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Living labs as orchestrators in the regional innovation ecosystem: a conceptual framework

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ABSTRACT

This research explores the conceptual integration of Living Labs (LLs) into the Regional Innovation Ecosystem (RIE) to understand their potential as facilitators of Responsible Innovation. While previous studies explored the role of Living Labs, they lack comprehensive integration strategies for addressing wicked problems. A conceptual framework is developed to understand the main role, detailed functions, and key elements for integration. Seven expert interviews were conducted to develop the conceptual framework, using the Interuniversity Microelectronics Centre (imec) within the Flemish Innovation Ecosystem as empirical context. The findings emphasise Living Labs as central orchestrators, enabling user-centric innovation, real-world experimentation, and stakeholder engagement. We identify four key elements that facilitate the proposed integration: government policy and funding, strategic integration, formal collaborations, and proof of concept. These findings have implications for advancing the theoretical understanding of Living Labs' integration into the Regional Innovation Ecosystem, and for practitioners who aim to foster Responsible Innovation.

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Living labs; regional innovation ecosystem; conceptual framework; innovation orchestration; wicked problems

Introduction

In the rapidly expanding body of literature on innovation ecosystems (Gomes et al. 2018), a growing emphasis emerges on adopting holistic innovation approaches to effectively tackle global challenges (Reichert 2019). These contemporary challenges encompass climate change, public health, and food security, commonly acknowledged as wicked problems (Ludwig et al. 2022). Wicked problems (Peters 2017; Rush 2019), characterised by their complexity and the absence of straightforward solutions across economic, societal, and environmental domains (Head and Alford 2015), require systemic innovation approaches (Zivkovic 2018). The multifaceted concept of 'systemic innovation' involves the integration of complementary innovations in ecosystems and the formulation of transformative solutions to complex challenges (Midgley and Lindhult 2021).

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Recent scholarship in Responsible Innovation (RI) highlights the limitations of traditional engagement approaches in addressing these challenges. Smolka and Böschen (2023) advocate for a systemic approach, termed 'responsible innovation ecosystem governance', which calls for diverse stakeholders to collaboratively reflect on the societal and ethical impacts of innovation (Smolka and Böschen 2023). This approach aligns with the core idea of RI, which highlights how current methods fail to fully consider societal needs and values (Van Oudheusden 2014). Existing RI frameworks, such as those proposed by Stilgoe, Owen, and Macnaghten (2013), emphasise the integration of ethical considerations and societal concerns into innovation development but tend to lack detailed explorations of how intermediaries can facilitate this process.

Concurrently in practice, European regions are emerging as key drivers of systemic innovation (Reichert 2019), yet they face diverse challenges within their Regional Innovation Ecosystem (RIE). These challenges include a complex innovation landscape with isolated innovation approaches (Gamidullaeva 2018) and the persistent 'European Paradox', representing the gap between research results and market innovations (Herranz and Ruiz-Castillo 2013). Further obstacles stem from limitations in ecosystem connectivity and targeted stakeholder interaction (Asheim 2019), emphasising the need for future exploration of appropriate frameworks to ensure effective interactions among Quadruple Helix stakeholders in the ecosystem (Del Vecchio et al. 2017; Plewa et al. 2013).

These developments have incentivized scholars to explore new approaches that combine the concept of innovation ecosystems with emerging innovation intermediaries like Living Labs (LLs) (Gamidullaeva 2018). LLs have been identified as crucial intermediaries that can potentially bridge the gap between societal needs and technological development and foster the key dimensions of RI (Campos and Marín-González 2023). These key dimensions of RI involve the inclusion of diverse stakeholders, anticipation of future impacts, responsiveness in research processes, and reflexivity in underlying beliefs (Burget, Bardone, and Pedaste 2017; Stilgoe, Owen, and Macnaghten 2013). Our study builds on existing frameworks in RI that emphasise the importance of integrating societal concerns and ethical considerations into technological development (Stilgoe, Owen, and Macnaghten 2013; Van Oudheusden 2014).

LLs emphasise the responsibility to anticipate future impacts of current technological and social change and stress the necessity for inclusive participatory processes to advance economic, environmental, and social sustainability (Adam and Groves 2011; Campos and Marín-González 2023). More precisely, LLs emerge as pivotal innovation intermediaries in their potential to coordinate innovation activities across multiple actors in the RIE (Gamidullaeva 2018; Schaffers and Turkama 2012). They foster open stakeholder collaboration (Gamidullaeva 2018), adopt a user-centric focus on societal needs (Almirall and Wareham 2011), and drive transformative innovation (Schaffers and Turkama 2012) that can be used to address social-political problems (Zivkovic 2018). They take a key role in solving the 'European Paradox' by tapping into user needs to adapt knowledge creation to market value for user-driven innovations (Almirall and Wareham 2011; Schuurman 2015). Recent studies consider LLs as catalysts and accelerators of systemic innovation in collaborative innovation networks (Schaffers and Turkama 2012; Toffolini et al. 2021). These inherent characteristics of LLs make them ideal vehicles and facilitators for continued learning, multiple perspectives, and productive

collaboration, elements proposed by Fisher et al. (2024) that are essential to further develop the field of RI.

Evidence on the performance of LLs remains a point of attention and studies are increasingly questioning outcomes and benefits (Ballon, Van Hoed, and Schuurman 2018; Paskaleva and Cooper 2021). Despite their potential, a theoretical gap appears in fully leveraging LLs within the RIE (Schaffers and Turkama 2012). Related concepts such as Open Innovation or user engagement require better integration into existing ecosystems to achieve their full potential (Schaffers and Turkama 2012). The literature reveals various obstacles in the effective implementation of LLs, including the lack of sustainability and scalability of the innovation activities due to their reliance on project-based funding (Evans et al. 2015; Schaffers and Turkama 2012; Schuurman 2015). In response, previous studies suggest the evolution of LLs into sustainable multi-level governance structures actively engaging user needs in coordinating regional innovation dynamics (Del Vecchio et al. 2017). The incorporation of LLs into their ecosystems holds the potential for systematically transforming existing innovation approaches and networks as these learning environments stimulate systemic innovation (Schaffers and Turkama 2012). This integration promises benefits such as streamlined innovation development, enhanced alignment with stakeholder needs, and increased competitiveness on a European scale (European Commission 2021; Schaffers and Turkama 2012). These evolutions result in the growing importance of exploring conceptual governance approaches for the sustainable integration of LLs into the RIE.

This study aims to address these gaps by developing a conceptual framework that integrates LLs into the broader RIE. The primary research goal is the development of a conceptual framework that integrates LLs into the broader RIE. The following research question guides the exploration: '*How can the concepts of LLs and RIEs be effectively integrated into a conceptual framework that visualizes the key elements and their links?*'. The resulting integration framework, which explores the main role, detailed functions, and key elements, provides a conceptual model aligning the synergies of contemporary innovation approaches. The findings position LLs as central orchestrators in the ecosystem, catalysing stakeholder collaboration, facilitating real-life experimentation, and ensuring user-centric innovation. Our study specifically examines the theoretical typology of LLs connected to regional policymakers, emphasising their role in actively facilitating innovation activities. Drawing from an interview study conducted within the specific context of the Interuniversity Microelectronics Center (imec) in the Flemish Innovation Ecosystem in Belgium, the study develops a conceptual framework with potential applicability across diverse contexts. Overall, the research contributes to the literature by providing an integrated perspective on the broader significance of LLs in regional innovation.

Our study contributes to the field of RI by moving beyond the descriptive, case-based approached that have previously connected LLs and RI. While earlier studies focused on specific contexts such as renewable energy (Campos and Marín-González 2023) and precision agriculture (Gardezi et al. 2024), our research offers a broader framework that transcends such thematical domains. We build upon key frameworks in RI, particularly those emphasising the integration of societal concerns and ethical considerations into innovation processes (Fisher 2021; Stilgoe, Owen, and Macnaghten 2013). By enhancing the role of LLs in the RIE, our study aims to propose a framework where LLs serve as crucial intermediaries to facilitate stakeholder collaboration and anticipate societal

impacts. This approach not only strengthens RI by aligning innovation processes with societal needs and values but also addresses existing gaps in RI frameworks.

Theoretical literature review

The regional innovation ecosystem

In the realm of complex global challenges, regions have emerged as central hubs facilitating systemic innovation across diverse domains by connecting regional and global development, economic and social growth, and innovation objectives with sustainability goals (Reichert 2019). Recognising this pivotal role, the European Commission has introduced Regional Innovation Ecosystems as a strategic policy tool, seeking to catalyse transformation through collaboration among Quadruple Helix stakeholders and the co-creation of effective solutions (European Commission 2021).

Derived from the broader concept of Innovation Ecosystems (Granstrand and Holgersson 2020), the Regional Innovation Ecosystem strategically fosters regional innovation and addresses contemporary challenges. Positioned as the institutional infrastructure supporting innovation within regional boundaries (Asheim and Gertler 2006), it plays a multifaceted role with the primary objective of leveraging regional innovation capacity through the integration of various innovation actors and resources in geographic proximity (Asheim 2019; Reichert 2019). Innovation capacity, in this context, refers to the present and potential innovation capabilities of a region to transfer knowledge into innovations for long-term economic growth (Freeman 1995; Schiuma and Lerro 2008).

The RIE emerges as a theoretical concept within policymaking, advocating a systemic innovation approach and emphasising the integration of regional sectors with broader policy frameworks (Asheim, Isaksen, and Trippl 2020; Hynes, Lees, and Müller 2020). It also acts as an umbrella and governance structure, promoting Quadruple Helix stakeholder collaboration in regional innovation, and strategically governing innovation activities to enhance the economic competitiveness of a region (European Commission 2021).

However, theoretical challenges in the RIE stem from insufficient integration approaches among different innovation concepts, leading to constraints in the understanding of their potential interaction (Asheim 2019). To address these challenges, there is a growing interest in considering the integration of innovation intermediaries like LLs into the RIE (Gamidullaeva 2018).

Living labs as innovation orchestrators

LLs emerged in the literature as dynamic innovation intermediaries (Gamidullaeva 2018) and are defined by the European Network of Living Labs (ENoLL) as 'Open Innovation Ecosystems' (ENoLL 2023). Leveraging iterative feedback processes, LLs create sustainable impact and provide real-life environments for testing and co-creating innovations (Leminen, Westerlund, and Nyström 2012). LLs orchestrate stakeholder networks across the Quadruple Helix, involving government, research institutes, companies, and citizens (ENoLL 2023; Schuurman et al. 2016). This orchestration occurs at multiple

levels, with a specific focus on the organisational level, where they manage, monitor, and coordinate different LL projects (Schaffers and Turkama 2012; Schuurman 2015).

In the early 2000s, when the LLs movement started gaining momentum in Europe, LLs originated mostly from university technology transfer organisations or city innovation centres (Almirall and Wareham 2008). In the early days, LLs were mostly linked to ICT innovation, with a heavy emphasis on the European context of these evolutions (Eriksson, Niitamo, and Kulkki 2005). The strong European support for LLs is linked to their envisioned potential to help solve the so-called 'European paradox' (Almirall and Wareham 2011; Schuurman 2015). The notion refers to Europe's leading position in scientific excellence, but its lagging ability to translate science into innovation and business applications (European Commission 1996). While the notion is debated upon in literature, it has stimulated a lot of support for innovation intermediaries that might play a role in resolving the paradox.

These early LL initiatives were mostly linked to EU and local policies regarding ICT introduction and innovation and built further on European phenomena such as cooperative design and digital cities (Ballon and Schuurman 2015). The current application domains of LLs are a lot more diverse in nature. Examples include LLs located on university campuses (Evans et al. 2015) and Urban Living Labs that focus on solving urban issues (Peters 2017; Steen and van Bueren 2017). This paper focuses on LLs connected to local and regional policymakers, pivotal in supporting, orchestrating, and facilitating local and regional innovation.

Within the RIE, LLs are considered multi-level governance structures that organise regional innovation dynamics, focusing on the inclusion of user needs in regional policy formulation (Del Vecchio et al. 2017; Marsh and Trapani 2011). LLs contribute to coordinating systemic innovation among stakeholders, dynamically managing knowledge, and enabling a collaborative approach to innovation (Gamidullaeva 2018; Leminen, Westerlund, and Nyström 2012). They facilitate the transition from research outcomes to market implementation by providing a scientific foundation for market validation and social acceptance, often through the central role of research centres (Del Vecchio et al. 2017). LLs have the potential to act in response to the vision of the Committee of the Regions (2012) to reinvent the future of Europe by transforming regions into real-world implementation fields (König and Evans 2013).

The conceptualisation of the relationship between LLs and the RIE is often explored based on the common underlying principles of Open Innovation and the Quadruple Helix model (Del Vecchio et al. 2017; Gamidullaeva 2018). The Open Innovation context refers to the collaborative innovation co-creation between actors from academia, industry, government, and civil society (Curley and Salmelin 2013), with LLs enabling this collaboration as 'innovation arenas' (Almirall and Wareham 2011). Importantly, LLs ensure active user involvement throughout the innovation process, expanding the ecosystem from the traditional Triple Helix configuration to the Quadruple Helix model (Del Vecchio et al. 2017). However, while the inclusion of user engagement is often claimed as the most important benefit, this characteristic is inherent to the definition of LLs. Such circularity does not help the scientific grounding of the LL construct and precludes effective evaluation thereof (Paskaleva and Cooper 2021). For example, in the context of smart cities, Nguyen, Marques, and Benneworth (2022) find that incorporating citizens into smart city models is more challenging than the Quadruple Helix discourse conveys.

Challenges to maximise the impact of living labs

While the literature underscores the significant role of LLs in RIEs, the challenge lies in the lack of frameworks for their effective integration into the broader innovation landscape (Schaffers and Turkama 2012). Veeckman et al. (2013) argue that if innovation is contemplated via LLs, intended inputs and hoped-for outputs should be considered more carefully for LLs to have practical significance. Existing obstacles primarily persist in the limited sustainability inherent to the often-short-term focus of LLs on organisational needs (Leminen, Westerlund, and Nyström 2012; Schaffers and Turkama 2012). Another complexity lies in the governance of LLs based on their multifaceted nature, involving multiple stakeholders with varying interests in joint innovation activities (Leminen and Westerlund 2012; Van Geenhuizen 2013). The effective recruitment of suitable user and stakeholder groups and their active engagement in the co-creation activities is a significant undertaking (Bergvall-Kåreborn and Stahlbrost 2009; Følstad 2008; Robaeyst et al. 2023).

Schuurman (2015) illustrated that the added value of LLs goes beyond a single project with LL characteristics and introduced a three-layered model distinguishing the LL organisation, orchestrating multiple LL projects over time, with specific user and stakeholder co-creation and real-life experimentation methods and tools being used during these projects. However, the long-term sustainability of this organisational level is one of the key challenges, which hinders their seamless integration into broader systems (Evans et al. 2015; Schaffers and Turkama 2012). This issue of sustainability can be illustrated by the fact that currently 152 of the ENoLL accredited LLs are active, whereas 314 historically accredited LLs are no longer active, which means that two out of three LLs ceased to exist in their former outlook after some time (Schuurman 2023).

The issue of sustainability, referring to a LL's viability and its responsibility to its surrounding community (Bergvall-Kåreborn et al. 2009), underscores the necessity for developing long-term sustainable business models and embracing standardisation. These measures are considered crucial for fully leveraging the potential of LLs as coordinators of systemic innovation in regional contexts (Schaffers and Turkama 2012) and tackle contemporary wicked issues in an integrated approach. To this end, an important debate emerges around the role of transdisciplinarity in such integration efforts. For example, drawing on transition management, Wanner et al. (2018) describe how phases of co-creation, co-production, and co-evaluation within real-world laboratories enable sustainable transitions through transdisciplinary research practices. Transdisciplinary research is a continuous problem-oriented process of convergence and consideration for the integration of the perspectives of science and practice (Laborgne et al. 2021). In the context of Living Labs, inclusiveness of perspectives, translation and communication of knowledge, and power asymmetries/relations deserve further attention (Laborgne et al. 2021; Menny, Palgan, and McCormick 2018; Nguyen, Marques, and Benneworth 2022).

Integrating living labs in the regional innovation ecosystem

Providing conceptual frameworks integrating LLs into the RIE is a critical step in supporting the development of regional innovation and addressing the complex challenges

Table 1. Relevant studies on the role of LLs in the (R)IE.

Title	Description	Article	Comments
Innovation Ecosystem Hub Model	LLs, as central hubs, coordinate innovation processes by brokering QHM actors and accumulating resources at various project stages (Claudel 2018).	Claudel (2018), adapted from Curley and Salmelin (2013) and Visnjic et al. (2016)	Model lacks specificity on LLs' role, functions, or benefits in the ecosystem, focusing on hubs in general.
Distributed Ecosystem Organisation	LLs function as crucial hubs, fostering organisational fields around QHM actors, contributing to participatory innovation and risk mitigation in urban experiments. They evolve through specialisation, splitting, or transitioning to a mediating role (Claudel 2018).	Claudel (2018)	Model lacks specificity on LLs' role, while focusing on ecosystem evolution, and suggests a limited, temporary function, hindering a clear view of integration.
Living Labs in Cross-Border Systemic Innovation	LLs are not well integrated into the RIE, with a need for better integration of Open Innovation and user involvement. LLs take on a coordinator role in systemic networks (Schaffers and Turkama 2012).	Schaffers and Turkama (2012)	Concept points out the lack of LLs' integration and potential benefits but lacks further elaboration on the implementation of the proposed integration.
Combining Innovation Ecosystem and innovation intermediaries	LLs, as distinct innovation intermediaries, focus on user involvement in an Open Innovation approach. They can take on a systemic innovation intermediary role, catalysing and coordinating activities across various actors (Gamidullaeva 2018).	Gamidullaeva (2018)	Concept outlines the potential roles and functions of LLs but lacks a model for integration and implementation.
Living Labs as concept to activate dynamic Innovation Ecosystems	LLs, focusing on users in the QHM, provide a systematic approach to activating Innovation Ecosystems. They take on multi-governance structures, enabling the active inclusion of users' needs to coordinate innovation dynamics in the region (Del Vecchio et al. 2017).	Del Vecchio et al. (2017)	Concept highlights the value of LLs but lacks specificity on their roles in integration or a specific integration approach.

of contemporary society. Despite efforts by previous studies to position LLs within the broader innovation ecosystem, the current literature exhibits limitations in providing a comprehensive framework for their integration within the RIE. Table 1 provides a comprehensive overview of relevant theories, emphasising and exploring the potential roles of LLs in various contexts within the domain of the innovation ecosystem.

The Innovation Ecosystem Hub Model, for example, views LLs as a central hub in the ecosystem, consolidating innovation activities by facilitating relations and collecting resources across different Quadruple Helix sectors (Curley and Salmelin 2013; Visnjic et al. 2016). The evolved Distributed Ecosystem Organisation Model emphasises a shift from the traditional hub structure, portraying LLs in a more distributed role that provides an initial niche for experimentation (Claudel 2018). It fosters dynamic organisational fields and transitions away from the original hub role over time (Claudel 2018). The relationship between LLs and the RIE is commonly established through

Open Innovation flows and the Quadruple Helix configuration (Del Vecchio et al. 2017; Gamidullaeva 2018), fostering dynamic and sustainable interactions. Present approaches, such as the Innovation Ecosystem Hub Model and the Distributed Ecosystem Organisation Model, focus on ecosystem evolution but lack specificity on LLs' roles, functions, or benefits in the innovation ecosystem. They often focus on specific contexts, which hinders the development of a holistic perspective on the broader integration of LLs (Paskaleva and Cooper 2021).

Further studies have explored the multifaceted roles of LLs within innovation ecosystems or networks. For instance, Gamidullaeva (2018) envisions LLs as crucial innovation intermediaries, fostering extensive networks and ensuring continuous integration. The study outlines three central functions of Living Labs as innovation intermediaries: facilitating Quadruple Helix collaboration, providing complementary services as experimental platforms, and bridging the realms of science and public authorities (Gamidullaeva 2018). These versatile roles contribute to the creation of dynamic innovation ecosystems, fostering collaboration in large networks of Quadruple Helix actors (Del Vecchio et al. 2017). Moreover, LLs function as catalysts for innovation, enabling open community-based transition arenas that drive broader industrial and societal transformation by overcoming institutional challenges (Schaffers and Turkama 2012). They can adopt a critical role in coordinating innovation activities among multiple actors at the systemic level, eliminating barriers, and harmonising the efforts of ecosystem participants (Gamidullaeva 2018; Schaffers and Turkama 2012). Despite these valuable insights, the existing body of literature collectively provides an incomplete exploration of the precise functions of LLs in the ecosystem. For example, innovation outcomes via quadruple helix interactions could also be considered intangible (e.g. concepts, ideas, or dialogues) rather than merely tangible (e.g. designs, products, or services) (Nguyen and Marques 2021). Indeed, LLs should not be regarded as mere technology tests under real-word conditions (Engels et al. 2019). Social order may itself become part of the experimentation as new socio-technical orders are (re-)configured on a regional scale.

While the potential role of LLs in operating collaborative networks within the ecosystem is acknowledged, studies often lack details on the specific functions and concrete strategies for enabling integration. Schaffers and Turkama (2012) propose valuable lessons learned to leverage LLs in this function, providing insights on establishing a collaborative ecosystem, defining clear roles, fostering competencies, ensuring technology compatibility, formalising agreements, promoting mutual understanding, and employing effective project planning. Despite these valuable lessons, the study shows limited insights in terms of the translation of the theoretical insights into actionable implementation. Additional limitations include the absence of precise practical implications for stakeholders and insufficient evidence demonstrating the impact of the proposed integration in practice.

The findings reveal a lack of studies that address the comprehensive integration of LLs into the RIE. This gap contrasts with the demonstrated need for holistic governance across diverse innovation approaches to tackle complex global challenges as well as the highlighted potential of LLs in this context (Gamidullaeva 2018; Schaffers and Turkama 2012). This research aims to address these gaps by introducing a conceptual integration framework specifying the role, key elements, and benefits of LLs in the ecosystem.

Methodology

Research design

This study employs a qualitative research design, focusing on in-depth exploration of contemporary concepts, namely the LLs and RIE. Qualitative research, recognised for its ability to offer holistic insights and understandings serves as the chosen methodology (Hennink, Hutter, and Bailey 2020; Lester, Cho, and Lochmiller 2020). We aim to create a conceptual understanding of the role of LLs in the RIE. We conducted semi-structured interviews using the Interuniversity Microelectronics Centre (imec) in Flanders, Belgium, as a context for our study. Imec is the largest LL in Belgium and is a full member in the European Network of Living Labs (ENoLL 2023; Schuurman 2015). The selection process involved a pre-evaluation of all Belgian Living Labs registered at ENoLL, examining their structure, connections, and contributions to the RIE. The purposefully selected context aligns with the criteria for qualitative research on LL (Leminen, Nyström, and Westerlund 2020), ensuring adherence to the LL approach, the involvement of multiple stakeholders in the innovation process, and the inclusion of various user or citizen groups.

Empirical context

Established in 1984 as an independent research centre by the Flemish government, imec specialises in nanoelectronics and digital technology (Imec 2023). Next to imec's international activities, it also operates as the 'Flemish Innovation Engine' to create local value within the Flemish Innovation Ecosystem by leveraging its global position as an R&D hub. This involves collaboration with local universities (KU Leuven, Universiteit Antwerpen, Universiteit Gent, Vrije Universiteit Brussel, and Universiteit Hasselt), industry, government, and citizens (Imec 2023; Schuurman 2015).

Imec's LL division, originating from iLab.o and later iMinds Living Labs, serves as an experimentation and test environment for co-creation and real-life testing of emerging technologies. In 2006, iMinds iLab.o was a founding member and part of the first wave of Living Labs of the European Network of Living Labs, the association of benchmarked Living Labs (ENoLL 2023). Since 2009, imec has offered 'Living Labs as a Service', involving over 20,000 users and a diverse range of modelling and prototyping expertise (Schuurman 2015). The LL methodology is project-based, focusing on preventing systematic failures by involving users and stakeholders early in the innovation process (D'Hauwers et al. 2017; Schuurman 2015). Over time, the role of imec and its LL activities shifted, driven by the changing needs within the Flemish Innovation Ecosystem, reflected in the five-year covenant between imec and the Flemish government, and because of the merger between iMinds and imec in 2016, which emphasised much more the link with imec's technological research. In 2021, imec received a total of 111.6 million euros from the Flemish government, which is the biggest amount of all research and technology centres in Flanders (Flemish Government 2022).

Over the years, imec's LL activities encompassed a wide range of projects, from early tests of digital television in 2003 to more recent initiatives like City of Things in Antwerp, the Internet of Water-project involving imec sensors and all relevant water players of Flanders, and the Physical Internet Living Labs in the logistics domain in 2023 (Imec

2023). Today, imec's formal LL division has evolved into the AI and Data department, supporting the region's innovation landscape in the domains of public health, mobility, logistics, sustainability, and lifelong learning, with AI and data technology as main technological enablers, connecting to imec's hardware research and capabilities. As the focus has shifted from bilateral SME projects towards more systemic ecosystem projects relying on imec's technology research with intense collaboration with the public sector, the user panel activities have been abolished in favour of intense ecosystem and community management, still aligning with the shift from the Triple to the Quadruple Helix approach (Schuurman 2015).

Data collection and analysis

Data collection is based on seven expert interviews to yield a deep understanding of the topic and generate theories based on empirical evidence (Dorussen, Lenz, and Blavoukos 2005). Experts are described as individuals with deep process, technical, and interpretive knowledge in their field of expertise (Bogner, Littig, and Menz 2009). Expert interviews are conducted to access their specialised knowledge and gain specific insights into the research area. Given the use of expert interviews and a bounded empirical context, the relevancy of our sample to address our research aim, rather than its size, served as a basis to evaluate its adequateness (Edwards and Holland 2013). The sample of respondents consists of three distinct groups that collectively offer a comprehensive exploration of the research topic (Table 2). The interviews included two experts engaged in LLs and innovation activities at Imec, two respondents involved in network and chairing activities at ENoLL, and three senior researchers and innovation managers from affiliated universities like Imec-SMIT and Imec-IMS at Vrije Universiteit Brussel (VUB). Diversity was considered as a relevant aspect in the selection of the interview sample including four male and three female participants.

The interview process was uniformly applied to all participants, with stringent selection criteria aimed at ensuring a high level of expertise in the field, extensive experience in the position, proficient English language skills, and, where applicable, relevant

Table 2. List of interview respondents.

Respondent	Gender	Institution	Recent Position	Experience
Respondent 1	Male	(a) ENoLL, (b) previously imec	(a) Network builder, (b) User involvement	(a) Min. 3 years, (b) min. 10 years
Respondent 2	Male	VUB imec-IMS	Research and innovation manager	Min. 2 years
Respondent 3	Female	Imec	Innovation manager and LL researcher	Min. 10 years
Respondent 4	Male	(a) Imec, (b) ENoLL	(a) Innovation expert LLs (b) LL specialist	(a) Min. 6 years, (b) min. 3 years
Respondent 5	Female	VUB imec-SMIT	Senior researcher	Min. 11 years
Respondent 6	Male	(a) ENoLL, (b) Brainport Eindhoven EU Office	(a) Vicechair, (b) Programme Director (c) European Affairs	(a) Min. 6 years, (b) min. 14 years
Respondent 7	Female	VUB imec-SMIT	Senior researcher	Min. 3 years

publications in the research domain. The interviews were conducted either in person or online, recorded, and later transcribed. Respondent identities were anonymized for confidentiality (Hennink, Hutter, and Bailey 2020). The primary data collection instrument describes a semi-structured interview guideline (Appendix), a widely used instrument in expert interviews (Lester, Cho, and Lochmiller 2020). The interview questions draw on the findings from the theoretical literature review, specifically addressing identified gaps in the exploration of the main role of LLs, necessary integration mechanisms, and benefits associated with the integration process.

The data analysis employs qualitative content analysis based on the methodology of Mayring (2015), ensuring the systemic evaluation of the data material with a prior definition of the evaluation units and evaluation rules (Maying and Fenzl 2014). The analysis uses a mixed approach; combining deductive and inductive analysis (Mayring 2014). The deductive 'structuring' approach systematically applies pre-defined categories to extract relevant aspects pertinent to the research question from the material (Mayring 2015). Concurrently, an inductive approach identifies emerging themes and categories that were not predetermined but emerged from the data itself (Maying and Fenzl 2014). Our deductive categories include the role of imec, role of LLs, functions of LLs, functions of RIE, functions of both, current integration, integration solutions, and integration benefits. Their sub-categories predominantly emerged inductively. For instance, within the category 'role of LLs', sub-categories emerged on the general role, catalyst function, orchestrator function, and stakeholder engagement function. In a final step, the 'summarizing' technique facilitated the subsequent material reduction through abstraction to develop a comprehensive overview of the base material (Mayring 2014). The NVivo R1 software (QSR International Pty Ltd, 2020) supported the data analysis by organising and extracting insights from the unstructured interview material.

Results

The interviews with key actors reveal valuable insights into the conceptual reasoning regarding the integration of LLs into the RIE. The framework (Figure 1) includes the roles, relationships, key elements, and benefits essential to the integration process. The integration leverages the distinctive strengths of both LLs and the RIE to enhance innovation sustainability and effectiveness in response to identified research gaps (Gamidullaeva 2018). This framework seeks to leverage their mutual capabilities in *stakeholder collaboration, systemic innovation, and societal impact*, addressing issues like the 'European Paradox' because of the explicit link between regional research capabilities and industrial innovation output, facilitated by government policies and funding (Herranz and Ruiz-Castillo 2013).

The RIE in the framework forms the broader innovation environment shaped by government initiatives to boost innovation capacity within the region, orchestrating Quadruple Helix collaboration, strategically governing innovation processes, and aiming to become a hub for systemic innovation, as previously highlighted in the literature review (Asheim 2019; Reichert 2019; Robaczewska, Vanhaverbeke, and Lorenz 2019). These ecosystems evolve, increasingly focusing on achieving societal cohesion, as demonstrated in the Flemish Innovation Ecosystem (Respondent 2; Respondent 7). Respondent 2 attributes its success to the openness, demand-driven nature and focus on societal

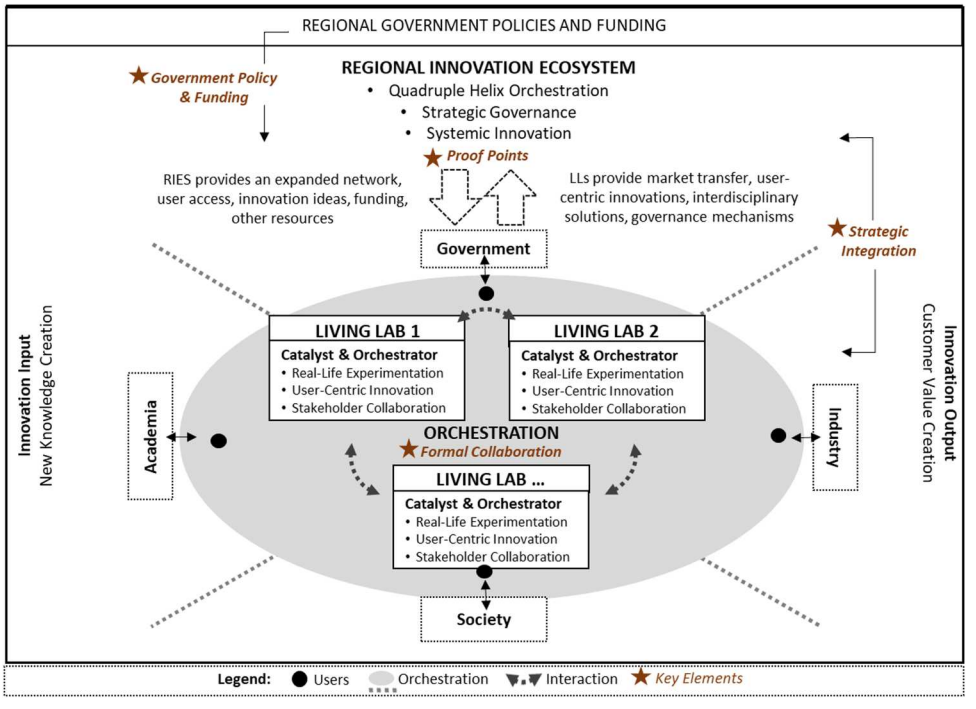

Figure 1. Proposed Framework for the Integration of LLs in the RIE.

concerns: '*It is about the openness of how they approach that incubation trajectory. (…) It's not very rigidly industry driven; it is always demand driven, are we solving a problem for anyone*'. The RIE employs a comprehensive, long-term strategy to bolster regional innovation capacity, whereas LLs adopt a more specific, use-case-oriented focus to advance innovations (Respondent 1). The common context for integration lies in their shared functions, which revolve around stakeholder collaboration, systemic innovation, and societal impact.

Role and key functions of living labs

LLs take on the main role of the *orchestrator* at the core of the proposed framework, managing and coordinating innovation activities across different Quadruple Helix stakeholders within the RIE, as identified in the literature (Schaffers and Turkama 2012). This role emphasises their function as connectors, integrating Quadruple Helix actors and providing vital skills, tools, and experiences to bridge various initiatives and ecosystems (Respondent 2). This aligns with the view that LL participants are driven by the theoretical notion of the Quadruple Helix and LLs as practical instrument (Nguyen and Marques 2021). LLs orchestrate the ecosystem through governance, structure, and decision-making processes, steering it towards outcomes beneficial for all stakeholders (Respondent 2; Respondent 5; Schaffers and Turkama 2012). The findings showcase imec and its LL activities as an exemplary orchestrator, connecting '*research polarization and policy information, i.e. having policy informed by means of involving citizens*' (Respondent 5). Additionally, '*the years of experience with Living Labs play a role there to see how we*

can harmonize and streamline the new challenges from the technology inputs, societal user inputs, and business side to one optimally functioning unit' (Respondent 5). These directions aim to establish orchestrated LL projects with key actors addressing current political agenda topics, offering use cases to fill gaps in the ecosystem (Respondent 5).

This incorporates their role as *catalysts,* brokering stakeholder networks and creating a '*thriving innovation ecosystem in the region*'. Respondent 1 also refers to the role of LL in the RIE creation: '*Living labs being the catalyst, being the tool to involve the right people, which you need if you want to create an innovation ecosystem*'. This role aligns with the theory of LLs as innovation intermediaries that broker the dynamic nature of innovation ecosystems (Claudel 2018; Del Vecchio et al. 2017; Gamidullaeva 2018). Literature revealed that the catalyst role involves activating stakeholder networks, driving transformational change, and facilitating systemic innovation (Schaffers and Turkama 2012). The framework presents individual LLs, often based on project-based foundations, emphasising their diverse methodology-based projects evolving from societal contexts (Schaffers and Turkama 2012). The LLs ideally collaborate, fostering innovation dynamics and mobility across different projects and stakeholders, like previous approaches (Claudel 2018). Overall, these key roles demonstrate the dynamic capabilities of LLs as orchestrators and catalysts to provide dynamic innovation reactions to changing needs in the surrounding ecosystem.

In their orchestrator role, LLs perform three primary functions within the ecosystem. They offer *real-life experimentation,* enabling realistic testing of innovations in local proximity within controlled but real-world settings (Respondent 2; Schuurman 2011). This involves considering external factors and regional context, facilitating multiple rounds of experimentation, prototyping, iteration, and validation to ensure innovation feasibility and adaptation to real-world effects (Respondent 4; Respondent 5; Almirall and Wareham 2011). It is worthwhile noting that the experimentation role is increasingly receiving scholarly attention (e.g. Bulkeley et al. 2019). Respondent 3 highlights the value contribution of LLs: '*You have a test environment where you can in a safe way and with maximum observation really in detail test your device before bringing it to the (…) factory floor itself*'.

These activities are firmly rooted in a *user-centric innovation* approach that places end-users at the core of the innovation process, ensuring that innovations continuously align with societal needs (Respondent 2; Almirall and Wareham 2011; Leminen, Nyström, and Westerlund 2020). Respondent 2 emphasises the importance of users in LLs by stating that '*a living lab is more about the user than technology, not the other way around*'. LLs distinguish themselves from similar innovation intermediaries through their capacity to 'act upon user feedback', adjusting the vision, mission, or projects in the innovation activities of the ecosystem (Respondent 2). At the core of LLs lies '*the flexibility and adaptability to the needs of the stakeholders and the users*' (Respondent 2).

LLs play a vital role in fostering *stakeholder collaboration* with Quadruple Helix actors in the RIE, utilising diverse co-creation tools and methods to support effective governance and shared visions (Respondent 2; Respondent 4; Leminen and Westerlund 2016). The challenge of handling unexpected outcomes in LLs (Leminen, Rajahonka, and Westerlund 2017) emerges as a positive attribute, fostering the creation of new visions that enhance innovation development in the ecosystem (Respondent 2).

Through the engagement of relevant stakeholders with the requisite expertise, LLs effectively address ecosystem challenges and promote mutual learning, thereby nurturing shared visions (Respondent 5; Del Vecchio et al. 2017; Nguyen and Marques 2021).

Overall, these functions enhance *innovation outcomes* by reducing the failure of innovation projects and fostering alignment between innovations and market demand (Respondent 1; Respondent 3). This plays a crucial role in bridging the gap between new knowledge creation and customer value generation to address the 'European Paradox' (Almirall and Wareham 2011), exemplified by the central position of LLs. LLs engage in *ecosystem support* through support mechanisms like attracting funding and raising awareness about regional innovations in policymaking, enhancing their impact on the overall ecosystem. Respondent 2 highlights the focus on societal value '*We are doing that because it is not about being the best, it is about providing solutions to everyone*'. The impact is evident in imec's LL activities: they '*put Flanders on the map as being one of the leading initiatives in the world regions*'.

Key elements facilitating integration

The findings highlight the '*need for some change management*' (Respondent 4) for the successful integration of LLs and suggest various *key elements* that facilitate the proposed integration. These key elements reach across different levels of the framework and include *government policy and funding, strategic integration, formal collaborations,* and *proof of concept*. The suggestion is supported by important studies in the field demonstrating the value of how different factors interact in an innovation system (Suurs and Hekkert 2009).

The empirical findings strongly emphasise the government as the main facilitator of the proposed integration by providing supportive long-term *government policy and funding* (Respondent 1). This clear responsibility of the government is expressed by one of the respondents: '*if the Flemish Government does not integrate it, it is not the job of the researchers who are doing the living lab projects*' (Respondent 1). Integration must be closely linked to the political agenda and innovation strategy of the region, with government policies, guidelines, and funding programmes serving as key resources (Respondent 1; Respondent 6). This integration key element demonstrates in the Flemish ecosystem:

> If you look at what has been the overall framework that the Flemish Government set into place in order to be able to finance these kinds of projects, you will realise that this is within a wider innovation strategy and development of innovation on a Flemish level' (Respondent 1).

This aspect further enhances the previous identification of the government's central role in promoting and initiating LL initiatives to achieve regional growth (Del Vecchio et al. 2017). The government must further support Open Innovation mechanisms, identified as the underlying principle of the mutual relationship (Gamidullaeva 2018), promoting mobility and collaboration across different LLs and their stakeholders in existing infrastructures (Respondent 2; Respondent 3).

Strategic integration requires aligning LL strategies with the long-term objectives of the innovation ecosystem through co-creation processes (Respondent 1; Respondent

2). Respondent 4 refers to a practical example of this goal alignment: '*What we normally do at the beginning of such a project is trying to align the goals and at regular intervals realign those goals*'. The introduction of formal structures to orchestrate LLs in a societal '*mission driven or challenge based*' innovation approach across technological advancements, societal needs, and business opportunities enhances ecosystem value (Respondent 5). This would enable LLs to take on the anticipated role of systemic innovation intermediaries, coordinating innovation processes across the political, industrial, academic, and societal domains (Gamidullaeva 2018). Respondent 5 further suggests aligning different LL activities*: 'We should think about creating a more formal structure, where we again label these living lab activities formally as a living lab together*'. Improved governance mechanisms were proven to be essential to aligning sustainable aspirations with innovation activities, ensuring that emerging technologies meet the needs of current generations while preserving opportunities for future generations (Foley, Bernstein, and Wiek 2016).

Formal collaborations describe the need for targeted cooperation with key players in the ecosystem (Respondent 2). Respondent 2 describes the example of a formal collaboration through an '*assigned memorandum of understanding, with the Joint Research Centre, which is seen from the policy makers perspective*'. The success thereby depends on the accurate reflection of the environment (Respondent 3), such as '*some stakeholders thinking a little bit beyond the day-by-day business*' (Respondent 5). This requires the engagement of specific target groups, like citizens interested in societal value, impactful actors, and younger generations (Respondent 5). Involving umbrella organisations, such as ENoLL, offers expertise to facilitate stakeholder interactions and knowledge sharing to enhance collaboration (Respondent 6). This overall reflects some of the lessons learned proposed by Schaffers and Turkama (2012), emphasising the need for a holistic approach with shared value and scalable solutions through clear process definition, expectation management, and goal setting involving all stakeholders (Respondent 6).

Additionally, the creation of *proof of concept* is essential for demonstrating the success of LLs, requiring host organisations, umbrella organisations, and other actors to establish effective impact measurement mechanisms for further concept adoption and integration (Respondent 2; Respondent 5). Respondent 5 expresses this key element as '*leading by example' with some proof points of 'projects that really run very well*'. These proof points are generated through bi-yearly impact studies carried out by an external company. For the concrete results of such an impact study, see Ballon, Van Hoed, and Schuurman (2018). These key elements are evident in the context of the Flemish Innovation Ecosystem, where imec as the host organisation connected government funding with LL research, thus incorporating the LL methodology as an early adopter into the Flemish Innovation Ecosystem (Respondent 1; Respondent 5).

Expected integration benefits

LLs contribute a range of benefits to the RIE through their integrated functions. They enable the successful *market transfer* of innovations, validating them for exploitation and enhancing business value in the ecosystem (Respondent 3; Respondent 7). This is evident in the case of imec as the 'Living Labs as a Service', which played a crucial role in supporting companies in testing and successfully launching their innovations

(Respondent 4). Emphasising *user-centric innovation* development, they employ comprehensive co-creation approaches, utilising user feedback for informed decision-making (Respondent 4; Respondent 5). Respondent 4 expressed that stakeholders can base their decision making on user feedback: '*if you participate with end users and you provide them with feedback, they can really base decisions on that*'. LLs offer *interdisciplinary solutions* with versatility to address diverse wicked issues by operating at the intersection of technology, business opportunities, and societal needs (Respondent 5). The evidence further confirms the stated potential of LLs (Del Vecchio et al. 2017) in providing multi-level *governance mechanisms*, overseeing, and directing innovation activities to align with ecosystem objectives (Respondent 5). This may connect to the broader scope of Responsible Innovation governance as the capacity of multiple stakeholders to reflect on broader societal dimensions (Smolka and Böschen 2023).

The RIE, on the other hand, provides LLs with expanded access to an *expanded network* of stakeholders, emphasising improved *access to users* (Respondent 7), effectively overcoming the previously identified challenge of recruiting suitable end-users (Bergvall-Kåreborn and Stahlbrost 2009). Furthermore, the ecosystem connects LLs with *innovation ideas*, *funding* possibilities, or other *ecosystem resources*, thereby accelerating innovation development (Respondent 1; Respondent 5; Respondent 6). The mutual benefits extend to the creation of *trusted relationships* with stakeholders beyond individual initiatives, fostering increased *knowledge transfer*, *sustainable innovations* for societal needs, and overall *ecosystem resilience* (Respondent 4; Respondent 5). Overall, the mutual interrelationship by portraying LLs as forerunner for other cities to showcase how it should be done, (…) while the regional innovation ecosystem is the potential adopter of the lessons learned' (Respondent 6). This finding is in line with scholarly work on the emergence of innovation ecosystem and the role of (positive) feedback loops for sustainable transitions and innovations (e.g. Suurs and Hekkert 2009; Walrave et al. 2018).

Overall, the integration fosters regional innovation capacities through different *impact* levels. This involves potential *economic impact* implications, mostly in terms of improved cost efficiency and economic competitiveness (Respondent 2). Moreover, it enhances *innovation impact* by increasing the feasibility and market potential of innovations by closely targeting end-user needs to effectively address societal concerns (Respondent 2). This links up with the argument of LLs contributing to solving the European Paradox. They accelerate the speed and value of innovation by fostering dedicated innovations (Respondent 7). Finally, the LL integration has a significant *societal impact* by promoting transparent and ethical innovation solutions that benefit all stakeholders and address real-life challenges (Respondent 2; Respondent 3). The results show that integrating LLs into the ecosystem has the potential to catalyse systemic innovation and transform existing structures (Schaffers and Turkama 2012).

Discussion and implications

This research contributes to the understanding of integrating LLs into RIEs. The proposed framework emphasises the roles, relationships, and key elements crucial for successful integration, offering a holistic perspective on the dynamic interplay between LLs and the broader ecosystem. Our findings emphasise the central role of LLs as orchestrators in the ecosystem, fostering stakeholder collaboration, systemic innovation, and

societal impact. These findings identify government policies, strategic integration, formal collaborations, and the provision of proof of LLs' success as key elements for integration. These integration strategies, along with evidence-based insights, provide a fresh perspective on how to foster long-term sustainability of LLs and on their role in addressing the 'European Paradox'.

Our study illustrates how LLs may potentially embody key dimensions of RI. Specifically, LLs support anticipation by facilitating iterative experimentation in controlled yet realistic environments, which helps forecast future risks and opportunities. They promote reflexivity and inclusion by adapting to the diverse needs of stakeholders and incorporating user feedback, rather than solely focusing on technological solutions. Additionally, LLs enhance responsiveness by continuously harmonising emerging needs into adaptable and integrative solutions.

This framework provides a new lens for operationalising RI principles in real-world innovation ecosystems. While previous studies have often examined LLs through sector-specific case studies (Campos and Marín-González 2023; Gardezi et al. 2024), our framework offers a structured approach for how intermediaries can facilitate RI in the RIE. It visualises the links between regional policies and funding on the one hand, and between innovation inputs and outputs on the other. Through orchestration, LLs can have an impact on innovation outcomes which enables a better transfer from academic knowledge to business and societal impact. Our proposed framework helps to position the different LLs vis-a-vis RIE elements and serves as a lens to analyse and evaluate other cases, which will enable more focused and robust impact assessment of LLs, RIEs and the links between them. This enables researchers, practitioners and policy makers to better understand and position LLs in RIE and use their capabilities of continued learning, adopting multiple perspectives, and facilitating productive collaboration (Fisher et al. 2024).

The principal integration strategies align with the crucial success factors outlined in earlier research on leading European regions (Committee of the Regions 2016). However, in our study, ambiguities emerged based on the diverse perspectives of respondents, particularly concerning the perceived role of government as initiator of the integration versus the perceived need for an increased bottom-up approach. This ambiguity highlights the essential balance between the necessity of government policy and funding, and stakeholder engagement for holistic innovation governance in transitional times. The relevance of such balance has been a topic of interest in commercial innovation literature as well, where innovation models have evolved from linear technology push or market pull models, to more interactive ones, ultimately embracing the open innovation paradigm (Curley and Salmelin 2013). Our findings strengthen the view that such evolution is of relevance in the RI discourse too and that it may help to disentangle these ambiguities further (Timmermans 2017).

Our framework adds to this literature stream by providing a holistic integration approach. Adaptability to other RIEs in Europe requires particular attention. Several social, cultural, economic, and political aspects could influence its implementation and effectiveness in different regional contexts. Our framework could help in clearly identifying and assessing these aspects. The effectiveness of our framework assumes some form of economic stability and the willingness of private and public sectors to invest in LLs. Such investment will, at least partly, be dependent on the measurable socio-economic

performance of LLs in the longer term (Paskaleva and Cooper 2021). Especially in turbulent times, not all regions are inclined to invest heavily in innovation fostered by LLs and rather conduct a savings policy, despite potential economic returns. On the other hand, such investment may be favoured by regions with a strong tradition of community engagement and participatory governance.

From a policy perspective, a favourable regulatory environment that encourages innovation and provides clear guidelines for LL operations is necessary. To this end, our framework can help organise and structure discussion around LLs, their components, and their integration in RIEs to address wicked problems (Hynes, Lees, and Müller 2020). The effectiveness of the framework is contingent on strong policy and institutional support, which might not be present in all regions. Cultural norms around collaboration and sharing knowledge might also play a role in how LLs can function as orchestrators. Moreover, some regions already have a long tradition of LL-activities whereas in other regions the concept might be relatively new.

Policymakers can make use of the proposed integration strategies and framework to formulate long-term policies and funding programmes to align initiatives across different innovation approaches and support the integration of LLs. To this end, our study aligns with existing initiatives, such as the European Digital Innovation Hubs (European Commission 2020), and more recently, the AI Testing and Experimentation Facilities (TEFs; European Commission 2023), aiming at integrating LLs as tools for innovation testing in the surrounding ecosystem. In both initiatives, imec plays a central role (Flanders AI EDIH and CitCom.ai). Industry and academic representatives can actively engage with LLs to accelerate innovation development and co-create interdisciplinary solutions addressing wicked problems. LLs and their host organisations should focus on creating proof points for success and employing effective impact measurement to attract further support and funding. Upon funding, LLs should require performance evaluations and impact assessments (Paskaleva and Cooper 2021). The active participation of society, especially end-users, is crucial to obtaining feedback for informed decision-making about innovations addressing societal needs.

Limitations and future research

Our study faces several limitations that need to be acknowledged to contextualise the findings and the proposed framework further. First, the study is limited in geographic scope focusing on the specific case of the Flemish Innovation Ecosystem, which may limit the generalizability of the findings to other regions with different innovation dynamics. Our empirical data relies on a limited yet qualitative set of interviews with diverse experts. While we are confident that our integration effort is justified, some actors, notably from connected (sub)ecosystems may not have been captured which limits full diversity of perspectives. Indeed, practical applications may involve interconnected ecosystems with various actors and roles (Valkokari 2015; Granstrand and Holgersson 2020). We encourage scholars to explore policymakers' perspectives on LLs integration, especially concerning policy formulation, funding mechanisms, and implementation barriers. This could provide invaluable insights for operationalising the integration strategies. Our integration omits interactions among different actors,

relations, infrastructures, and activities in these ecosystems for a focused research approach, while a more complex representation should be considered for real-world implementation.

Second, while the framework aims to represent Regional Innovation Ecosystems accurately, it might oversimplify more nuanced and intangible elements like the interactions between different LLs or their multi-level governance structure. For example, the framework envisions the co-existence of multiple LL projects evolving based on specific societal use cases. It simplifies connections between similar LLs but recognises unexplored interactions among them, with a remaining ambiguity on how different LLs collaborate in the ecosystem orchestration. At the same time, the project-based nature of Living Labs implies potential role changes after project completion that require further investigation. The connections highlight the desired dynamism and mobility among LLs to overcome integration hurdles. Further research could focus on potential orchestration mechanisms across the macro-, meso-, and micro-structures of LLs (Schuurman 2015).

Third, the study inherently adopts a positive stance regarding the potential integration of LLs, leveraging established advantages within the conceptual framework derived from the chosen context. However, as highlighted by some contradictory perspectives with regards to the effectiveness of LLs (e.g.Del Vecchio et al. 2017; Evans et al. 2015; Paskaleva and Cooper 2021; Veeckman et al. 2013), it is crucial to acknowledge that the framework needs further empirical validation across diverse cases for a more nuanced understanding of the different integration possibilities. Hence, building further on our discussion section, we encourage researchers to test the proposed framework in diverse geographic and sectoral contexts to assess its broader applicability and adaptability. Longitudinal studies could provide insights into how the integration of LLs and RIEs evolves over time and under different conditions. This would also contribute to the discussion on LLs ability to help solving the European Paradox.

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Disclosure statement

No potential conflict of interest was reported by the author(s).

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Janin Fauth is a graduate of the MSc in International Business from Vrije Universiteit Brussel (VUB). The article submitted is an extension of her master's thesis, which explored the Role of Living Labs in the RIE in Flanders, Belgium. Focusing on the integration of Living Labs into the RIE to address complex societal challenges, she provides a comprehensive framework for regional innovation governance. As a former Research Assistant at Karlsruhe Institute of Technology (KIT), she actively contributed to research initiatives, focused on EU-project

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Data availability statement

The participants of this study did not give written consent for their data to be shared publicly, so due to the sensitive nature of the research supporting data is not available.

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Appendix: Semi-structured interview guideline

Introduction: Brief overview of study • Interview procedure • Practical (incl. consent form, interview recording, data ethics)
Conceptualization: Definitions and boundaries on living labs and (regional) innovation ecosystems.
Exploring LLs roles in RIE: What is their general role? • *Follow-up questions:* Role of imec, role as 'vlaamse Innovatie motor' • *Control questions:* Subordinate roles, rephrase identified role
Exploring LLs functions in RIE: Which functions do they fulfil? • *Follow-up questions:* attach importance to identified and known functions • *Control questions:* specify, other functions, suitability of functions, differences and similarities
Exploring integration LLs and RIEs: How do you see this integration? • *Follow-up questions:* current state of integration at imec, how to better integrate in practice, tools and mechanisms • *Control questions:* justify level of integration, how to tools and mechanisms support
Exploring integration benefits: Benefits from enhanced integration? • *Follow-up questions:* specific benefits for imec, benefits for RIE • *Control questions:* examples, elaborate
Exploring impact on complex challenges: Assess impact? • *Follow-up questions:* how to strengthen regional innovation capacity • *Control questions:* examples, elaborate
Closing: Double check interviewee details and expertise • Referrals