry for different purposes. When including citizens, three external conditions that affect local governments' efforts include the purposes of existing partnerships, the types of citizens and their willingness, and, finally, the characteristics of the operating field. Meanwhile, the three internal conditions of local governments that may enhance the effectiveness of citizen engagement are interactive approaches, organisational learning capacity and open communication.

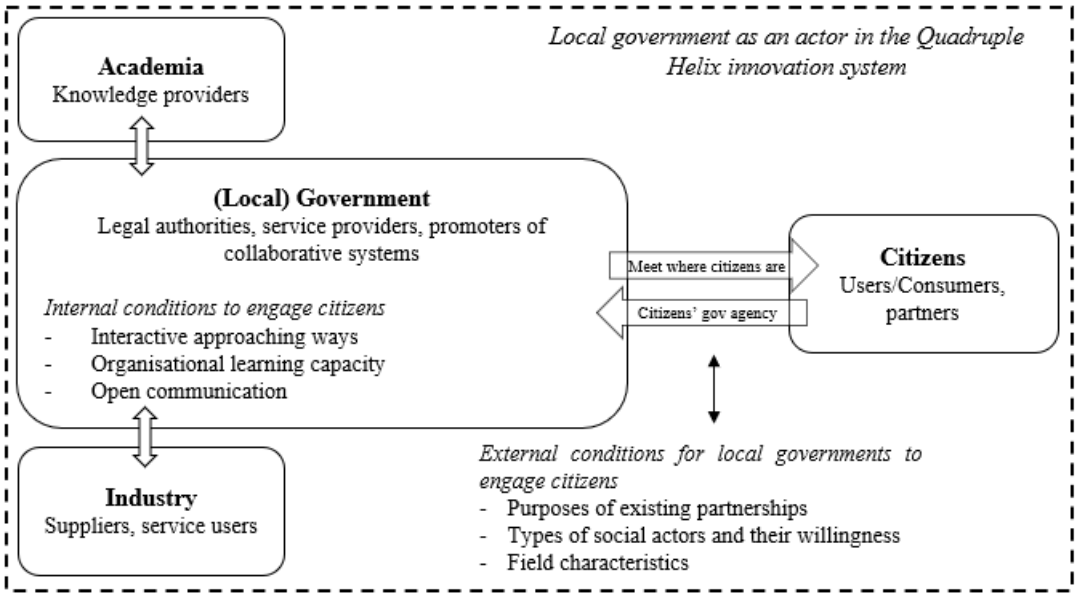

Figure 3. Internal and external conditions for local governments to organise citizen engagement for public sector innovation

5.2.1 Structural and organisational changes

When including civil society, MacGregor et al. (2010, p. 187) believed that 'high levels of maturity in the triple helix are not always necessary before moving towards the [Quadruple Helix innovation architecture]'. Recent empirical evidence has offered contrasting viewpoints. On the one hand, a well-established Triple Helix system does not support the extension to the Quadruple Helix; in fact, it even hinders it, as explained by the strong ties among existing participants (Grundel & Dahlström, 2016). On the other hand, a well-functioning Triple Helix model would not hinder the Quadruple Helix implementation because the experience in Triple Helix collaboration might help governments facilitate the extension (Roman et al., 2020). Those perspectives are not essentially paradoxical; instead, the levels of analysis must be considered, for instance, networks or organisations.

The findings suggest that a public organisation with substantial experience in working with Triple Helix stakeholders might be open to collaborating with civil society if it is perceived to be beneficial. Yet, their effort in moving to the Quadruple Helix is likely to be dependent on three key external elements. First, the paper confirms that the existing partnerships affect the efforts to include new types of partners (Grundel & Dahlström, 2016), even though partner inclusion mainly depends on the purposes of the partnerships rather than on the maturity of the partnerships per se. Nevertheless, only considering existing partnerships is not enough as the types of social actors and their willingness to participate also matter. Citizens are heterogeneous (Leino & Puumala, 2020; Vigoda, 2002); so are their resources and motivations. Citizens as end-users might be motivated to provide know-how with the prospect of enjoying better products and services, while citizens as solution proposers tend to appreciate the ownership of their ideas. Lastly, the field characteristics decisively affect the mobilisation of diverse stakeholders (Hofstad & Torfing, 2015). The changing stake of partners with the presence of civil society should be taken into account. For instance, stakeholder alignment is probably more challenging in the environmental domain if there are no congruent interests between businesses and CSOs.

5.2.2 Practical changes and challenges

From the municipality's side, three main practical changes and challenges to facilitate citizen engagement concern (i) interactive approaches, (ii) the learning capacity of new activities and (iii) open communication.

First, the findings suggest that effectively approaching citizens involves two-way interactions. On the one hand, it requires the presence of governmental agencies that persistently reinforce relationships with citizens and mobilise resources to facilitate their active contribution. On the other hand, 'meeting where citizens are' calls for the availability of municipal departments or intermediary organisations that are adjacent to citizens. Serious commitments from the local governments are critical to enabling this change. Conventional bureaucratic organisations may consider citizens as a homogeneous crowd and, therefore, might adopt the notion that 'you cannot find them; they find you' (Kornberger et al., 2017, p. 187). Nevertheless, it has been proven that citizen enthusiasm should not be taken for granted, even with the technological development that facilitates their engagement (Leino & Puumala, 2020).

Second, the implementation of new citizen engagement activities and concepts, such as living labs and co-creation, entails organisational capacity building. The learning curve is steep for either existing governmental staff with shifting professional identities or new employees who perform facilitating roles (Hofstad & Torfing, 2015; Horsbøl, 2018). The research indicates that any scenario would take a significant amount of time to enable the translation of theoretical concepts into practice (e.g. via trainings, experiments) and allow behavioural changes in both governments and citizens. In addition, collecting ideas from citizens is only the tip of the living lab and co-creation operations. The meaningful incorporation and realisation of citizens' inputs are contingent on the availability of resources (e.g. human, financial, infrastructure) and the smooth liaison of the whole organisation to avoid role confusion and enact changes. Ultimately, these activities should represent a profound shift towards including citizens, as opposed to one-off events (Leino & Puumala, 2020) or engaging with citizens at data-gathering points only.

Finally, open communication is essential to catalyse citizen engagement success. Communication is often cited as an important factor in collaborations to exchange knowledge, build trust and deliver expectations to partners (Fonseca, 2019; Nieth, 2019). The case study supports this statement and further points out that adaptation is needed for each type of actor, especially citizens. An effective interaction in the whole process necessitates the use of empowering language to attract citizen participation, open attitudes to allow negotiation and clear procedures to elicit the expected results. Nevertheless, power asymmetries between citizens and governments mean that these factors do not play out straightforwardly. At the same time, whilst public organisations may sincerely express the will to collaborate, the flexibility towards changes and compromise is still in question because governments embody classic hierarchical systems. The governmental interviewees repeatedly emphasised the importance of explaining municipal rationales when coming to an action or decision in the collaboration. This implies a tension between the desire to be open yet remain in control, which public organisations have to confront (Sorrentino et al., 2018).

5.3 Theoretical and empirical contributions

This paper contributes to the literature on collaborative innovation and helix models of innovation systems, particularly the debates on actors and their roles in promoting public sector innovation. It is the first study that connects and examines the applicability of the emergent Quadruple Helix model to public sector innovation. The research proposes several influential factors when local governments select actors to work with during an innovation process. The complexity of the different levels in an innovation system emphasises the over-simplification of the Quadruple Helix model, where the four types of actors are supposed to be present and interact in intermittent ways.

Although all Quadruple Helix actors may be relevant, empirical evidence suggests that the choice of partners differs even among internal communities in the same municipality with their own interests and challenges. To accommodate the emergent need for citizen inclusion in the innovation system, different instruments have been employed by public organisations, such as living labs and citizens' agencies, instead of incorporating citizens into the existing partnerships. This strategy is consistent with practices employed elsewhere (Nguyen & Marques, 2021; Roman et al., 2020). Effective citizen engagement first requires lead actors,

such as local governments, to empower citizens and provide opportunities to establish themselves as legitimate actors in the innovation systems of classic organisations.

5.4 Limitations and future research

This research has two main limitations that invite further investigation. First, the empirical data allowed the exploration of the perspectives of municipal employees and, to a certain extent, of academics, but not companies and citizens. Thus, future research could examine how companies and citizens reflect and act on their changing roles in public sector innovation processes. Second, the qualitative case presents a municipality that is open to taking risks and is characterised by a relatively high level of trust among stakeholders, which might not be the case elsewhere. Although this case led to a strong conclusion on the challenges of building a Quadruple Helix innovation system, case studies in other contexts would be valuable to validate the findings.

References

Aalborg Kommune. (2016). *Co-creating a smart and sustainable Aalborg*. Retrieved from https://www.youtube.com/watch?v=mWYBUJjYLh4

Aalborg Kommune. (2018). Aalborg in figures 2018.

Aalborg Kommune. (2020). Over 9.500 virksomheder i Aalborg [Over 9,500 companies in Aalborg]. Retrieved from https://www.aalborg.dk/business/erhvervsnyheder/alle-nyheder-fra-businessaalborg/over-9500-virksomheder-i-aalborg

Agger, A., & Sørensen, E. (2018). Managing collaborative innovation in public bureaucracies. *Planning Theory*, *17*(1), 53–73. https://doi.org/10.1177/1473095216672500

Arundel, A., Bloch, C., & Ferguson, B. (2019). Advancing innovation in the public sector: Aligning innovation measurement with policy goals. *Research Policy*, *48*(3), 789–798. https://doi.org/10.1016/j.respol.2018.12.001

Bach, T., Niklasson, B., & Painter, M. (2012). The role of agencies in policy-making. *Policy and Society*, *31*(3), 183–193. https://doi.org/10.1016/j.polsoc.2012.07.001

Barrutia, J. M., & Echebarria, C. (2019). Drivers of exploitative and explorative innovation in a collaborative public-sector context. *Public Management Review*, *21*(3), 446–472. https://doi.org/10.1080/14719037.2018.1500630

Bekkers, V., & Tummers, L. (2018). Innovation in the public sector: Towards an open and collaborative approach. *International Review of Administrative Sciences*, *84*(2), 209–213. https://doi.org/10.1177/0020852318761797

Benneworth, P., Cunha, J., & Cinar, R. (2020). Between Good Intentions and Enthusiastic Professors: The Missing Middle of University Social Innovation Structures in the Quadruple Helix. In L. Farinha, J. J. Ferreira, M. Ranga, & D. Santos (Eds.), *Regional Helix Ecosystems*

and Sustainable Growth (pp. 31–44). https://doi.org/10.1007/978-3-030-47697-7_3

Benneworth, P., Smith, H. L., & Bagchi-Sen, S. (2015). Special Issue: Building Inter-Organizational Synergies in the Regional Triple Helix. *Industry and Higher Education*, *29*(1), 5–10. https://doi.org/10.5367/ihe.2015.0242

Bloch, C., & Bugge, M. M. (2013). Public sector innovation - From theory to measurement. *Structural Change and Economic Dynamics*, *27*, 133–145. https://doi.org/10.1016/j.strueco.2013.06.008

Bouckaert, G., & Kuhlmann, S. (2016). Introduction: Comparing Local Public Sector Reforms: Institutional Policies in Context. In S. Kuhlmann & G. Bouchkaert (Eds.), *Local Public Sector Reforms in Times of Crisis: National Trajectories and International Comparisons* (pp. 1–20). Palgrave Macmillan. https://doi.org/10.1057/978-1-137-52548-2

Brandsen, T., Trommel, W., & Verschuere, B. (2017). The state and the reconstruction of civil society. *International Review of Administrative Sciences*, *83*(4), 676–693. https://doi.org/10.1177/0020852315592467

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. https://doi.org/10.1191/1478088706qp063oa

Brogaard, L. (2019). Innovative outcomes in public-private innovation partnerships: a systematic review of empirical evidence and current challenges. *Public Management Review*. https://doi.org/10.1080/14719037.2019.1668473

Bryson, J. M., Crosby, B. C., & Stone, M. M. (2015). Designing and Implementing Cross-Sector Collaborations: Needed and Challenging. *Public Administration Review*, *75*(5), 647–663. https://doi.org/10.1111/puar.12432.Designing

Bunders, J. F. G., Broerse, J. E. W., & Zweekhorst, M. B. M. (1999). The Triple helix enriched with the user perspective: A view from Bangladesh. *Journal of Technology Transfer*, *24*(2–3), 235–246. https://doi.org/10.1023/A:1007811607384

Carayannis, E. G., & Campbell, D. F. J. (2012). *Mode 3 Knowledge Production in Quadruple Helix Innovation Systems*. SpringerBriefs in Business 7. https://doi.org/10.1007/978-1-4614-2062-0_1

CGO. (n.d.). The Green Agents. Retrieved from http://www.centerforgrønomstilling.dk/in-english/the-green-agents

Christiansen, P. M., Mach, A., & Varone, F. (2018). How corporatist institutions shape the access of citizen groups to policy-makers: evidence from Denmark and Switzerland. *Journal of European Public Policy*, *25*(4), 526–545. https://doi.org/10.1080/13501763.2016.1268194

Christiansen, P. M., Nørgaard, A. S., Rommetvedt, H., Svensson, T., Thesen, G., & Öberg, P. O. (2010). Varieties of democracy: Interest groups and corporatist committees in Scandinavian policy making. *Voluntas*, *21*(1), 22–40. https://doi.org/10.1007/s11266-009-9105-0

Cinar, E., Trott, P., & Simms, C. (2019). An international exploration of barriers and tactics in the public sector innovation process. *Public Management Review*. https://doi.org/10.1080/14719037.2019.1668470

Clausen, T. H., Demircioglu, M. A., & Alsos, G. A. (2020). Intensity of innovation in public sector organizations: The role of push and pull factors. *Public Administration*, *98*(1), 159–176. https://doi.org/10.1111/padm.12617

COI. (2018). *Better together: a handbook on innovative collaborations in public sector (Nyt sammen bedre: en håndbog om innovative samarbejder i den offentlige sektor)*. Retrieved

from https://innovationsbarometer.coi.dk/media/49841/nyt-sammen-bedre_web.pdf

COI, & Statistics Denmark. (2019). *The Innovation Barometer Questionnaire*. Retrieved from https://www.innovationbarometer.org/media/51709/questionnaire.pdf

De Vries, H., Bekkers, V., & Tummers, L. (2016). Innovation in the public sector: A systematic review and future research agenda. *Public Administration*, *94*(1), 146–166. https://doi.org/10.1111/padm.12209

Demircioglu, M. A., & Audretsch, D. B. (2019). Public sector innovation: the effect of universities. *Journal of Technology Transfer*, *44*(2), 596–614. https://doi.org/10.1007/s10961-017-9636-2

Drejer, I., & Christensen, J. L. (2021). The Danish regional innovation system in transition. In J. L. Christensen, B. Gregersen, J. R. Holm, & E. Lorenz (Eds.), *Globalisation, New and Emerging Technologies, and Sustainable Development: The Danish Innovation System in Transition* (pp. 70–88). Routledge. https://doi.org/10.4324/9781003037750-6

Edquist, C., & Hommen, L. (1999). Systems of innovation: Theory and policy for the demand side. *Technology in Society*, *21*(1), 63–79. https://doi.org/10.1016/S0160-791X(98)00037-2

Etzkowitz, H. (2008). *The Triple Helix: University–Industry–Government Innovation in Action*. New York: Taylor & Francis.

Etzkowitz, H., & Leydesdorff, L. (2000). The dynamics of innovation: from National Systems and "Mode 2" to Triple Helix of university-industry-government relations. *Research Policy*, *29*(2), 109–123. https://doi.org/10.22503/inftars.XVII.2017.4.2

European Commission. (2010). Europe 2020. A strategy for smart, sustainable and inclusive growth. Brussels. Retrieved from http://ec.europa.eu/eu2020/pdf/COMPLET EN BARROSO 007 - Europe 2020 - EN version.pdf

Fisker, H. M. (2015). Dead or Alive? Explaining the Long-Term Survival Chances of Interest Groups. *West European Politics*, *38*(3), 709–729. https://doi.org/10.1080/01402382.2014.962246

Fonseca, L. (2019). Designing regional development? Exploring the University of Aveiro's role in the innovation policy process. *Regional Studies, Regional Science*, *6*(1), 186–202. https://doi.org/10.1080/21681376.2019.1584050

Foray, D., Goddard, J., Beldarrain, X. G., Landabaso, M., McCann, P., Morgan, K., … Ortega-Argilés, R. (2012). *Guide to Research and Innovation Strategies for Smart Specialization (RIS3)*. Luxembourg. https://doi.org/10.2776/65746

Gioia, D. A., Corley, K. G., & Hamilton, A. L. (2012). Seeking Qualitative Rigor in Inductive Research: Notes on the Gioia Methodology. *Organizational Research Methods*, *16*(1), 15–31. https://doi.org/10.1177/1094428112452151

Godenhjelm, S., & Johanson, J. E. (2018). The effect of stakeholder inclusion on public sector project innovation. *International Review of Administrative Sciences*, *84*(1), 42–62. https://doi.org/10.1177/0020852315620291

Grundel, I., & Dahlström, M. (2016). A Quadruple and Quintuple Helix Approach to Regional Innovation Systems in the Transformation to a Forestry-Based Bioeconomy. *Journal of the Knowledge Economy*, *7*(4), 963–983. https://doi.org/10.1007/s13132-016-0411-7

Hartley, J. (2005). Innovation in governance and public services: Past and present. *Public Money and Management*, *25*(1), 27–34. https://doi.org/10.1111/j.1467-9302.2005.00447.x

Hartley, J., Sørensen, E., & Torfing, J. (2013). Collaborative innovation: A viable alternative to

market competition and organizational entrepreneurship. *Public Administration Review*, *73*(6), 821–830. https://doi.org/10.1111/puar.12136

Hofstad, H., & Torfing, J. (2015). Collaborative innovation as a tool for environmental, economic and social sustainability in regional governance. *Scandinavian Journal of Public Administration*, *19*(4), 49–70. Retrieved from http://ojs.ub.gu.se/ojs/index.php/sjpa/article/view/3300

Höglund, L., & Linton, G. (2018). Smart specialization in regional innovation systems: a quadruple helix perspective. *R&D Management*, *48*(1), 60–72. https://doi.org/10.1111/radm.12306

Horsbøl, A. (2018). Co-Creating Green Transition: How Municipality Employees Negotiate their Professional Identities as Agents of Citizen Involvement in a Cross-Local Setting. *Environmental Communication*, *12*(5), 701–714. https://doi.org/10.1080/17524032.2018.1436580

Hunold, C. (2001). Corporatism, pluralism, and democracy: Toward a deliberative theory of bureaucratic accountability. *Governance: An International Journal of Policy and Administration*, *14*(2), 151–167. https://doi.org/10.1111/0952-1895.00156

Huxham, C., & Vangen, S. (2005). *Managing to Collaborate: The theory and practice of collaborative advantage*. Routledge.

Jensen, C., & Trägårdh, B. (2004). Narrating the Triple Helix concept in "weak" regions: Lessons from Sweden. *International Journal of Technology Management*, *27*(5), 513–530. https://doi.org/10.1504/IJTM.2004.004287

Kommune, A. (2018). *Aalborg in figures*. Retrieved from http://www.e-pages.dk/aalborgkommune/2598/html5/

Kornberger, M., Meyer, R. E., Brandtner, C., & Höllerer, M. A. (2017). When Bureaucracy Meets the Crowd: Studying "Open Government" in the Vienna City Administration. *Organization Studies*, *38*(2), 179–200. https://doi.org/10.1177/0170840616655496

Kronsell, A., & Mukhtar-Landgren, D. (2018). Experimental governance: the role of municipalities in urban living labs. *European Planning Studies*. https://doi.org/10.1080/09654313.2018.1435631

Leino, H., & Puumala, E. (2020). What can co-creation do for the citizens? Applying co-creation for the promotion of participation in cities. *Environment and Planning C: Politics and Space*. https://doi.org/10.1177/2399654420957337

Lewis, J. M., Ricard, L. M., & Klijn, E. H. (2018). How innovation drivers, networking and leadership shape public sector innovation capacity. *International Review of Administrative Sciences*, *84*(2), 288–307. https://doi.org/10.1177/0020852317694085

Leydesdorff, L. (2012). The Triple Helix, Quadruple Helix, ..., and an N-Tuple of Helices: Explanatory Models for Analyzing the Knowledge-Based Economy? *Journal of the Knowledge Economy*, *3*(1), 25–35. https://doi.org/10.1007/s13132-011-0049-4

Leydesdorff, L., & Etzkowitz, H. (1996). Emergence of a Triple Helix of university—industry—government relations. *Science and Public Policy*, *23*(5), 279–286. https://doi.org/10.1093/spp/23.5.279

Leydesdorff, L., & Etzkowitz, H. (2003). Can "the public" be considered as a fourth helix in university-industry-government relations? Report on the Fourth Triple Helix Conference 2002. *Science and Public Policy*, *30*(1), 55–61. https://doi.org/10.1007/BF02647154

Lopes, A. V., & Farias, J. S. (2020). How can governance support collaborative innovation in the

public sector? A systematic review of the literature. *International Review of Administrative Sciences*. https://doi.org/10.1177/0020852319893444

Lundvall, B.-Å. (2010). *National Systems of Innovation: Toward a Theory of Innovation and Interactive Learning* (Reprint). London: Anthem Press.

MacGregor, S. P., Marques-Gou, P., & Simon-Villar, A. (2010). Gauging Readiness for the Quadruple Helix: A Study of 16 European Organizations. *Journal of the Knowledge Economy*, *1*(3), 173–190. https://doi.org/10.1007/s13132-010-0012-9

Maraña, P., Labaka, L., & Sarriegi, J. M. (2020). We need them all: development of a public private people partnership to support a city resilience building process. *Technological Forecasting and Social Change*, *154*. https://doi.org/10.1016/j.techfore.2020.119954

Mele, V., & Belardinelli, P. (2019). Mixed Methods in Public Administration Research: Selecting, Sequencing, and Connecting. *Journal of Public Administration Research and Theory*, *29*(2), 334–347. https://doi.org/10.1093/jopart/muy046

Miller, K., McAdam, R., & McAdam, M. (2018). A systematic literature review of university technology transfer from a quadruple helix perspective: toward a research agenda. *R&D Management*, *48*(1), 7–24. https://doi.org/10.1111/radm.12228

Ministry for Economic Affairs and the Interior. (2014). *Municipalities and Regions - Tasks and Financing*. Copenhagen.

Mintrom, M. (2012). *Contemporary Policy Analysis*. Oxford University Press.

Nguyen, H. T., & Marques, P. (2021). The promise of living labs to the Quadruple Helix stakeholders: exploring the sources of (dis)satisfaction. *European Planning Studies*, 1–20. https://doi.org/10.1080/09654313.2021.1968798

Nieth, L. (2019). Understanding the strategic "black hole" in regional innovation coalitions: reflections from the Twente region, eastern Netherlands. *Regional Studies, Regional Science*, *6*(1), 203–216. https://doi.org/10.1080/21681376.2019.1578259

Nordberg, K. (2015). Enabling regional growth in peripheral non-university regions—The impact of a quadruple helix intermediate organisation. *Journal of the Knowledge Economy*, *6*(2), 334–356. https://doi.org/10.1007/s13132-015-0241-z

OECD/Eurostat. (2005). *Oslo Manual: Guidelines for Collecting and Interpreting Innovation Data*. *The Measurement of Scientific and Technological Activities* (Third). https://doi.org/10.1787/9789264013100-en

OECD. (2000). *Regulatory Reform in Denmark: Government Capacity to Assure High Quality Regulation*. Retrieved from https://www.oecd.org/denmark/2510615.pdf

Ongaro, E., & van Thiel, S. (2018). *The Palgrave Handbook of Public Administration and Management in Europe*. https://doi.org/10.1057/978-1-137-55269-3

Osborne, S. P. (Ed.). (2010). *The New Public Governance? Emerging Perspectives on the Theory and Practice of Public Governance* (1st ed.). Abingdon: Routledge. https://doi.org/10.4324/9780203861684

Pestoff, V. (2006). Citizens and co-production of welfare services. Childcare in eight European countries. *Public Management Review*, *8*(4), 503–519. https://doi.org/10.1080/14719030601022882

Reiermann, J. (2017). New study: Municipalities move from service to co-creation (Ny undersøgelse: Kommunerne rykker fra service til samskabelse). *Mandag Morgen Think Tank*.

Retrieved from https://www.mm.dk/artikel/ny-undersoegelse-kommunerne-rykker-fra-service-til-samskabelse

Roman, M., Varga, H., Cvijanovic, V., & Reid, A. (2020). Quadruple Helix models for sustainable regional innovation: Engaging and facilitating civil society participation. *Economies*, *8*(2), 48. https://doi.org/10.3390/ECONOMIES8020048

Røste, R. (2005). *Studies of innovation in the public sector, a literature review* (Publin Report No. D16). Oslo.

Siebers, V., & Torfing, J. (2018). Co-creation as a new form of citizen engagement: Comparing Danish and Dutch experiences at the local government level. *International Public Management Review*, *18*(2), 187–208. Retrieved from www.ipmr.net

Sønderskov, M. (2020). Councillors' attitude to citizen participation in policymaking as a driver of, and barrier to, democratic innovation. *Innovation Journal*, *25*(3), 1–20.

Sørensen, E., & Torfing, J. (2011). Enhancing collaborative innovation in the public sector. *Administration and Society*, *43*(8), 842–868. https://doi.org/10.1177/0095399711418768

Sørensen, E., & Torfing, J. (2018). Co-initiation of Collaborative Innovation in Urban Spaces. *Urban Affairs Review*, *54*(2), 388–418. https://doi.org/10.1177/1078087416651936

Sorrentino, M., Sicilia, M., & Howlett, M. (2018). Understanding co-production as a new public governance tool. *Policy and Society*, *37*(3), 277–293. https://doi.org/10.1080/14494035.2018.1521676

Span, K. C. L., Luijkx, K. G., Schalk, R., & Schols, J. M. G. A. (2012). What Governance Roles do Municipalities use in Dutch Local Social Support Networks? *Public Management Review*, *14*(8), 1175–1194. https://doi.org/10.1080/14719037.2012.664013

Statistics Denmark. (n.d.). Population figures. Retrieved from https://www.dst.dk/en/Statistik/emner/borgere/befolkning/befolkningstal

Strokosch, K., & Osborne, S. P. (2020). Debate: If citizen participation is so important, why has it not been achieved? *Public Money and Management*, *40*(1), 8–10. https://doi.org/10.1080/09540962.2019.1654322

Szkuta, K., Pizzicannella, R., & Osimo, D. (2014). Collaborative approaches to public sector innovation: A scoping study. *Telecommunications Policy*, *38*(5–6), 558–567. https://doi.org/10.1016/j.telpol.2014.04.002

Thøgersen, D., Waldorff, S. B., & Steffensen, T. (2020). Public Value through Innovation: Danish public managers' views on barriers and boosters. *International Journal of Public Administration*. https://doi.org/10.1080/01900692.2020.1750030

Torfing, J. (2019). Collaborative innovation in the public sector: the argument. *Public Management Review*, *21*(1), 1–11. https://doi.org/10.1080/14719037.2018.1430248

Torfing, J., Sørensen, E., & Røiseland, A. (2019). Transforming the Public Sector Into an Arena for Co-Creation: Barriers, Drivers, Benefits, and Ways Forward. *Administration and Society*, *51*(5), 795–825. https://doi.org/10.1177/0095399716680057

Trousset, S. (2014). Current trends in science and technology policy research: An examination of published works from 2010-2012. *Policy Studies Journal*, *42*(S1), 87–117. https://doi.org/10.1111/psj.12053

Vangen, S., Hayes, J. P., & Cornforth, C. (2015). Governing Cross-Sector, Inter-Organizational Collaborations. *Public Management Review*, *17*(9), 1237–1260.

https://doi.org/10.1080/14719037.2014.903658

Vigoda, E. (2002). From responsiveness to collaboration: Governance, citizens, and the next generation of public administration. *Public Administration Review*, *62*(5), 527–540. https://doi.org/10.1111/1540-6210.00235

von Hippel, E. (1988). *The sources of innovation*. Oxford University Press. https://doi.org/10.1016/0169-2070(89)90046-0

Waardenburg, M., Groenleer, M., de Jong, J., & Keijser, B. (2020). Paradoxes of collaborative governance: investigating the real-life dynamics of multi-agency collaborations using a quasi-experimental action-research approach. *Public Management Review*, *22*(3), 386–407. https://doi.org/10.1080/14719037.2019.1599056

Warsen, R., Greve, C., Klijn, E. H., Koppenjan, J. F. M., & Siemiatycki, M. (2020). How do professionals perceive the governance of public–private partnerships? Evidence from Canada, the Netherlands and Denmark. *Public Administration*, *98*(1), 124–139. https://doi.org/10.1111/padm.12626

Weber, M. (2019). *Economy and Society: A new translation*. (K. Tribe, Ed.). London: Harvard University Press.

Wegrich, K. (2019). The blind spots of collaborative innovation. *Public Management Review*, *21*(1), 12–20. https://doi.org/10.1080/14719037.2018.1433311