Governing Quintuple Helix Innovation: Urban Living Labs and Socio-Ecological Entrepreneurship

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"*Cities are never random. No matter how chaotic they might seem, everything about them grows out of a need to solve a problem. In fact, a city is nothing more than a solution to a problem, that in turn creates more problems that need more solutions, until towers rise, roads widen, bridges are built, and millions of people are caught up in a mad race to feed the problem-solving, problem-creating frenzy*."

Neal Shusterman
Author of young-adult fiction
In *Downsiders* (2001)

Abstract

Growing urbanization puts pressure on both social and ecological systems. This pressure raises complex and multi-facetted challenges that can only be tackled by collaborative and distributed innovation development processes. However, theoretical frameworks that assess such collaborations are often very conceptual, with little focus on the actual governance mechanisms that facilitate them. This article studies the urban living lab concept as an inter-organizational design and multi-stakeholder innovation development process to govern the quintuple helix model for innovation by means of an action research based multidimensional case study design, which focusses on the concepts of innovation democracy, mode 3 knowledge production, the innovation ecosystem as a system of societal subsystems, and socio-ecological transition. In this way, we provide a more profound understanding of such innovation processes to tackle socio-ecological challenges by means of public–private interactions driven by eco-entrepreneurship.

Introduction

Society is confronted with challenges of an increasingly complex and global nature. It is hard for a single societal actor to come up with the right solutions, given that knowledge and resources are distributed among a wide network of stakeholders (Bogers & West, 2012). Thus, innovation actors must reach out to external knowledge. Among the most pressing and interesting challenges are those involving public value and market failure. As urbanization continues at a rapid pace, socio-ecological systems are put under heavy pressure, inducing ecological issues such as global warming, decreasing air quality, increasing hazardous emissions, and geological instability. Although a sense of urgency for solutions is widespread, society is still struggling to find an adequate, sustainable, and agile way to react. It is clear, however, that these challenges need to be dealt with by a diverse ecosystem of private actors, universities, civil society, and politics.

Nevertheless, in innovation management theory, the question is not *why*, but rather *how* such challenges can be tackled. In the collaborative knowledge production and innovation management literature, one of the frameworks that attempt to take the natural environment into account is the "quintuple helix model" for innovation (Carayannis & Campbell, 2010). Although this rather recent analytical framework is very promising, only little empirical evidence exists that explores its possibilities and limitations. On top of that, this model is mainly applied to assess larger innovation ecosystems such as national or regional innovation systems, and to a lesser extent to the innovation development process.

Therefore, this article focusses on the specific governance mechanisms that can facilitate quintuple helix innovation at the level of the individual innovation development process. More

specifically, the "urban living lab" concept is explored as an inter-organizational R&D design and multi-stakeholder innovation development process to govern the quintuple helix model for innovation. Hence, this article contributes to a more profound understanding of local collaborative innovation processes that are designed to tackle socio-ecological challenges by means of public–private interactions, driven by eco-entrepreneurship. In other words: How can urban living labs be a way to put quintuple helix innovation into practice?

First, we discuss the urbanization process to better understand the context in which these challenges occur. Next, we relate this evolution to collaborative innovation literature, and elaborate on the (urban) living lab concept as a way to put this into practice. Finally, we develop an analytical framework, which is structured along the concepts of innovation democracy, mode 3 knowledge production, the innovation ecosystem as a system of societal subsystems, and socio-ecological transition, and apply this framework to two urban living lab cases.

Background

Urbanization, socio-ecological challenges, and urban innovation

The speed of urbanization is overwhelming (Bocquier, 2005). This rapid evolution puts pressure on social, physical, and ecological systems as city populations continue to grow and more and more people are live in densely populated areas. This pressure, in combination with the associated emergence of grand societal challenges and rapid technological evolutions, forces cities to look for new ways to reinvent themselves (Atkinson, 1998; Foth, 2009; Viitanen & Kingston, 2014).

In practice, however, local governments often lack the capability and resources to tackle these challenges in a flexible way (O'Flynn, 2007). In the search for new ways to cope with this tension, transparency and close interaction with grassroots initiatives are increasingly put forward as solutions to overcome this gap (Buscher, Tomordy, Ashley, & Tabet, 2010). This approach involves a wide variety of urban stakeholders (e.g., citizens, universities, enterprises, non-governmental organizations), thereby potentially leveraging the distributed knowledge in the urban environment.

Nevertheless, these interactions need to be governed and in some way be able to connect the traditional top-down approach with a grassroots or bottom-up approach. This strategy is in line with the open or distributed innovation approach (Bogers & West, 2012; Chesbrough, 2003), causing city governments to question the dominant paradigm of top-down innovation development, and implementation, and to experiment with innovation processes together with, and even by, citizens and other organizations in the urban environment (Paskaleva, 2011).

Understanding collaborative innovation processes

A useful framework for the analysis of such complex collaborative innovation networks is the "triple helix" model for innovation (Etzkowitz & Leydesdorff, 1995), which originally focused on collaboration and knowledge production in university–government–industry partnerships (Etzkowitz & Leydesdorff, 2000). It was later expanded with a fourth helix to incorporate civil society (Carayannis & Campbell, 2009).

However, from a socio-ecological systems point of view, the urban evolutions described above also need to be studied as changes in human–environment systems (Young et al., 2006). Hence, a socio-ecological systems approach integrates social and ecological systems thinking in a holistic

way to assess "system threats" (Berkes, Folke, & Colding, 2000). Such socio-ecological systems can be considered complex units in which resources are exchanged and regulated by social and ecological systems (Berkes, Colding, & Folke, 2002; Machlis, Force, & Burch, 1997), which makes them interesting conceptual frameworks to assess socio-ecological innovation in an urban environment. They also encourage the integration of this logic and analytical dimensions in the innovation ecosystem literature. Therefore, a fifth helix should be added to the quadruple helix model, to also take the natural environment into account (Carayannis & Campbell, 2010). This is what makes the quintuple helix model for innovation an interesting and valuable model to analyze innovation ecosystems.

To explain processes of knowledge exchange that take place in such collaborative innovation ecosystems, these models apply the concepts of "mode 3" knowledge production and "open innovation diplomacy". Mode 3 knowledge production is conceptualized as an extension of mode 1 knowledge production (traditional research by universities) (Godin & Gingras, 2000) and mode 2 knowledge production (knowledge that is generated when mode 1 knowledge is applied and put into practice) (Gibbons et al., 1994; Nowotny, Scott, & Gibbons, 2003). Mode 3 adds a third component to this representation of knowledge production by highlighting the overarching system in which this knowledge is produced and exchanged (i.e., innovation networks and knowledge clusters). "Open innovation diplomacy", on the other hand, is used to describe the way in which different organizations and ecosystem are able to collaborate and bridge the divides that exist between traditionally separated domains (this can be social, organizational, cultural, or technological) (Carayannis & Campbell, 2011).

Living labs and the urban environment

Triple, quadruple, and quintuple helix models have a strong theoretical nature. One approach that tries to facilitate such models in a structured way is the "living lab" approach, which can be defined as an ecosystem approach in which end users and other stakeholders are involved in the development of an innovation over a long period of time, in a real-life environment, following an iterative process (Niitamo & Kulkki, 2006; Schuurman, Lievens, De Marez, & Ballon, 2012) applying multi-method, user-centric innovation research with a strong focus on user empowerment and real-world experimentation (Følstad, 2008; Schuurman et al., 2013; Ståhlbröst, 2008). Furthermore, it offers a structured process and environment to govern input from a wide variety of stakeholders and research methods (Eriksson, Niitamo, Kulkki, & Hribernik, 2006; Ståhlbröst & Holst, 2012).

In the urban environment, living labs gain importance as a way to govern (complex) urban collaborative innovation processes (Buscher et al., 2010; Paskaleva, 2011). Although the process is similar, *urban* living labs have a distinct nature because the focus is on civic participation, and the output is aimed at increasing quality of life in the city rather than the development of a commercial product or service (Baccarne, Mechant, Schuurman, Colpaert, & De Marez, 2014). As such, urban living labs are an instrument to include a wide variety of stakeholders (citizens, municipalities, entrepreneurs, etc.) in the search for innovations that meet local socio-ecological challenges (Franz, 2014). Juujärvi and Pesso (2013, p.22) define an urban living labs as “a physical region in which different stakeholders form public–private–people partnerships of public agencies, firms, universities, and users collaborate to create, prototype, validate, and test new technologies, services, products, and systems in real-life contexts”.

However, despite strong European support, this research and development concept is still struggling for an adequate and more profound theoretical anchoring and remains too much of a

"practice-based" concept (Kviselius, Ozan, Edenius, & Andersson, 2008; Schuurman, 2015). Quintuple helix (-related) concepts provide potentially valuable tools and assumptions for the assessment and theoretical foundation of the more practical oriented living lab literature, embedded within a broader socio-ecological system. On the other hand, the living lab literature might provide a practical framework to put quintuple helix innovation into practice. Furthermore, exploring the quintuple helix model in the context of urban innovation contributes to a more profound understanding of urban innovation in relation with socio-ecological transition in urban areas.

Methodology

Research design

To investigate quintuple helix innovation in relation to urban living labs, we conducted an action research study (Reason & Bradbury, 2001) in which we purposefully designed and participated as researchers in two urban living lab projects. This approach allowed us direct access and control over the projects, as well as more profound insights on the observed phenomena. The analysis is structured following the principles of a multidimensional case study design (Eisenhardt, 1989; Yin, 1984). The unit of analysis in this design is the individual project-centric innovation ecosystem.

The two cases had to: i) focus on eco-entrepreneurship, ii) target the urban environment, iii) be open for the researcher team to shape and mold (cfr. action research), iv) be collaborative in nature, and v) encompass an innovation development process. The two selected research projects were instigated by start-up organizations with socio-ecological goals in the urban environment, and they were both incubated by a regional incubating organization (funded by the Flemish

government in order to stimulate innovation in ICT). Both projects involved the set-up of an ad hoc collaborative network of stakeholders and a structured, semi-formal adaptive iterative product development process. Project A was set up around the development of an interactive platform to engage, collaborate, and communicate on the topic of air quality. Project B concerned the development of a peer-to-peer car sharing initiative for electric vehicles.

Both living lab processes were designed along principles whereby the living lab project had to: i) incorporate multiple iterations (Pierson & Lievens, 2005; Schaffers & Budweg, 2009), ii) involve multiple stakeholders (Feurstein, Hesmer, Hribernik, Thoben, & Schumacher, 2008; Frissen & Lieshout, 2004; Juujärvi & Pesso, 2013), iii) be driven by multi-method research (De Moor et al., 2010; Eriksson et al., 2006; Niitamo & Kulkki, 2006), iv) involve real-world experimentation (Følstad, 2008; Niitamo & Kulkki, 2006), and v) be based on active co-creation by stakeholders (Følstad, 2008; Schumacher & Niitamo, 2008; Schuurman et al., 2012; Ståhlbröst, 2008). In line with the conceptualization of an urban living lab, the local government was a required stakeholder in the innovation development ecosystem. Between each iteration, steering committee meetings were held to evaluate the process and modify it if necessary. These steering committees consisted of the researchers, the project managers, and the project instigators (eco-entrepreneurs) (see also Rits, Schuurman, & Ballon, 2015).

Research framework

A beneficial aspect of case study design is the opportunity to include multiple sources of evidence, thus enhancing the validity of the analysis through data triangulation (Yin, 1984). The sources of evidence in this study include ethnographic field notes, in-depth interviews, email communications, meeting reports of steering committees, initial project proposals, project

reports, and project deliverables. These sources of evidence were coded and interpreted by the author team following an analytical protocol (Yin, 1984) that encompassed the four dimensions that are key elements in the literature on innovation ecosystems, and in particular the quintuple helix model and socio-ecological systems:

1. *Innovation diplomacy:* the praxis of bridging barriers between traditionally separated actors and fields (Carayannis & Campbell, 2011).

   Assumption: properly targeted initiatives are able to connect know-how, tacit knowledge, creativity, and formal knowledge between different domains and nurture entrepreneurship.

2. *Mode 3 knowledge production*: based on a system-theoretic perspective in which knowledge is molded, remixed, shared, and applied within a knowledge-driven society.

   Assumption: quintuple helix ecosystems are knowledge production, distribution, and application systems in which knowledge is generated through the exchange of knowledge between actors in the ecosystem (Carayannis & Campbell, 2012).

3. *A system of subsystems:* the quintuple helix ecosystem encompasses the different domains that resonate and collaborate to solve mutual challenges.

   Assumption: each ecosystem actor provides unique resources to the ecosystem, but also mixes, translates, and processes resources from others. The quintuple helix model describes five societal subsystems (Carayannis, Barth, & Campbell, 2012): i) the educational system, which generates and disseminates new knowledge; ii) the economic system, which controls, possesses, and generates economic capital; iii) the

political system, which has political and legal capital (e.g., laws, clearances, policy, public goods); iv) civil society, which has social capital, and is characterized by traditions, values, and behavioural patterns; and v) the natural environment, which has natural capital (e.g., natural resources, climate, air quality, geological stability).

4. *Socio-ecological transition:* the main contribution of the quintuple helix model is the integration of the natural environment, which is conceptualized as a contextualization of the four helices of the quadruple helix.

   Assumption: if this context is taken into account, it is possible to achieve sustainable socio-ecological transition, creating synergies between economy, society, and democracy (Carayannis & Campbell, 2011).

Analysis

Quintuple helix innovation in a structured process

An urban living lab follows a structured process in which a central problem, idea, concept, or prototype is at the heart of the collaboration. This innovation development process implements a combination of different methodologies (e.g., for Project A: interviews, focus groups, surveys, co-creation workshops, online crowdsourcing, and a field trial) to involve a wide variety of stakeholders (e.g., for Project A: different local government divisions, citizens, civil society organizations, large and small research organizations, and startups). As described earlier, this formal but flexible staged process was, in both cases, instigated by the eco-entrepreneurs, was financially supported by the Flemish government, and was managed by iMinds Living Labs, a semi-public living lab organization, embedded in an interdisciplinary and cross-university, technology-driven research centre. The formal living lab process structured the innovation

development and governed stakeholder interaction, knowledge production, and knowledge transfer. For example, the process facilitated steering committees, safeguarded the overall planning and resources of the project, leveraged social capital within the different subsystems, provided coaching and implementation resources, and translated knowledge between ecosystem stakeholders.

Innovation diplomacy

The formal commitments within both cases were limited to the eco-entrepreneurs and the semi-public living lab management organization. However, both cases also had semi-formal commitments from their respective local governments. Both projects were unable to convince other key actors in the ecosystem to become a formal partner of the project because these other actors were not willing to commit themselves to an *uncertain* and *open* project. However, once the project gained momentum and tangibility, collaborations were still possible on an ad hoc basis. Not only were key stakeholders eventually attracted to the ecosystem, but also several unexpected smaller institutions (i.e., research institutes, companies, and civic organizations), who were very willing to contribute and share their knowledge. The ad hoc, open-ended, and semi-formal design of these temporal collaboration networks served as an *risk reducing* characteristic and helped to overcome collaboration barriers. As such, the collaborative design of the urban living lab stakeholder ecosystem acted as a *centripetal force* within the urban environment, as acupuncture to congregate urban actors with similar goals. Although every collaborator had their own agenda (e.g., leveraging their own business, connecting with the local government, pushing local change), this did not interfere with the overall goals of the project.

Finally, when it came to the involvement of the local government, the process facilitated access and interaction with different governmental levels. The deployment of a *temporal experimental window*, which was considered "neutral" and "external" to existing organizations, enabled individuals to detach themselves from restraining organizational structures and collaborate in a more agile environment, and to stretch the boundaries of what is generally possible (e.g., temporarily sharing data sources, talking freely outside the governmental organization, providing favourable exceptions on the use of public space).

Mode 3 knowledge production

In the air quality domain (*Project A*), a lot of knowledge is generated in mode 1. Traditionally, research institutes obtain grants to study atmospheric particulate matter (e.g., as $PM_{2.5}$) or ozone concentrations. Most of these data remain hidden to the public. However, there are some initiatives that attempt to disseminate these data to civil society. Most of the time, these initiatives are built upon open data principles and are, for example, translated in dashboards showing air quality values. In theory, these initiatives distribute and apply mode1 knowledge (potentially generating mode 2 knowledge). However, this information cannot be interpreted by actors outside the knowledge domain (e.g., regular citizens). Even if the raw numbers are translated in visual information (e.g., public visualizations of the air quality have been created in the city of Project A), the academic complexity was not interpretable for citizens and citizens had no idea how to act upon this information.

Through an iterative, multi-method research approach, the (tacit) knowledge of all stakeholders could be captured, exchanged, (re)combined, mixed, and molded. By distributing and translating fundamental chunks of knowledge to actors outside the original knowledge domain, unexpected

but valuable interpretations and interactions occurred. However, such "sparks" and often volatile knowledge must be adequately captured and managed to contribute to the project goal. For Project A, this process of knowledge capture resulted in the development a conceptual model for socio-ecological change, which served as the basis for design requirements and the development of the project prototypes. Project B, on the other hand, focused on understanding end-user needs and frustrations in relation to technological evolutions and other stakeholder needs and knowledge, mainly to set-up a field trial experiment that matched the usage context. These insights were necessary for both practical and substantial reasons in order to be able to test the electric-car sharing system.

The ecosystem and circulation of knowledge

In both cases, various exchanges between different knowledge domains took place. Some examples include knowledge transfers from the political system to the economic system (i.e., knowledge regarding policy, internal procedures, the value network, and business model opportunities) and from civil society to both the educational system (e.g., the interpretation of complex data by citizens and the relation to their everyday behaviour) and the economic system (i.e., regarding needs and adoption potential). Furthermore, for the local government, the urban living lab projects also bridged different divisions and individuals *within* the organization (e.g., different divisions were working on open data and air quality for some time, but it took the project to connect them and expose the overlap between their efforts). This bridging can be conceptualized as an *intra-organizational centripetal force,* which is the mobilizing effect of an urban living lab *within* an organization to connect like-minded individuals beyond organizational structures. As such, the projects facilitated horizontal and agile collaboration and knowledge exchange on an ad hoc basis, largely bypassing traditional structures and processes.

Socio-ecological transition

As for the "natural context", both projects aimed to interact with the socio-ecological environment through their environmental goals. Against this backdrop, it makes sense to conceptually model the innovation ecosystem using the quintuple helix model. Using this framework, it is clear that (urban) innovation is related to issues regarding the socio-ecological context in which we live and (co-)develop our common socio-technological future. Neglecting this dimension is a failure to contextualize innovation development in a broader environment. Although this model fits with the theoretical understanding of urban living labs, they in turn offer an implementation approach for the quintuple helix model for innovation.

Concerning sustainability, both projects exposed the difficulty of designing viable business models in a "public" domain. Both civil society and the economic system consider it the duty of the political system to take responsibility. However, the political system is facing decreasing resources, which makes it hard to develop a sustainable business model. For Project B, this challenge resulted in the establishment of a cooperative organization with limited liability. Different actors who were previously involved in the urban living lab became members of this organization. As such, some of the social capital that was generated within the urban living lab was leveraged to help sustain the innovation.

Nevertheless, socio-ecological transition must also be considered in a broader sense. Through (series of) experiments, project-based quintuple helix innovation can foster long-term change on a more latent level, by inspiring and stimulating debate on contemporary urban challenges and solutions. Applied to the socio-ecological systems way of thinking, urban living labs contribute to the *resistance* of an urban socio-ecological system. More specifically, this goal is achieved

through the facilitation of flexible and agile experimentation with possible solutions for issues related to "system stress" caused by urbanization itself, and by doing so, adding to a long-term and latent social transition that is closely interrelated with ecological concerns and associated knowledge.

Conclusions and Discussion

This article bridges the theoretical propositions of the quintuple helix model and the practice-based concept of urban living labs. More specifically, we discussed the concepts of innovation diplomacy, mode 3 knowledge production, the innovation ecosystem as a system of subsystems (related to the circulation of knowledge), and socio-ecological transition to analyze the urban living lab approach. Our findings largely support the theoretical assumptions of the quintuple helix model and elaborate on the urban living lab approach as a way to put this model into practice at the level of a single innovation development process. Urban living labs can be a way to work with ad hoc collectives, lowering the barriers for collaboration. The project-centric nature is a catalyst for knowledge exchange and collaborations within and outside the project and involved organizations.

A successful urban living lab can facilitate and balance top-down governance with bottom-up initiatives in the city. However, some challenges remain. Whereas experimental urban living lab activities activate and reinforce the quintuple helix ecosystem, it is still hard to harness the creation potential within the city in a sustainable way. Nevertheless, urban living labs facilitate urban transitions through an accumulation of experiments, which allow urban actors to experience change, leading to transitions in the long run. This logic suggests that urban living labs contribute to (long-term) sustainable socio-ecological transition, which is mainly facilitated

by an interdisciplinary (and transdisciplinary) temporal experimental window that promotes collaborative learning and stakeholder engagement. However, although value is being created at the meso level (i.e., the project level), there is a need for a more formal value capture and retention processes at the macro level (i.e., the level of ecosystems and the overarching organization). In the urban context, it makes sense that local governments fulfil such a role. This is to some extent in line with the conceptualization of the government as a platform (O'Reilly, 2011).

The quintuple helix is a useful concept to understand and analyze how knowledge is created and exchanged in an urban environment. This environment can be studied as a collaborative innovation development ecosystem, while also taking the ecological context into account. Although such awareness is growing in most organizations, this dimension is not present in most distributed innovation theories and processes. An urban living lab thus can generate and evolve tacit and codified knowledge while focusing on the exchange of knowledge within a natural environment system. In this way, both the innovation outcomes and the urban socio-ecological transition can become more sustainable and recover ecological balance, thus ensuring the quality of life for future generations.

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