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Cities in Transition and Urban Innovation Ecosystems: Place and Innovation Dynamics in the Case of Boston and Cambridge (USA)

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Abstract: Urban transition is gaining relevance in the academic and policy debate for rethinking urban development strategies toward resilience and sustainability. The transformative power of innovation and knowledge is called upon to speed up the process. In this paper, we address the issue of urban transition by exploring how the urban innovation ecosystem is a crucial factor in operationalizing city transition strategies. For this scope, we propose a methodological approach to identify the city-level innovation ecosystem by connecting innovation dynamics with urban transformation. The objective is to highlight how transition dynamics are spurred by the urban innovation ecosystem in its maturity stage. Therefore, the paper proposes a case study of the Boston area (the cities of Boston and Cambridge, USA) where it is possible to detect a mature urban innovation ecosystem. The case analysis unveiled the urban characterizing factors of the innovation ecosystem. Here, the concentration of innovation activities stimulates the demand for urban transformations, which are managed through urban planning and zoning and specific supportive policy-planning initiatives.

Keywords: urban transition; innovation ecosystem; urban governance and planning

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1. Introduction

In this paper, we address the issue of urban transition by exploring how the urban innovation ecosystem (UIE) is a crucial factor in operationalizing cities' transition strategies. Urban transition is gaining relevance in the academic and policy debate for rethinking urban development strategies toward resilience and sustainability, and the transformative power of innovation and knowledge is called upon to speed up the process. In the context of responding to the pandemic effects and implementing suitable recovery strategies, the recent geopolitical events that may hamper sustainable development and climate change [1] are just a few of the complex tasks to address for cities. Recently, the UN-Habitat World Cities Report [1] emphasized the possible directions for future urban development toward sustainability. In this direction, cities are surging as "promising leverage points to facilitate system transitions by promoting local innovation and policy experimentation" [2] (p. 1494). In cities, indeed, crises deploy their effects in showing social, economic, and environmental vulnerabilities, but systemic innovations and experimentations also emerge and unfold [3,4]. In addition, cities came to the fore as frontrunners and active shapers of the European Union's current and future policies (REACT-EU), confirming the significance of city-level governance in addressing societal challenges [5,6]. At the same time, innovation and technologies have proven to be crucial in the post-pandemic policy response of cities [7]. Their relevance—together with urban governance and planning—also emerges in managing their recovery and defining their future urban development strategies [1].

Considering this background, we focused on the institutional–technological nexus shaping local context [4] by investigating cities' urban governance and planning mechanisms and processes coupled with knowledge and innovation dynamics by considering

this nexus the cornerstone for urban transition [8]. Local context, indeed, is assumed as crucial for innovation in cities as it can drive local development and growth [9].

In Europe, Smart Specialization Strategies (S3) have been introduced to spur innovation-oriented development across territories and reduce the gap between (technologically) advanced and less advanced regions. Despite the policy efforts to promote a local innovation-led policy agenda oriented at more inclusive growth, such an objective seems difficult to reach [10]. In the S3, the valorization of the nexus between place and innovation is one of the main focuses of the policy framework, as the S3 concept focuses on place-based innovation-driven growth [11]. However, the risk that only the most economically advanced regions can realize the potentials linked to the S3 rationale by diversifying into highly complex activities is high [12]. Such risks also call for a direct connection between urban and local economic development policies and planning for developing embedded and innovative strategies leveraging local assets [13].

In the United States, the focus of the most recent overall "innovation policy" [14] aims for "policymakers to hear firsthand technology companies' perspectives to inform effective policy that maintains and advances the U.S. technological edge" [14] by stimulating national and local stakeholders to understand better the role of new technologies in specific places and urban areas [14]. However, the nexus between innovation and place was already occurring in response to the economic downturn of the late 2000s—the beginning of the 2010s with the rising of "innovation districts" [15] and the policymaker's debate on the possible exploitation of the Opportunity Zones economic development tool for the deployment of place-based innovation ecosystem-oriented policies and strategies for the creation of Innovation Zones [16].

Recently, the Driving for Urban Transition (DUT) [8,17] approach has brought an interesting perspective on this topic, in which the role of knowledge, research, and innovation in urban transition through the focus on UIEs in fostering transition processes and addressing urban challenges is emphasized. Indeed, "Municipalities must commit to a new kind of partnership with the scientific community—a partnership based on data, research, and innovation—to guide investment and policy decisions" [17] (p. 9). One of the general objectives of the DUT approach is to "shape a quadruple-helix innovation ecosystem on urban transition" [17] (p. 17), which "should offer different ways of interaction between science, policy, business, and society to ensure that research efforts better meet the needs of urban actors and society" [17] (p. 17). Therefore, exploring how cities design or support urban transition through urban governance and planning and the involvement of knowledge and innovation assets and resources in their urban innovation ecosystem can contribute to a better understanding of the urban transition dynamics. In this direction, the UIE can act as a central element to re-orient EU regional policies toward the green and digital transition of EU cities if adequately supported by urban governance and planning oriented at more inclusive and sustainable development.

In light of this background, we argue that the transformative processes activated by knowledge and innovation dynamics at the city level can drive cities' resilient transition reinforcing their proactive role in multi-level governance processes—thanks to the supportive role of urban planning and governance—by exploiting the innovation ecosystem (IE) ability to facilitate the restructuring processes of cities and regions in response to the structural changes imposed by globalized dynamics [18].

The literature examined for this paper outlines the interest of cities to analyze their innovation ecosystem and encourage initiatives for development [19]. Moreover, it explores the innovation ecosystem from a conceptual perspective and with a case study approach [19,20]. Therefore, following this rationale, the paper attempts to answer the following research question: How can the urban innovation ecosystem (UIE) be exploited to facilitate urban transition dynamics in cities and empower the local dimension while coupling innovation-led development policies and urban planning?

Specifically, the paper seeks to understand "where" innovation concentrates in cities, how it stimulates the demand for (physical) change, and how local authorities (cities)

support transformative processes through urban planning and governance. For this purpose, the paper proposes a multidisciplinary analytical approach for investigating the exploratory case of the Boston area (cities of Boston and Cambridge, USA) by focusing on the analysis of knowledge and innovation dynamics through the design of a cluster spatialization methodology (CSM) to detect and identify the urban areas where innovation concentration, dynamics, and urban transformation occur and on the detection of urban transition dynamics following the Driving Urban Transition (DUT) approach [8] thematic areas. The choice of Boston as a case study lies in the uniqueness of its context condition in terms of knowledge and innovation concentration dynamics, innovation ecosystem assets, and public–private initiatives and partnerships that characterize a mature innovation ecosystem. A better comprehension of these unique characteristics and triggering mechanisms could be helpful—if purposefully adapted to the different social, economic, political, technical, and normative contexts—for EU cities in supporting their knowledge and innovation dynamics following the ecosystem approach.

The paper is structured as follows. The next section casts light on the complexity of innovation ecosystems as critical elements for the transition and their relevance in activating urban regeneration processes. Section three explains the methodological approach finalized for the urban characterization of the UIE by detecting innovation concentration dynamics in a city and exploring UIE assets. The results and discussion section frames the dynamics detected in the case's urban development strategies and policy initiatives oriented at the transition. Finally, the paper discusses a conceptual framework to understand better how cities can facilitate the urban transition toward sustainability through urban governance and planning.

2. Literature Review

2.1. The Complexity of Innovation Ecosystem for the Urban Transition

It is commonly recognized that individual innovations are often embedded in broader systems. Therefore, understanding an innovation's consequences requires understanding its relationship to its external context [21]. Meanwhile, the ecosystem-based transformation of institutional and industrial landscapes needs to be facilitated with active policies to ensure sustainable growth in the age of globalization and non-linearity [22]. Moreover, stimulating and facilitating sustainable urbanization by focusing on UIEs is coming to the fore as an urban transition driver [8]. The concept of "innovation ecosystem" arose in the early 2000s, connected with its ability to facilitate emerging knowledge-based economies, in which the production of innovations and the associated development processes are increasingly non-linear and network-based [23]. Three main approaches structure the work on innovation ecosystems: platform-based ecosystem or digital ecosystem, regional/local ecosystem, and industrial ecosystem [24]. Various definitions of "innovation ecosystem" are available in the literature, focusing on components such as relationships and networks, value co-creation, place/milieu, etc. (Table 1).

Table 1. Definitions of "innovation ecosystem".

Author(s)	Innovation Ecosystem Definition
Adner and Kapoor [21]	Heterogeneous constellations of organizations, which co-evolve capabilities in the co-creation of value.
Russell et al. [25]	Networks of sustainable linkages between individuals and organizations, which emerge from a shared vision of desired transformations and provide an economic context (milieu) to catalyze innovation and growth.
Jackson [26]	The complex relationships formed between actors or entities whose functional goal is to enable technology development and innovation.
Autio and Thomas [27]	A network of interconnected organizations, organized around a focal firm or a platform, incorporating both production and use-side participants, and focusing on the development of new value through innovation.

Table 1. *Cont.*

Author(s)	Innovation Ecosystem Definition
Autio and Thomas [28]	A community of hierarchically independent yet interdependent heterogeneous participants who collectively generate an ecosystem output.
Katz and Wagner [15]	A synergistic relationship between people, firms, and place (the physical geography of the district) that facilitates idea generation and accelerates commercialization.
Mulas et al. [29]	(Urban technology innovation ecosystems are) the collection of stakeholders, assets, and their interactions in city environments resulting in technology (in particular ICT)-based innovation and entrepreneurship.
Russell and Smorodinskaya [22]	Open non-linear entities that are characterized by changing multi-faceted motivations of networked actors, high receptivity to feedback, and persistent structural transformations.
Granstrand and Holgersson [30]	The evolving set of actors, activities, artifacts, and the institutions and relations, including complementary and substitute relations, that are important for the innovative performance of an actor or a population of actors.

They also point out the characteristics of innovation ecosystems, including heterogeneity, complexity, evolutiveness, production–consumption integration, and openness. Recent literature uses "ecosystem" to associate with innovation, which shows, in knowledge economies, such distinct features as (1) more explicitly systemic; (2) the central role of ICT; (3) open innovation; (4) public relation value due to mimetic quality; (5) a greater emphasis on differentiated roles, or "niches"; and (6) the greater importance of market forces [31]. In addition, the explicit inclusion of use-side participants differentiates the ecosystem construct from other networks in the management literature, such as clusters, innovation networks, and industry networks, which are focused on the production side [27]. These features imply that innovation ecosystems, on the one hand, consist of economic agents, economic relations, and non-economic parts such as technology, institutions, sociological interactions, and culture [32]. On the other hand, they demand context conditions supportive of continual innovation, for which social, organizational, and cultural shifts are indispensable to underpin the development of the knowledge-based economy [23]. This is because, as a multi-level, multi-modal, multi-nodal, and multi-lateral system that features co-existence, co-evolution, co-specialization, and co-opetition [33], innovation ecosystems mark a non-linear model of innovation largely dependent on a system's social and structural transformations [22]. Therefore, innovation ecosystems are a priori dynamic systems, and both their structure and context conditions are in constant transformations and evolution [34–36]. Despite different realities, innovation ecosystems in different localities often go through the same stages of evolution [35]. According to the literature, they evolve following three significant phases: seed/nascent, cultivate/emergent, and nourish/mature [19,37], to which the fourth phase of self-renewal (or death) is added [20,38]. Through continuous transformation and reconfiguration, innovation ecosystems can generate new operating methods, systemic relationships, and functions [39]. Innovation ecosystems obtain adaptive capacity and sustainability [39,40]. For this reason, innovation ecosystems are increasingly perceived as complex adaptive systems [22–24,41,42], which are better positioned to exhibit resilience to change [28] and are responsive to socio-technical transitions, namely systemic transformations [43]. This adaptive ability enables them to meet today's need for more radical system innovations or transitions directed toward redesigning entire systems of practice and provisions [44]. Furthermore, facing crisis and transition-induced shocks, innovation ecosystems can provide mechanisms to enhance both resilience and competitiveness by avoiding technology lock-ins and structural and organizational rigidity [24]. The transformation of innovation ecosystems marks a co-evolutionary process, where environmental and ecosystem participants' changes mutually influence each other, prompting mutual adjustments [28,45,46]. First, their elements (actors, artifacts, and activities) are linked together through the dynamics of complement and substitute relations [30]. In addition, they constitute dynamic organizational spaces, namely, a sophisticated milieu of actors, assets, and linkages generated by collaborative activities within and among networks [22].

Grounded in such dynamic spaces and relations, they can organize isolated locally embedded assets into "complementary assets" [43] to achieve "collective functionality" [38,47] and manage systemic change with flexibility [48], thereby creating system output [28]. Innovation ecosystems have two concurrent goals: value co-creation through collaboration among networked actors [23] and forming an innovation-supportive milieu [49]. To develop innovation ecosystems, top-down and bottom-up approaches are needed [24,42], and it is necessary to create the right conditions for developing an external knowledge base that serves urban innovation strategies [50]. This is because while intra-regional connections are of great relevance to the functioning of innovation ecosystems, they bear the risk of lock-in effects [51]. In addition, digital transformation continuously changes ecosystems, highlighting inter-organizational partnerships in ecosystems as value is co-created among multiple stakeholders [52].

In light of these characteristics, understanding their urban dimension proves to be relevant to facilitate cities' transition as they can facilitate the restructuring processes of cities and regions in response to the structural changes imposed by globalized dynamics [18].

2.2. The Urban Dimension of Innovation Ecosystems: The Relevance of Urban Regeneration Mechanisms

The EU has long recognized the developmental role of local authorities and generally supported decentralization as an instrument to achieve better economic outcomes [53]. Despite that "regions have increasingly been perceived as responsible for their economic fortunes" [9] (p. 11), following the decentralization logic, the geography and economy of innovation privileges primarily the local dimension [9]. The dominance of the regional dimension has created a spatially blind framework focusing on successful models of agglomeration and efficiency, perhaps boosting overall growth but doing very little to address the problems of declining and lagging-behind areas [54]. Empirical evidence showed that knowledge production is strictly dependent on the context and that "location and geographic space have become key factors in explaining the determinants of innovation and technological change" [55] (p. 1). The increasing attention to the context, which has attracted researchers' interest in studying the relationship between innovation and places, has gradually shifted from the regional to the city level. The role and relevance of knowledge and innovation dynamics in cities and for cities are the focus of several scholars in different fields [9,56]. Florida [56] has outlined how cities are emerging as "key organizing units for innovative activities, bringing together the firms, talent, and other regional institutions necessary for them" [56] (p. 17). The analysis of the urban dimension of innovation and knowledge dynamics shows that innovation is geographically concentrated [55–58] and clustered "in locations where specialized inputs, services, and resources for innovation processes are located" [59] (p. 7). In this perspective, the paper considers "cluster" as a central component of urban innovation ecosystems. The rationale is that, first, when innovation ecosystems are viewed as complex adaptive systems, special attention needs to be paid to the complexity of innovation clusters [22]. Localized innovation ecosystems, as sustainable nodes of network communications among various actors that enable continual innovation, often take the form of innovation clusters or university–industry partnerships (ibid.). Second, clusters are powerful instruments for fostering industrial competitiveness, innovation, and regional growth [60,61]. Third, they offer considerable potential for S3 implementation by providing the necessary resources [62]. For example, urban innovation clusters can develop their specializations in ways that enable them to become geographically localized network nodes of global value chains [23]. Fourth, innovation clusters constitute a unique variety of innovation ecosystems [23], in which quadruple helix interactions (i.e., government, university, enterprise, and society), when embedded in robust urban fabrics, generate unique economic effects through innovation boost and co-create innovative goods and services [13,33]. Fifth, given that ecosystem overlap with clusters [61], it is necessary to orchestrate clusters and innovation ecosystems [22]. This paper uses the term "innovation ecosystems" instead of "innovation clusters" as the concept of "ecosystem" suggests (1) a

more open innovation system than clusters may entail [63]; (2) a significant shift toward a network-based organizational design and the collaborative organizational culture of the emerging innovation-led economies [22,23]; (3) a significant role of developing social capital and interpersonal relationships in public and business practices [22]; and (4) the interaction between knowledge dynamics and context (time, space, and relationship with others) [64].

Innovation concentration dynamics result from an economic integration process, both regionally and globally, which has favored agglomeration economies, fueling the concentration of higher-level economic activities and services in major cities [65]. Such processes led to a new geography of knowledge more concentrated in metropolitan cities [66–69]. Several authors have recently focused on cities as places where innovation can be nourished [9,15,56,70,71], indicating how innovation is becoming "urban" as cities are increasingly emerging as the new centers of technological innovation [29]. The relevance of cities and the urban dimension in these processes has brought the development of different—but interrelated—concepts focused on the urban dimension of innovation: innovation districts [15], urban technological innovation ecosystems [29], city innovation ecosystems [72], and place-based innovation ecosystems [13]. While these concepts help explain the localization, concentration, density, proximity, and networking of innovative activities in cities, they do not explore in depth the interaction among all the sub-systems involved in the overall exploitation of knowledge and innovation dynamics to leverage economic development. In this process, cities coordinate internal and external knowledge dynamics, integrating local initiatives from different communities and coordinating them globally [73]. Innovation ecosystems find in cities, as innovation hubs [74], their natural incubation and expansion, due to the behavior of entrepreneurs in grasping the "advantage of city agglomeration effects to a greater extent than before" [29] (p. 98). The urban dimension within the innovation ecosystem unveils a relevant urban regeneration discourse. First, the rationale relies on raising attention to the context for the relevance of the "place", or an environment consisting of physical fabrics and socio-economic and institutional structure, in performing innovation ecosystems and sustainability [75]. Social filter conditions (educational achievement, productive employment of human resources, and demographic structure), together with other geographical characteristics, are fundamental for the productivity of innovation efforts [76]. Also, it is necessary to look beyond the technological elements of innovation ecosystems to see the importance of non-technological ones (strategies, cultures, organizations, and institutions) to build the innovation ecosystems' competency [31]. Improving institutional and business contexts matters more than targeting the rapidly changing technologies [22]. Moreover, regeneration proves a crucial link in the ecosystem lifecycle. Mature ecosystems must renew themselves to respond to emerging threats from new ecosystems and innovations or significant upheavals and environmental alterations [38]. Therefore, urban regeneration sustains the innovation ecosystem by enabling both its functions: exploitative and generative or autopoiesis [24]. Indeed, urban regeneration is a "comprehensive and integrated vision and action which seeks to resolve urban problems and bring about a lasting improvement in the economic, physical, social and environmental condition of an area that has been subject to change or offers opportunities for improvement" [77] (p. 17). Urban regeneration can be related to the innovation diffusion process [78]. It is widely recognized that the rise of the knowledge economy has reshaped the global urban system into metropolitan regions where knowledge-based industries find agglomeration economies accommodated in the core, global cities, and metropolitan areas [71,79–83]. Meanwhile, it is emerging that the urban economic landscape is changing with more distributive focal points that expose different urban areas to knowledge-intensive economies. These focal points are physical centers in which the local buzz–global pipelines approach creates a dynamic process of learning, knowledge production, and innovation [84]. The multi-nodal characteristic of the UIE suggests that the associated "innovation spaces", distributed city-wide, are a constellation of various spaces, including research institutes, incubators, accelerators, innovation centers, co-working spaces, start-ups, and labs [85]. In a broad

sense, innovation spaces with a collaborative nature function as connectors of regional innovation ecosystems [86]. Therefore, urban regeneration appears as a mechanism to foster innovation spaces and capture new forms of collaboration sustained by new forms of urban governance, enabling collective actions [87]. As an empowering mechanism, urban regeneration can acquire a conducive role in reshaping the innovation ecosystems "through more inclusive, cooperative and progressive forms of governance" [87] (p. 189), also reducing the possible side effects related to pure market-oriented transformations in cities. In this framework, the strategic approach of urban regeneration can emphasize the linkage between urban innovation and spatial planning, confirming the rise of a new rationale in contemporary urban planning and urban economic development that "strategically envisions a spatial form for economic development objectives" [88]. However, such a strategic vision also requires the proper urban planning tools to reach its objectives: the general plan and the zoning code/ordinance. The first draws the spatial elements of the strategy by shaping the city and its functions/activities, and the second provides the rule to realize them.

3. Methodology: Toward an Analytical Framework of Urban Innovation Ecosystems

The methodology section aims to characterize the urban dimension of innovation ecosystems and to detect urban transition dynamics in cities by grasping their connections and unveiling the potential of urban planning and governance to manage the complexity of transition. The analytical approach is grounded on a multidisciplinary analytical framework aimed at better understanding the co-evolutionary paths of transition, knowledge, and innovation dynamics in cities and the role of cities in their facilitation through urban governance and planning. In this direction, the cities of Boston and Cambridge were selected as a single exploratory case study to investigate. Case study research allows a better understanding of complex social phenomena [89] over which the research has limited control [90]. Following Stake [91], the paper focuses on a single case study that presents a particular situation and can potentially inform other situations [92]. Moreover, the advantage of selecting "atypical or extreme cases", intended as cases above the average conditions, "often reveal more information because they activate more actors and more basic mechanisms in the situation studied" [93] (p. 13).

Therefore, the proposed analytical framework of urban innovation ecosystems aims to look into their adaptive and self-regenerative attributes and highlight interesting and valuable elements that can contribute, if purposefully adapted, to facilitating transition dynamics by exploiting UIEs' potential. Grounded in the planning–governance nexus concerning innovation–place dynamics, it follows the spatial-led analytical logic. Central to this analytical framework is selecting and analyzing "target areas" (TAs) as a proxy of urban innovation ecosystems. The rationale is threefold:

- Where innovation is concentrated at the local level is a piece of essential information if the ecosystemic approach to innovation were to be place-sensitive.
- Target areas with strong cluster and urban regeneration dynamics can help characterize the adaptive and self-regenerative attributes of urban innovation ecosystems. In addition, target areas are relevant to study how innovation tends to drive the economic system to reorganize and evolve into related economic activities that are concentrated and clustered in cities.
- Target areas offer insight into the self-regenerative/physical attributes of the urban innovation ecosystem. It demonstrates how the demand for "clustered" innovation is driving the improvement of the "context", namely, the physical fabrics and socio-economic and institutional structure, which is equally relevant for the sustainability of urban innovation ecosystems [22,24,31,38].

The case study area under investigation presents unique context characteristics in which the evolution of the UIE (in its mature stage) is supported by urban planning and governance mechanisms and processes that are supposed to facilitate urban transition dynamics. The case study analysis aims to highlight those insights and interesting mech-

anisms that can inform other cases and be purposefully adapted in the EU context for stimulating the cities' transition. Therefore, the proposed analytical framework is meant to investigate urban innovation concentration and explore urban transformations. In so doing, it aims to examine the spatial configuration of innovation dynamics and the adaptive and (self-)regenerative attributes of urban innovation ecosystems.

Therefore, the analytical approach is articulated as follows:

- First, a brief presentation of the case study area is provided by highlighting the main socio-economic characteristics of Boston and Cambridge (MA, USA), which outlines its strong knowledge and innovative economic structure.
- Second, we analyzed UIE's characterizing assets by using cluster spatialization methodology (CSM—developed in the MAPS-LED Research Project H2020-MSCA-RISE) as a starting point to detect the UIE economic, physical, and networking assets [29] and their embeddedness in urban transformation processes. The cluster occurrence at the urban level is considered not only a proxy of innovation concentration but also associated physical transformations as parts of the city that have experienced the cluster dynamics and adapted their urban fabrics to meet the demand for innovation. Moreover, to grasp the interactions among innovation actors and places, target areas are selected and investigated to show the relationship between the embedded urban regeneration mechanism and context conditions.
- Third, the planning framework for both cities is presented to better comprehend how the planning process—from the overall vision to urban regeneration—contributes to the management of cities' urban transition.

4. Case Study

4.1. Overview of the Case Study

The case study area selected for the investigation includes the cities of Boston (MA, USA) and Cambridge (MA, USA). This area is located in Massachusetts, in the northeastern part of the United States (Figure 1). The two cities are home to 771,866 inhabitants (US Census Bureau Quick Fact, 2023) [94] across approximately 141 sq. Km, with a population density of more than 5000 inhabitants per sq. Km. Despite the difference in numbers, their economic structure presents some similarities. Indeed, data on employment by industries [95] show how the top three industries in this area are Educational Services, Health Care and Social Assistance, and Professional Scientific and Technical Services, which employ around 50% of the workers in the area. These data outline how the economic structure is strongly characterized by educational and scientific activity, which is also confirmed by the high number of universities and research centers and also the presence of two worldwide-recognized innovation districts: Kendall Square (Cambridge) and the Boston Innovation Districts (Boston), where universities, start-ups, companies, and businesses cluster together and conduct innovation-oriented activities. Given its unique characteristics, such conditions make this area interesting for investigating the nexus between knowledge and innovation dynamics and urban planning and governance for the ecological and digital transition of cities. Through its investigation, it is expected to outline the critical triggering mechanisms of the supportive role of planning for the innovation ecosystem that, if purposefully adapted to specific context characteristics, can provide interesting drivers for the future transition of EU cities.

4.2. Detecting Innovation Concentration at Micro-Level: The Cluster Spatialization Methodology (CSM)

Based on spatially led and governance-oriented approaches, the CSM allows tracking the behavior of "place" in fostering knowledge dynamics to promote innovation. The CSM is grounded in Porter's seminal work on clusters [96–100] and the Harvard Business School—US cluster mapping portal. For this paper, "comparability" is one of the advantages Porter's methodology offers in studying clusters. Indeed, the definition of clusters is based upon the measurement of average inter-industry linkages at the national level, "allowing

comparison across locations" [100] (p. 5). By scaling down the general definition into any regional unit, the approach allows comparison across and within regions. This feature substantially distinguishes Porter's "benchmark cluster" definition from other, narrower "region-specific" ones, which can only account for "observed linkages" and inevitably overlook activities that are not present in the region [100] (p. 6).

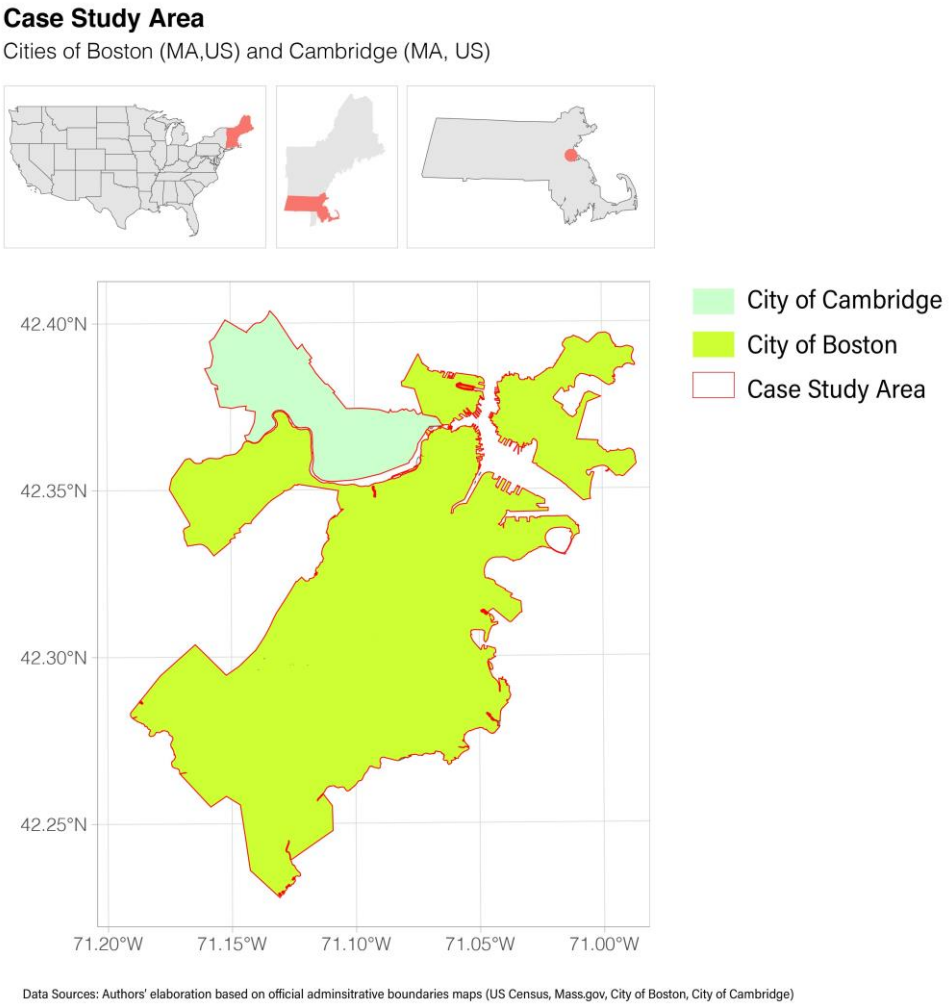

Figure 1. Case study area: cities of Cambridge (MA, US) and Boston (MA, US). Source: Authors' elaboration.

Furthermore, the methodology relies upon the utilization of multiple sources of inter-industry linkages' data, such as the co-location of employment or establishments, input–output linkages, and occupational correlation, making this methodology comprehensive and significant to capture "many types of externalities present across industries" [100] (p. 12). The CSM allows the detection of the configuration of clusters at the city level for investigating how spatial factors, such as the localization of universities, real estate trends, housing, public transportation, and services supply, can explain the localization pattern of innovation. The nexus of cluster spatialization with urban regeneration initiatives unveils the importance of "innovation spaces" in knowledge and innovation dynamics and how these dynamics define new land-use patterns and design standards through regeneration tools.

The CSM is based on two data-processing methods. The first enabled identifying clusters for exploring the key socio-economic variables associated with the MSA and county level (Appendix A). The second, using GIS analytical tools (mapping and data queries) allowed the following:

- Identifying the NAICS—North American Industry Classification System—codes for the industries belonging to each cluster/subcluster as identified by Porter's work;
- Combining NAICS and Land Use codes allowing one to locate each industry in a specific area;
- Labeling each area according to the corresponding cluster/subcluster occurring;
- Overlaying the mapping of urban regeneration initiatives connected with innovation-led economic development and programs.

The innovation ecosystem configuration based on the nexus cluster-urban regeneration-innovation spaces emerged in specific target areas (TAs). The CSM exploits GIS-supported analytical tools built to spatially identify the relationship between the NAICS and land-use codes [101,102]. The rationale is that a specific land-use code can be associated with a set of economic activities classified within NAICS codes and subsequently with subclusters and clusters (Figure 1) as identified by the cluster mapping portal. The occurrence and typology of clusters vary by the geographic scales of inquiry. Therefore, the CSM followed a multi-scalar approach (Table 2) covering three interrelated geographic dimensions: the Boston Metropolitan Statistical Area (MSA); the county level (Middlesex and Suffolk); the city level (Cambridge and Boston); and the urban level using the parcel as the primary unit of analysis.

Table 2. The overall CSM multi-stage process (authors' elaboration).

	First Stage	**Second Stage**	**Third Stage**	**Fourth Stage**
Action	Cluster configuration	Cluster morphology	Cluster and urban fabric	Target area Analysis
Criteria	Cluster–subcluster	Cluster portfolio	Performing cluster	Cluster spatialization
	(US cluster mapping)	Performing cluster	Cluster urban planning	Policy initiatives—innovation-oriented tools (PDA-PUD)
Analytical tool	Literature review (knowledge-based database)	GIS	Interview form GIS	Survey form Mapping GIS
Territorial unit	MSA/County (zipcode)	County/City (zipcode)	City (zipcode)	Parcel
Method	Attribute association	Overlay mapping	Zoning mapping	Attribute association

This process resulted in the selection and spatialization of eight—traded [100]—clusters across Cambridge and Boston: Business Services, Education and Knowledge Creation, Financial Services, Fishing and Fishing Product, Design and Publishing, Biopharmaceutical, Performing Arts, and Insurance (Figure 2).

To investigate the innovation–place nexus, we detected cluster-based policy initiatives and urban regeneration initiatives within these areas. The analysis of cluster-based initiatives followed the definition set out by the OECD [103]: "organized efforts to support the development of the cluster with a person, organization, or consortium leading the action". Consequently, we identified six TAs: Business Services in Cambridge, Roxbury, Insurance, Financial, and Venture Development Center (VDC) in Boston, and Education in Cambridge and Boston (Figure 3). TAs are specific urban areas where the cluster dynamics are combined with the concentration of urban regeneration initiatives characterized by zoning rules that strongly encourage the creation of innovation spaces. Such initiatives are represented in Figure 3 as Planned Development Units (PUDs) for the City of Cambridge and Planned Development Areas (PDAs) for the City of Boston. The PUD districts "are intended to provide greater opportunity for the construction of quality developments on large tracts of land by providing flexible guidelines which allow the integration a variety of land uses and densities in one development" [104]. A PDA "is an overlay zoning district

that establishes special zoning controls for large or complex projects. The Zoning Commission may approve a request to establish a PDA where a development that is well-suited to its location cannot be accommodated by the general zoning for the area. For example, a PDA may be appropriate where development involves a large building, a cluster of buildings, or a mix of uses" [105]. Therefore, these districts in both cities highlight areas that cities plan to transform according to their strategic development vision.

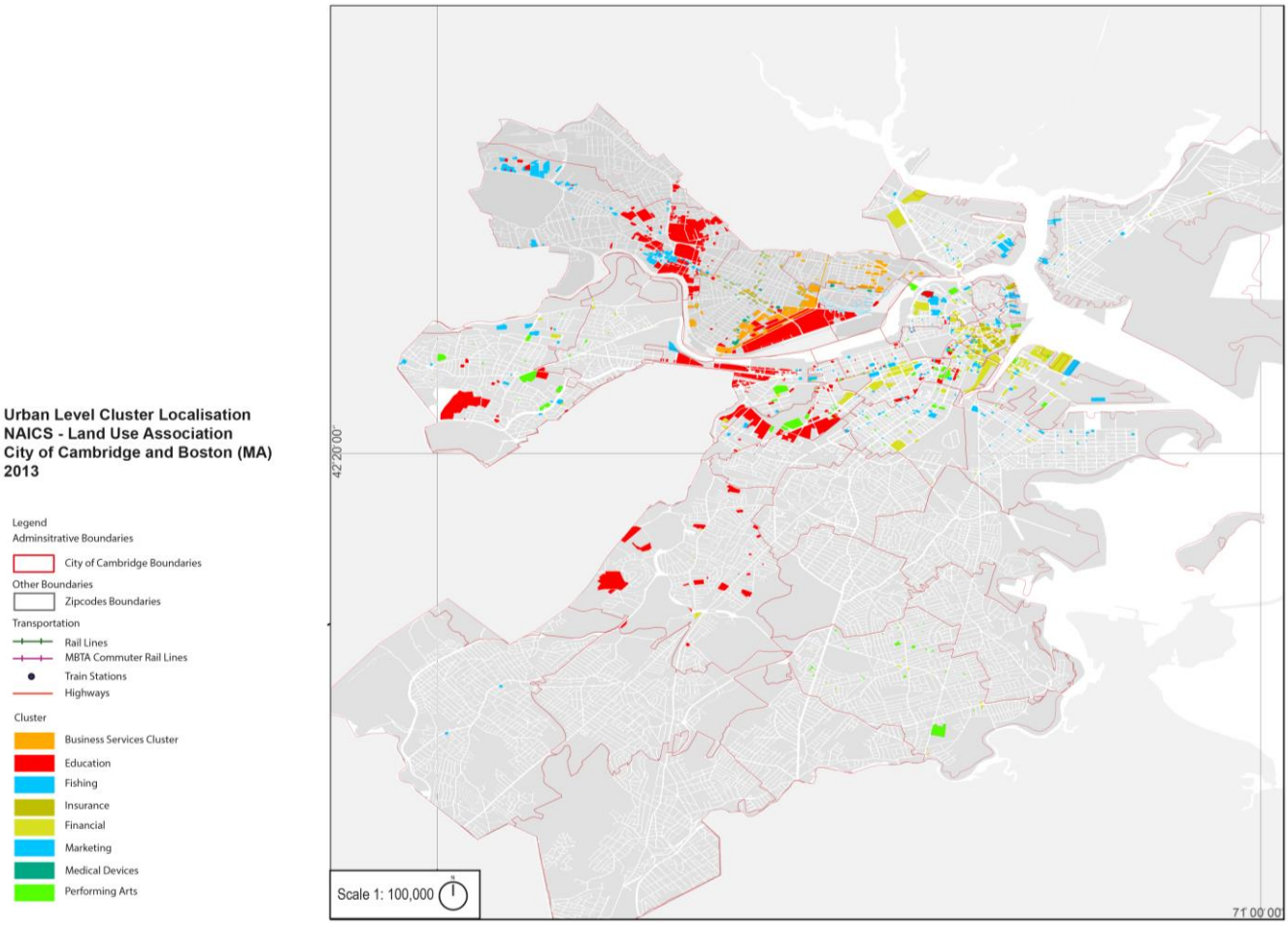

Figure 2. Cluster spatialization at the parcel/ward level in Boston and Cambridge. Source: MAPS-LED project (Multidisciplinary Approach to Plan Smart Specialisation Strategies for Local Economic Development—Horizon 2020).

TAs were analyzed using three analytical tools: survey and interview forms and online questionnaires (Appendix B). The quantitative survey had the scope to investigate the context conditions concerning socio-economic dynamics, the urban environment, and the innovation ecosystem in 2008–2016. It retrieved data from the US Census Bureau (ACS five-year estimates) and unofficial sources, like Techscene and Starthub websites, for characterizing innovation ecosystems and Zillow for analyzing real estate market values. The interview form was designed to gather relevant information about innovation-oriented public and private initiatives by complementing and integrating the survey's data on knowledge and innovation dynamics. In addition, the interview implied investigating the planning and governance of the initiatives from different perspectives (public and private actors) concerning three key drivers: place, knowledge, and innovation. The questionnaire aimed to disclose the dynamics of innovation hotspots in specific areas identified by overlaying the cluster occurrence and zoning, and it was distributed to the users of different innovation spaces located within the target areas. It explained how

innovation spaces could spur networking activities among entrepreneurs, start-uppers, researchers, students, and citizens [106–108].

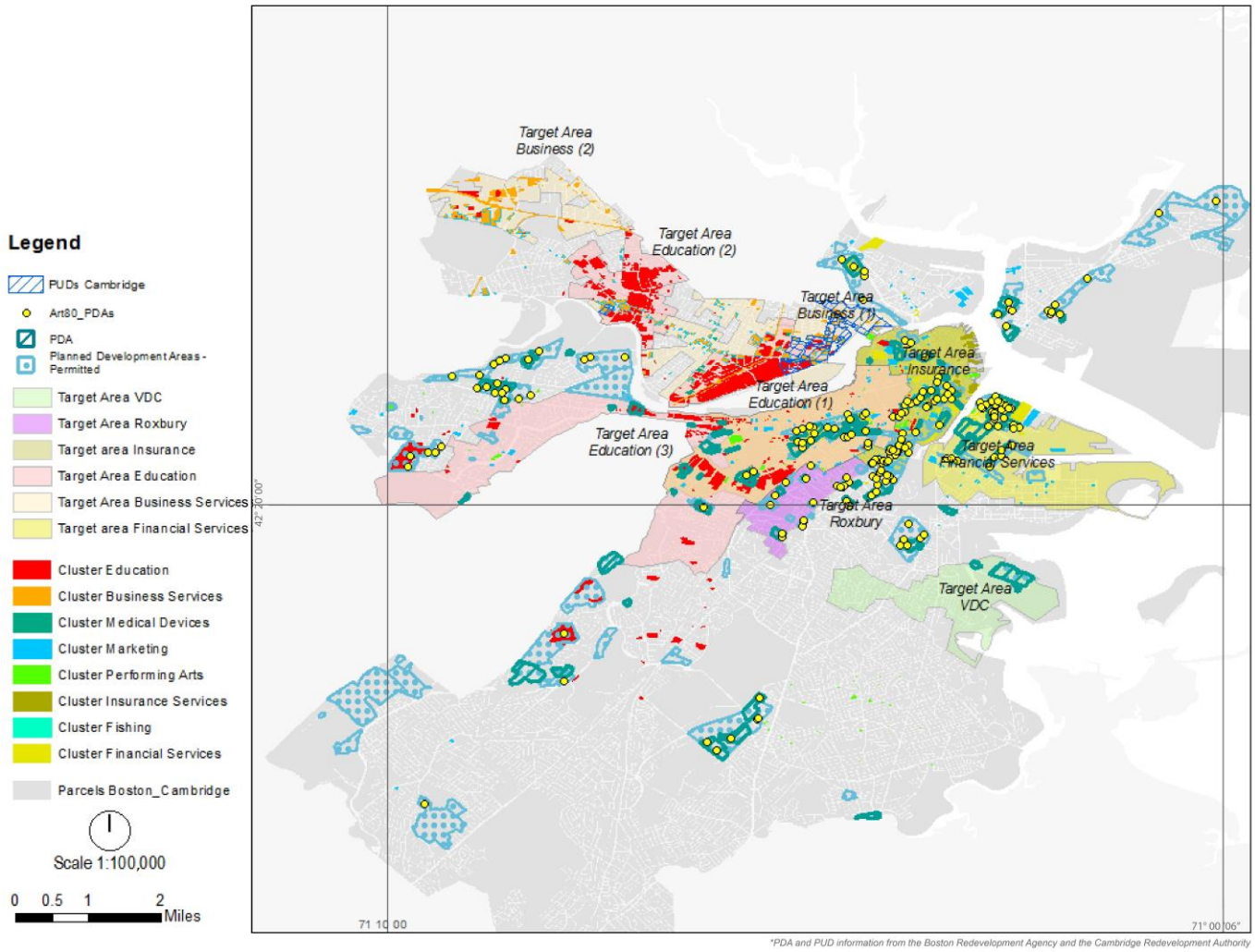

Figure 3. TAs showing clusters and urban regeneration initiatives in Boston and Cambridge (overlay of TAs, clusters at the parcel/ward level, and PDA/PUD areas). Source: MAPS-LED project.

4.3. The Urban Characterization of Innovation Ecosystem

Based on the CSM results, we examined the UIE's assets by considering selected indicators and tracking their variation according to the available data within the six TAs. Following Mulas et al. [29], the indicators selected to identify UIE assets are distinguished into economic, networking, and physical. Mulas et al. [29] (p. 19) identified economic assets as "elements such as the variety of industries, business, and sectors; the size, amount, and diversity of companies and businesses", as well as "universities and research and development facilities". Given this definition, we assumed the spatialized cluster as an economic asset of the UIE. Moreover, given the relevance of education activities for the area under inquiry, Figure 4 shows, as an example of the CSM, the spatialization of the Education cluster in Cambridge and Boston. The "Education and Knowledge Creation" cluster "contains all educational and training institutions and supporting establishments. It also includes research and development institutions in biotechnology, physical sciences, engineering, life sciences, and social sciences" [102] (p. 18). In addition, following the Cluster Mapping Portal, this cluster is strongly connected to other clusters such as Biopharma, Financial Services, Insurance, Marketing, and Performing Arts [109].

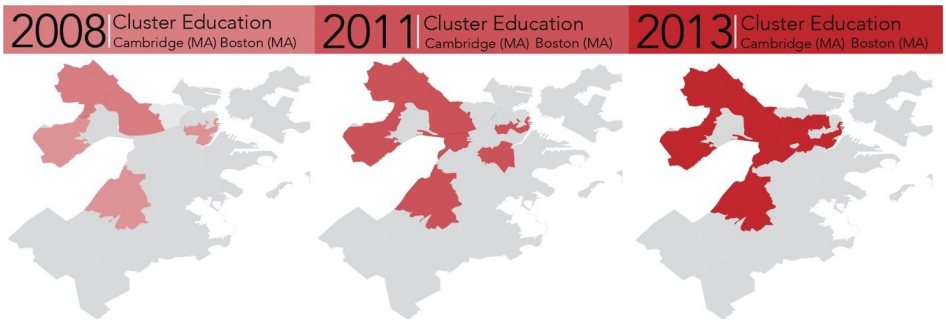

Figure 4. Education and Knowledge Creation cluster evolution in Boston and Cambridge. Source: MAPS-LED project.

Initially situated in Cambridge, including a small part of Boston, the cluster expanded toward Boston's inner-core urban areas. Following Porter's cluster definition, the observed expansion indicates a particular business environment dynamism that evolved over time, following the academic and research-related activities consolidated in this area. By exploiting the CSM, we identified the TAs as economic assets of the innovation ecosystem (Figure 4). However, to generate innovation, actors' connections and relationships need dedicated spaces and specific activities [29]. These networking assets include "meetups, tech community events, boot camps and skill training programs, collaboration spaces, accelerators, incubators, angel investors, venture capital, and networks of mentors" [29] (p. 20). Accordingly, we considered incubators/accelerators and co-working spaces under the general label of innovation spaces to track the UIE's networking asset. The innovation spaces of almost all TAs expanded in the period considered (Table 3), except for the VDC TA. The growth of innovation spaces is evident: from 2016 to 2020, three times more for the Financial TA while almost five times more for the Insurance TA (Table 3). The variation of innovation spaces in both cities is positive but follows different patterns. In Cambridge, the innovation spaces' growth rate observed is lower than in Boston for both Business Services (+6) and Education and Knowledge (+10) target areas (Table 3).

Table 3. The variation of UIE networking assets (innovation spaces) in the target areas between 2016 and 2020. Source: MAPS-LED project and authors' elaboration.

Target Areas	Innovation Spaces (Incubators/Accelerators/Co-Working Spaces)	
	2016	2020
Business Services	20	26
Education	15	25
Roxbury	1	3
Insurance	6	29
Financial	12	37
VDC	2	2

Both official and unofficial publicly available information was used to map innovation assets. Innovation space location is obtained by using the Starthub Boston online and publicly available information (available at https://starthub.org/ (accessed on 4 June 2020)).

It is possible to argue that the different growth in the number of innovation spaces is due to their already consolidated presence as a result of different knowledge and innovation dynamics in the Education and Business Services TAs, where knowledge transfer processes between higher education institutions, companies, and start-ups are consolidated. In Boston, the growth rate is higher, especially in the Financial and Insurance TAs. Part of these TAs overlaps with urban regeneration initiatives implemented in the last decade by the city administration, as in the Boston Innovation District (BID) case. As the Roxbury TA shows, the presence of innovation spaces and start-ups follows its socio-economic variation. In this case, community-based urban regeneration is in place, and innovation

initiatives are used for innovation diffusion. Figure 5 shows the localization of innovation spaces—divided into incubators/accelerators and co-working spaces categories—in the area. Many of them are situated within the identified target areas. In Cambridge, they are located close to the higher education institutions (such as the MIT). In Boston, they are mainly located in the inner core urban areas where financial and insurance companies are clustered. Innovation spaces are localized in dense, transit-accessible, and compact urban areas in both cases. The last indicator relates to the UIE's physical assets that "facilitate interactions among people and economic assets" [29] (p. 19). Given that "offices are needed to house tech firms; start-ups need inexpensive and adaptable venues (that is, flexible office space)" [29] (p. 20), we used start-ups' concentration in the area as a proxy map of the physical assets/infrastructures of the UIE. Table 4 shows an overall positive variation of the physical asset indicator from 2016 to 2020 for all TAs except for the VDC one.

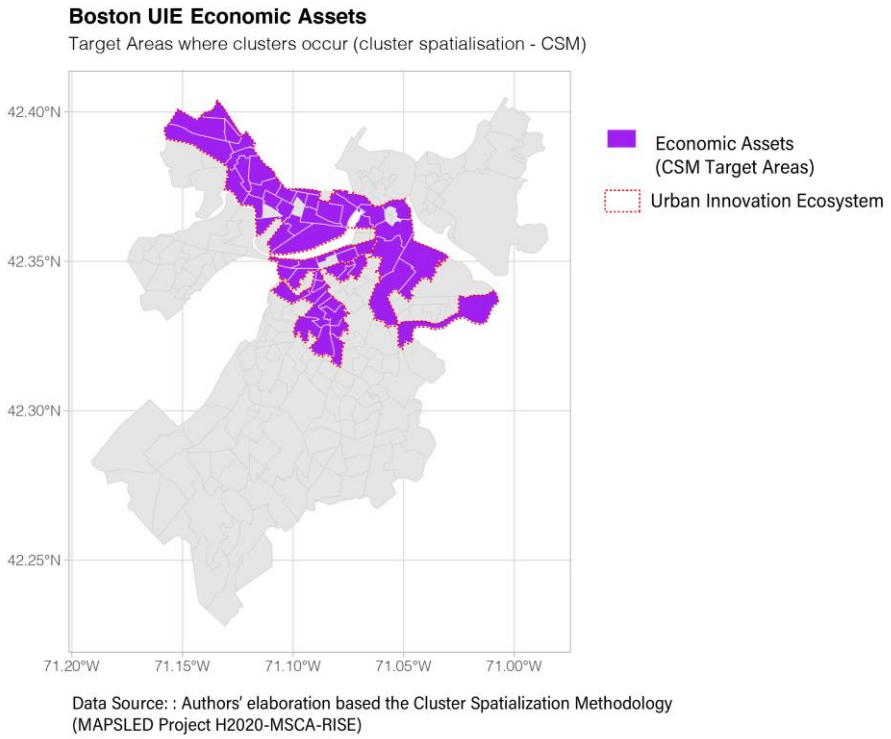

Figure 5. The urban characterization of the Boston Area Innovation Ecosystem. Economic assets: target areas. Source: Authors' elaboration based on the cluster spatialization methodology (MAPS-LED project H2020-MSCA-RISE).

Table 4. The variation of the UIE physical assets (start-ups) in the target areas between 2016 and 2021. Source: MAPS-LED project and authors' elaboration.

Target Areas	Start-Ups	
	2016	**2020**
Business Services	217	698
Education	248	560
Roxbury	2	8
Insurance	174	543
Financial	331	913
VDC	32	6

Both official and unofficial publicly available information was used to map innovation assets. Source: MAPS-LED project and authors' elaboration based on techscene.at/boston website publicly available information (manually counting and last visualization 2021; therefore, the data are reported as 2020 given the lack of precise information).

Since official public data on start-up locations were unavailable, we adopted existing and publicly available information on start-up location interactive web maps (Techscene.at) to highlight the areas with the highest concentration of start-ups, counting them (approximate number) in the occurring TA. As shown in Figure 6, start-ups are concentrated in inner-core urban areas close to higher education institutions (MIT, Harvard University, Northeastern University) and Boston downtown (Financial and Insurance TAs), which is a dense, compact, and transit-accessible area located in the center of the city.

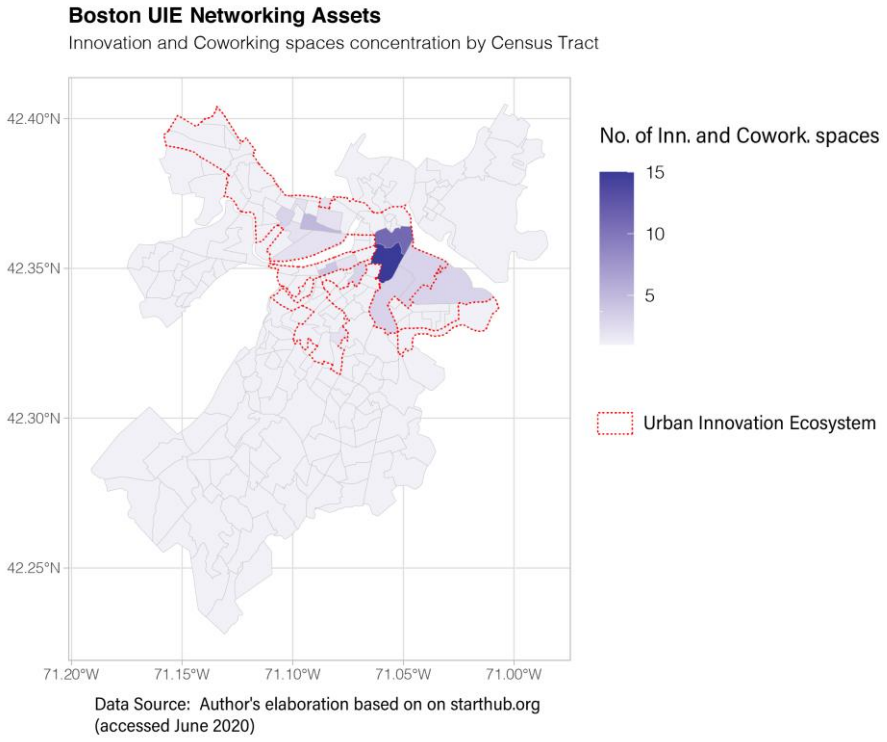

Figure 6. The urban characterization of the Boston Area Innovation Ecosystem. Networking assets: innovation (incubators and accelerators) and co-working spaces. Source: Authors' elaboration based on starthub.org website publicly available information (accessed 16 June 2020).

Following this process based on the literature and data sources, Figures 5–7 show the resulting urban characterization of the Boston Area Innovation Ecosystem. Here, the spatialization of clusters at the micro-level in the area, considered economic assets, shows the concentration of economic activities innovation-oriented mainly in the most central and dense urban areas, with an initial push toward more peripheral ones such as the Roxbury neighborhood. However, economic assets, represented by the TAs reflecting a concentration of economic activities, are distributed in both cities' central and less central areas (Figure 5).

Regarding networking assets (Figure 6), which include innovation and co-working spaces, their concentration follows a similar path with two main location characteristics. Innovation spaces are more concentrated in the center of the City of Boston (downtown), an area of the city that is more connected in terms of transportation and has a high concentration of financial activities and services. Co-working spaces tend to concentrate close to universities (Cambridge) and innovation spaces (Boston), with a rising occurrence in more peripheral areas such as the neighborhood of Roxbury and the Boston Innovation District. Physical assets (Figure 7), here interpreted as start-ups, follow a more heterogeneous concentration path. In the City of Boston, detecting three main spatial clusters is possible. The first, which concentrates their majority, is located in the downtown area. The second is close to universities (Northeastern area). The third is concentrated in the Boston Innovation District Area. In Cambridge, it is possible to notice a similar path. Part of the start-ups

detected are located close to the MIT and Harvard campuses, and part of them are located in areas where urban regeneration processes are taking place, such as North Cambridge.

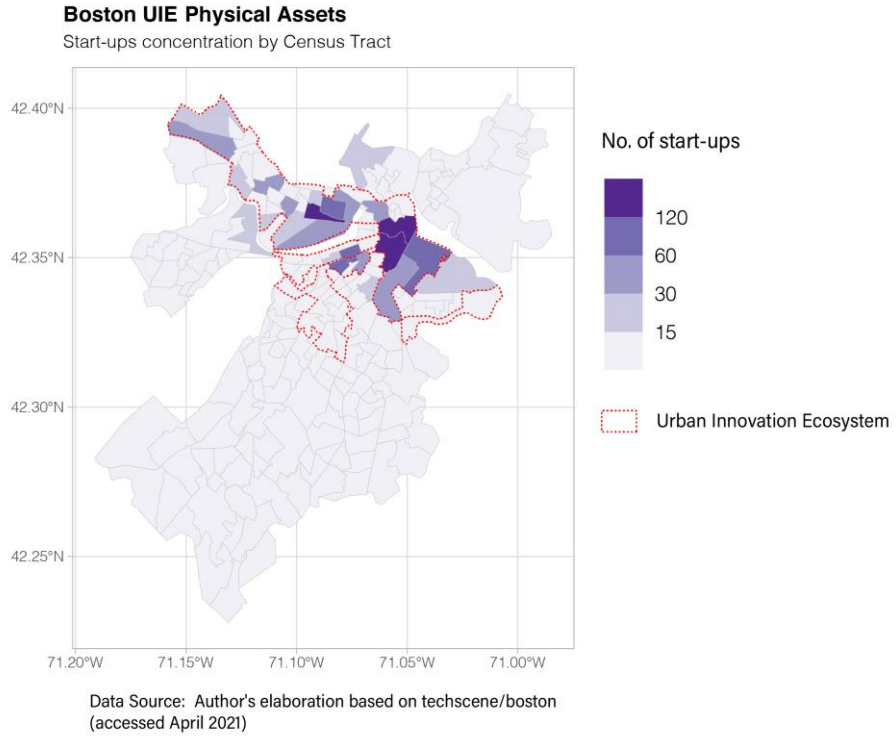

Figure 7. The urban characterization of the Boston Area Innovation Ecosystem. Physical assets: start-up concentration. Start-up concentration by Census Tract. Source: Authors' elaboration based on techscene.at/boston website publicly available information (last visualization 23 April 2021, the data are reported as 2020 given the lack of precise information as in Table 4).

4.4. The Supportive Planning Context: Multi-Level Governance, Comprehensive Planning, Zoning, Policy Initiative, and Data-Driven Perspectives (Spostato da Discussion)

In this section, we discuss and emphasize those aspects supposed to facilitate cities' green and digital transition following the DUT approach perspective [8,17]. The exploratory case of the Boston area allows us to bring into the discussion four main elements useful for the debate, which may have implications in the design and formulation of urban transition strategies: (i) the importance of multi-level governance and economic development strategies; (ii) comprehensive planning and zoning approaches that highlight transition-oriented supportive elements; (iii) the policy/planning initiatives for the transition; and (iv) a data-driven perspective that facilitates the creation of the supportive conditions for urban transition by strengthening and exploiting the urban innovation ecosystem assets and resources.

4.4.1. Multi-Level Governance

The first element relates to the multi-level governance context that can facilitate urban transition thanks to implementing integrated planning approaches from the federal to the local level. From the multi-level governance perspective, an interesting element that can facilitate the implementation of urban transition strategies lies in the economic development and planning nexus, which finds its operation both in the regular economic development planning and comprehensive planning tools and in specific economic development tools in the area under investigation. In this direction, the analysis of the UIE allows bringing economic development tools such as the Opportunity Zones (OZs) into the discussion. OZs gain relevance for this contribution given the academic and policymakers' debate on their shift to Innovation Zones (IZs). OZs were introduced in 2017 by the US Congress to

revitalize distressed urban areas. In these purposefully designated urban areas, private investors can invest their capital net gains—through Qualified Opportunity Funds (QOFs)—in local business assets to foster job creation and spur economic development. The proposal to develop the Innovation Zone (IZs) instrument [16] aims at promoting cities' transition through urban regeneration processes and urban innovation ecosystem reinforcement. The IZ proposal follows three main drivers: district development, talent development, and research and development [16]. One of the characteristic elements of the proposal is the dedicated focus on place-based innovation ecosystems furthering the current innovation district model, which are "compact, mixed-use neighborhoods that co-locate academic, entrepreneurial, corporate, and business support entities intending to spark new ideas, products, and services and create, attracting, and growing thriving businesses" [16] (p. 4), emphasizing the robustness of the linkage between economic development and planning from a multi-level perspective. The debate on the shift from OZs to IZs can offer interesting elements for defining suitable urban transition and resilience strategies. However, despite the interest in transforming OZs into IZs, the implementation of this tool presents some limitations. Their implementation is demanded at the state-level organization, and cities' governments provide only regulations (land use, zoning, business activities regulation, etc.) for the activities promoted by the OZ's investment funds. On the contrary, cities can unleash their potential to revive economically urban distressed areas through a more decisive role in their design and implementation from an innovation-ecosystem perspective. Indeed, cities have the potential role of channeling financial resources for local communities, coordinating the investments to drive more equitable growth, and implementing institutional and financial reforms "that will reposition cities for success over the long haul" [110] (p. 6) by exploiting the potential of urban innovation ecosystems.

4.4.2. Comprehensive Planning and Zoning Approaches

The second element relates to the comprehensive planning and zoning approaches, highlighting transition-oriented supportive elements. Developing innovation ecosystems requires preparing and supporting the evolving processes of actors and elements regarding local conditions, culture, and strategic goals [34]. On this basis, policymakers can formulate policies and provide incentives while actors of innovation ecosystems can promote their growth and adapt to the ecosystem's maturity [19]. Therefore, we related the evolution of the UIE with the cities of Boston and Cambridge's official long-term planning documents: Envision Cambridge 2030 [111] and Imagine Boston 2030 [112]. Both cities' long-term plans are characterized by two main elements: the integration of all the existing plans and strategies that may contribute to increasing their resilience level (climate change, housing, transportation, economic strategies, digital strategies) and the implementation of mixed-use zoning as a tool to facilitate the transformative development of urban areas. Since the 2010s, both cities have designed and implemented a resilient strategy to identify and address their respective social, economic, and environmental vulnerabilities. In the case of Cambridge, resilience was included in the Climate Change and Preparedness Plan (CCPP) and subsequently has been incorporated into the Envision Cambridge Comprehensive Plan as the overall long-term goal. In the case of Boston, the resilience strategy has placed racial inequality as the main challenge to address, together with environmental and economic problems. Starting in 2014, the city administration started developing a resilient strategy for the city, inspired by the work of the 100 Resilient Cities partnership promoted by the Rockefeller Foundation. The City of Boston's Resilient Strategy has been embedded into Imagine Boston 2030, the citywide Comprehensive Plan that outlines the future long-term development of the city.

Zoning plays a crucial role in implementing both cities' visions. It acquires a flexible and adaptive nature to the evolving demand for urban transformation stimulated both by the demand for a resilient and transition-oriented development and by the UIE's dynamics allowing both cities to reshape their urban development strategies in response to the current demand for transformation. Therefore, both cities have adapted their zoning

codes/ordinances [104,105], updated the existing regulations, and used them to create more resilient and sustainable cities. Specifically, in Boston, two articles of the zoning code have been updated: Article 25A—Coastal Flood Resilience Guidelines & Zoning Overlay District and Article 37—Green Building and Climate Resiliency Guidelines. In addition, article 89 has been updated to Urban Agriculture Rezoning Initiative. In Cambridge, to foster resilience, a specific task force to adapt the zoning to the resilience needs of the city was created in 2015. Also, all the energy and emission aspects included in the overall city strategy for climate change mitigation have been translated into the zoning codes. For example, Article 22 "promotes environmentally sustainable and energy-efficient design and development practices" [105]. The mixed-use zoning approach characterizes zoning flexibility. In the case of Cambridge, the peripheral area of the TAs and the central ones (Kendall Square) address "evolving" mixed-use districts (purple in Figure 8). Here, it is held "the bulk of the city's growth and change, taking advantage of transit proximity, and positively transforming areas characterized by surface parking lots, automobile-oriented uses, and obsolete commercial buildings" [111] (p. 10). In the higher education institution areas (MIT and Harvard), it is possible to adopt mixed use both in the existing campuses and new expansions (gray). Moreover, mixed-use corridors (orange) and transition areas (blue) allow the integration of different uses to take advantage of transit proximity and accommodate the development of varying types in selected city corridors [111] (p. 2). The mixed-use approach is also the core of the City of Boston Comprehensive plan. It is encouraged in inner-core urban areas (Encourage Mixed-use), in the close neighborhoods (Expanding Neighborhoods), and the planned "Fairmont" transit corridor aimed to "expand access to opportunities and reduce disparities through coordinated investments in transportation, neighborhood vibrancy, and education" [112] (p. 7). In line with their respective resilience strategies, both cities focused on identifying the most vulnerable areas concerning the environmental risks, the socio-economic weaknesses, and local potentials to be strengthened by promoting the increase in density and the concentration of activities (Figure 8).

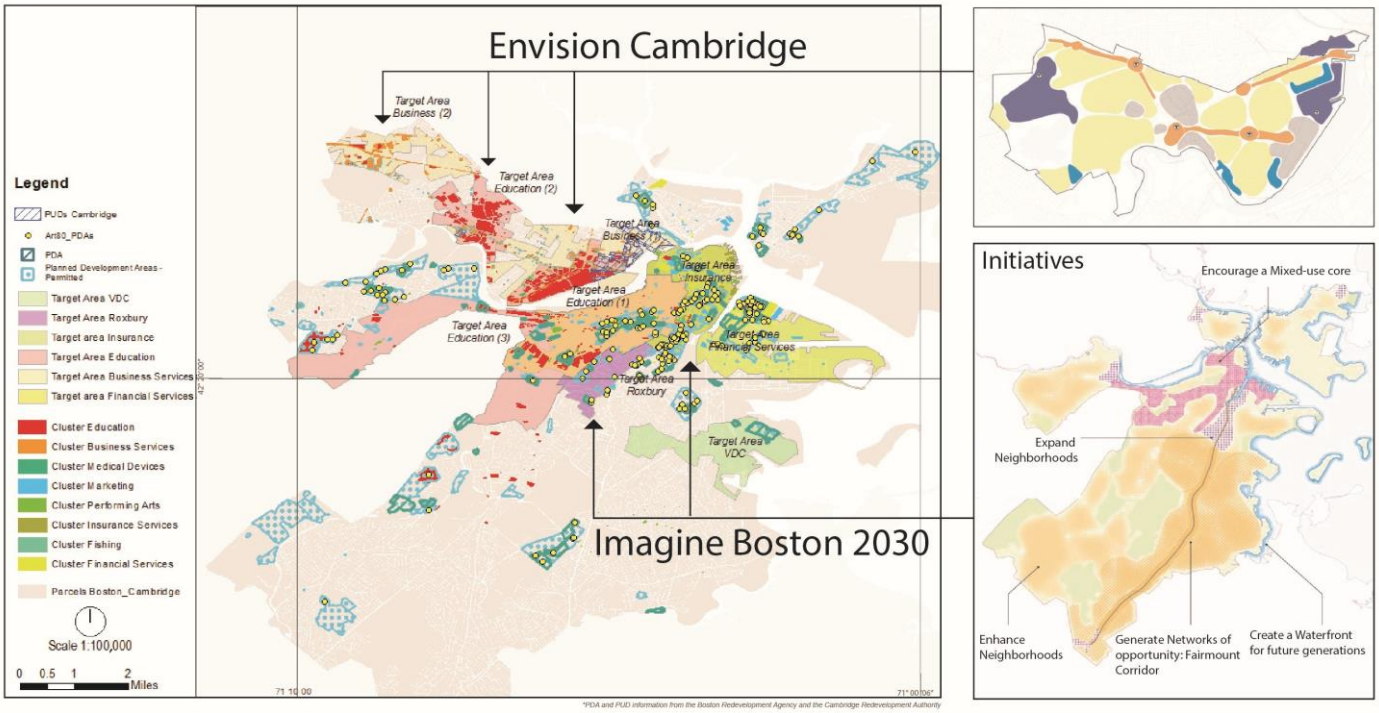

Figure 8. Urban Innovation Ecosystem and Resilience strategy in Boston and Cambridge (Sources: MAPS-LED project; Comprehensive Plans: Envision Cambridge and Imagine Boston 2030).

4.4.3. Policy/Planning Initiatives for the Cities' Transition

The third element is related to the policy/planning initiatives for the transition, which both cities' administration promotes in all the thematic areas identified by the DUT approach. Implementing specific urban policy/planning initiatives is important in facilitating the urban transition. Both cities have different strategies and instruments that can be framed in the DUT rationale. For example, in Boston, the Mass Timber Accelerator and the Boston Smart Utilities programs aim to facilitate a circular economy and exploit innovation and new technologies to make utilities more sustainable, green, and efficient [113]. In Cambridge, the overall strategy is to reduce GHG emissions and produce renewable energy. Such a strategy is supported by specific programs that apply to the entire city, targeting primarily public and private buildings. As for the Boston Smart Utilities program, the City of Cambridge also adopts innovation and new technologies for public services. For example, the pilot "CitySmart" program provides information and resources to the users about public transportation, bikes, pedestrians, and electric vehicles [113], which may help reduce GHG emissions and facilitate the 15 min city rationale. Table 5 lists the main policy/planning initiatives and the zoning articles that emphasize the strategic aim of both cities to facilitate transition processes toward sustainability and resilience. Given both cities' technical and normative systems, only zoning articles have binding conforming rules for any development to plan as specified in Table 5. Policy and planning initiatives are guidance documents that follow the overall strategic vision of both cities in their Comprehensive Plan.

Table 5. Policy and planning initiatives supporting the urban transition in the Boston Area.

	Boston	Cambridge	DUT Transition
Overall development strategies	Imagine Boston 2030 (Comprehensive Plan) Resilience Strategy	Envision Cambridge 2030 (Comprehensive Plan) Climate Change Vulnerability Assessment & Preparedness/Resilience Plan	Energy, Sustainable Mobility, Circular Economy
Specific programs/policy/planning initiatives/ordinances	Boston Smart Utilities vision; Boston Mass Timber Accelerator; Building Energy Use Disclosure Ordinance	NetZero Action Plan; Low Carbon Energy Supply Strategy; Resilient Cambridge; Building Energy Use Disclosure Ordinance	Energy (Boston and Cambridge), Circular Economy (Boston)
	Ecodistrict	Planning Studies	Energy, Sustainable Mobility
Zoning (binding/conforming rules)	Article 37 Green Building and Climate Resiliency Guidelines; Coastal Flood Resilience Guidelines & Zoning Overlay District (Article 25A)	Article 22 Green Building Requirements; Climate Resilience Zoning (Task Force)	Energy, Sustainable Mobility, Circular Economy
UIE connection initiatives	MONUM BARI	BARI Open Data strategy CitySmart	Urban Innovation Ecosystems

4.4.4. Data-Driven Perspectives

Finally, the data-driven perspective facilitates the creation of supportive conditions for the urban transition by strengthening and exploiting the urban innovation ecosystem assets and resources. In Cambridge, the presence of anchor institutions, private companies, venture capitalists, and real estate actors allows the attraction of start-ups and innovative businesses. In Boston, internal administrative processes, new city–citizen interactions, and research-oriented partnerships seem to be the pillars to exploit innovation to facilitate the green and digital transition. For example, it is the case of the two cities' ordinances

on building energy use (BERDO in Boston and BEUDO in Cambridge). Such ordinances focused on the obligation to report energy and water data about public and private buildings that exceed a specific size. These data are made available to the public and are used by the cities' administration to monitor the progress of their strategy. In this direction, the uniqueness of the context in which worldwide-recognized universities operate has allowed for developing a strong innovation ecosystem. In Cambridge, it is supported by the lead of higher education institutions (HEIs) that facilitate the creation of innovation thanks to their activities strictly targeted to start-ups, young talented entrepreneurs, and joint public–private partnerships. In Boston, the approach is more articulated. On the one hand, universities like Northeastern University have tailored a specific research-driven partnership based on exploiting big data and new technology to address urban challenges. The Boston Area Research Initiatives (BARI) bring HEIs (Harvard and Northeastern), the City of Boston, and other private and non-profit organizations. This partnership promotes a data-driven research approach to inform urban policies and address urban challenges [114]. In this context, the city exploits such potential through new urban governance mechanisms such as the Mayor's Office of Urban Mechanics (MONUM), allowing for a new interaction between citizens and city governments [115]. Table 5 summarizes both cities' elements helpful in defining an urban governance and planning framework argued to facilitate urban transition dynamics toward resilience and sustainability.

5. Discussion: Understanding UIE Evolution and the Supportive Role of Planning for the Transition

The UIE catalyzes and anchors global innovation dynamics in urban areas with city governments' support that facilitates the complex relationships among all the actors involved and paves the ground for transformative development by deploying resilient-oriented urban development strategies.

The analytical process presented allowed us to draw some interesting insights into the nexus between innovation and place in the case under investigation. First, the output of the CSM at the urban level reveals the spatial configuration (concentration) of innovation dynamics (clusters) of urban innovation ecosystems. Second, we found a close connection between innovation dynamics and urban regeneration initiatives. Consequently, innovation spaces are commonly located in urban areas where urban regeneration and cluster dynamics occur. Namely, innovation concentration tends to generate new demand for urban transformation in such areas, as confirmed by TA analysis. This means that the physical transformations of cities nowadays are increasingly driven by knowledge and innovation dynamics. In addition, anchor institutions, entrepreneurship, and innovation spaces grow in urban areas with specific functions. As the case studies pointed out, UIEs can be conducive to driving the urban transition, given their complex adaptive and self-regenerative nature. By providing the UIE spatial configuration and the interaction between innovation dynamics (UIE assets), urban transformation (urban regeneration), and urban transition dynamics, the paper unveiled the significance of the governance–planning nexus concerning innovation–place dynamics as a driver for transition. For this purpose, we synthesized a conceptual framework highlighting the relationship between the UIE lifecycle and the urban governance and planning processes toward sustainability (Figure 9) based on the UIE dynamics according to the evolutionary phases of the innovation ecosystem [19].

To sustain the development of innovation ecosystems, it is necessary to prepare and support the evolving process of actors and elements regarding local conditions, culture, and strategic goals [34].

Following the evolutionary phases of innovation ecosystems [19,20,38], the conceptual framework (Figure 9) opens a discussion: it interprets the supportive role of urban planning and governance in the UIE development, and it highlights the relevance of the UIE in facilitating cities' transition. At this point, the supportive role of planning for the UIE in facilitating cities' transition at each UIE development stage is qualitatively scored (Table 6). The authors assigned the scores based on their experience and the findings that emerged

in the previous section. For the scoring, the authors used a scale based on five degrees of intensity: low, medium/low, medium, medium/high, and high.

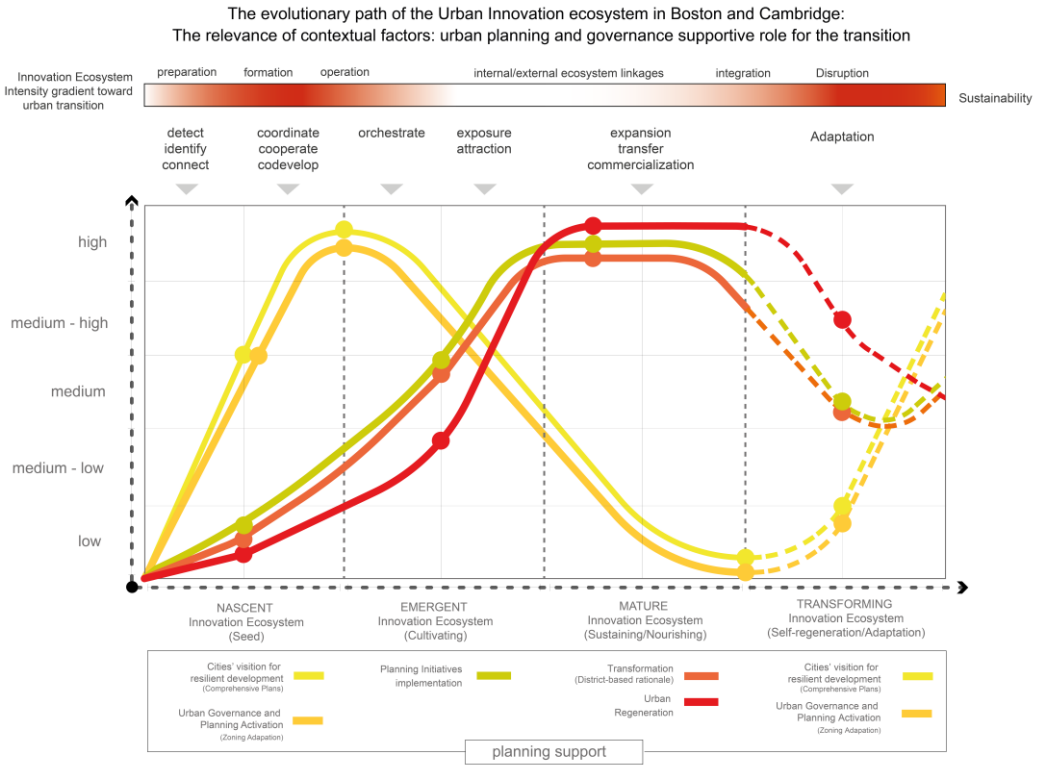

Figure 9. Conceptual framework for the understanding of the supportive role of urban planning and governance in exploiting the innovation ecosystems in Boston and Cambridge as leverage for urban transition. Authors' elaboration.

Table 6. Findings: the supportive role of urban planning and governance in UIE.

	Comprehensive Planning	Zoning Adaptation	Planning Initiatives	Transformation (District-Based)	Urban Regeneration
Nascent	Medium/high	Medium/high	Low	Low	Low
Emergent	High	High	Medium/high	Medium	Medium/low
Mature	Low	Low	High	High	High
Transforming	Medium/low	Medium/low	Medium	Medium	Medium/high

In Figure 9, we represent the characterization level of the urban planning and governance process related to the evolutionary phases of the innovation ecosystem concerning the context conditions (case study area). During the nascent phase of the UIE, the construction of the city vision for resilient development (comprehensive planning) is crucial as it points out the vision for the city's future development. In the case of Boston, the aim is explicitly stated to leverage the city's economic growth by exploiting the knowledge and innovation potential in the area. The comprehensive plan informs the city zoning, which is adapted to the new demand for change. In this stage, urban planning and governance are stimulated through the engagement of different public and private actors, community-based organizations and citizens, and zoning adaptation (for example, see the MONUM case in Boston) [115].

In the case under investigation, the supportive role of planning and zoning is also emphasized by the request of both cities to allocate a certain percentage of the gross commercial areas (5–20%) in Planned Urban Development Areas to activities related to knowledge, research, and innovation [104,105]. In the emerging stage, the UIE starts

its orchestration phase, and the UIE becomes attractive. In this phase, planning/policy initiatives are designed and deployed. It is the phase where specific urban areas are targeted based on social, economic, and environmental characteristics. In both cities, the planning initiatives target inner-core and highly dense urban areas and marginal distressed areas characterized by urban decay (Cambridge North in Cambridge, Roxbury in Boston). The area of the Boston Innovation District and Kendall Square is emblematic. When the UIE is in its maturity stage (like the case study), its attraction ability determines the demand for transformation, which contributes to materializing urban regeneration through the district-based rationale of the zoning codes and ordinances.

6. Conclusions

The paper offers a multidisciplinary analytical approach to understanding the interplay between innovation and "place" dynamics by exploring the UIE of the Boston area. The UIE catalyzes and anchors global innovation dynamics in urban areas with city governments' support that facilitates the complex relationships among all the actors involved and paves the ground for transformative development by deploying transition-oriented urban development strategies. Considering the coevolving nature of innovation ecosystems, highlighted by the literature review and confirmed by the analytical approach discussed, this paper conceptualizes UIEs as an adaptive and self-regenerative milieu of heterogeneous yet complementary clusters of actors, assets, and networks conducive to transformative urban development underpinned by knowledge-based innovation and entrepreneurship.

On the one hand, innovation ecosystems' complexity [22,30,116–119] allows us to capture the new dynamic development processes nurtured by research and innovation dynamics. It can contribute to a better design of Smart Specialization Strategies (S3) that are more responsive to continuous changes, crises, and shocks [120–122]. On the other hand, cities are central to creating a sustainable future [123]. They possess a great potential to reach global dynamics through economic specialization to be leveraged as a platform for diversification [124], and they are an arena of innovation where direct and indirect policies support innovation [125]. Some of them—such as labor market or regulative land-use planning policies—can impact urban development by enhancing or hampering innovation capacities [125].

As the case studies pointed out, UIEs have the potential to be conducive to driving the urban transition, given their complex adaptive and self-regenerative nature. The ability to orient innovation-related activities to address local urban issues—following the DUT rationale—should place UIE development strategies at the core of public administration efforts to boost the activation of actors and processes toward sustainability. In this direction, the paper unveils the significance of the urban planning–governance nexus by providing the UIE spatial configuration and the interaction between innovation dynamics (UIE assets) and urban transformation (urban regeneration). Specifically, it unveils the potential of urban regeneration in bridging the demand for transformation. As a result, UIE's dynamics stem from an implicit and explicit urban governance process that advocates for functional multi-level decision making in which cities play a crucial role. The city emerges as the place where explicit and implicit governance finds its explanatory synthesis, fostering the spill-over effect of knowledge dynamics and innovation processes due to the co-evolving nature of UIEs and urban regeneration mechanisms. If purposefully orchestrated, managed, and supported (also through urban planning and governance), UIEs can provide helpful support to facilitate the restructuring processes of cities and regions [18].

With the awareness that innovation-oriented policies and actions at the city-urban level supporting UIEs in cities with high levels of innovation do not automatically imply approaches and planning policies oriented at sustainability and resilience, this study detected two central urban governance and planning implications beyond the local scale. The first is related to how cities—or local administrations—detect their local innovative potential in terms of assets to be leveraged, which is a difficult task for cities that often are not fully aware of the complexity of the knowledge and innovation dynamics in place at the local

level. The urban characterization of the innovation ecosystem from the spatial perspective by identifying economic (through the cluster spatialization methodology), networking, and physical assets and relating them to the ongoing urban transformation processes (urban regeneration) can offer an alternative data-driven perspective to be adapted in other contexts. Secondly, urban planning and governance are crucial for responding to the demand activated by knowledge and innovation dynamics and managing the complexity of cities' transition, especially to avoid its side effects and ensure an inclusive transition toward sustainability. In this direction, multi-level governance approaches, comprehensive plans, zoning, specific planning and policy initiatives oriented at city transition, and the data-driven perspective that characterizes the planning and governance processes appear to be an interesting approach for city transition. Such elements, if purposefully adapted to the different social, economic, institutional, and urban policy/planning contexts, can result in helpful elements to consider for EU cities.

The study presents some limitations. The first lies in the difficulty of gathering micro-level data for the urban characterization of the innovation ecosystem (especially for start-up concentration). A more detailed analysis of zoning data and urban regeneration processes could open more insights into such complex processes. The second one lies in the need for a better contextualization of knowledge and innovation dynamics with the socio-economic characteristics of the context itself. Such a perspective could be helpful to better assess the effectiveness of urban regeneration processes according to their multi-dimensional nature (social, economic, and environmental). Nevertheless, such limitations do not undermine the relevance of this study because it provides interesting details and insights on the spatial detection and visualization of innovation concentrations in cities, the urban characterization of innovation ecosystems, and the identification of urban planning and governance mechanisms that can support their transition.

Given the limitations outlined, it is possible to draw possible research trajectories to explore in further studies. Given the surge of research on transition and its urban dynamics, the analytical approach centered on detecting complex dynamics in cities could be extended to the transition topic to detect and measure city transition dynamics (ecological and digital) for cities' UIE characterization and socio-economic characteristics both in terms of the spatial characterization of these dynamics to better comprehend the phenomena under investigation and the effects (positive or negative) of ecological and digital transition dynamics in cities. Such a trajectory could potentially reveal how the transition of cities is inspired by—or aiming at—equity and inclusiveness and how it could effectively lead cities toward sustainability and transition.

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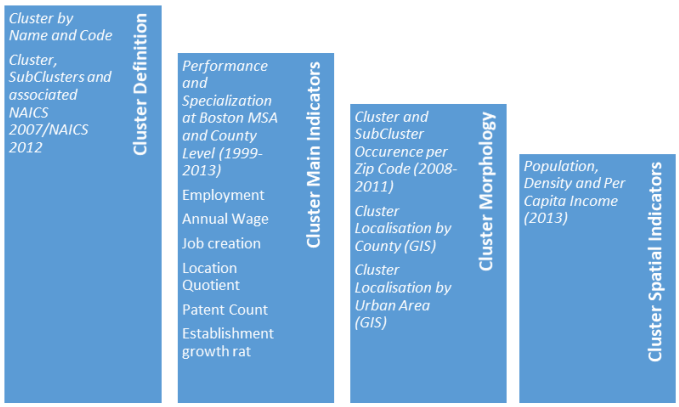
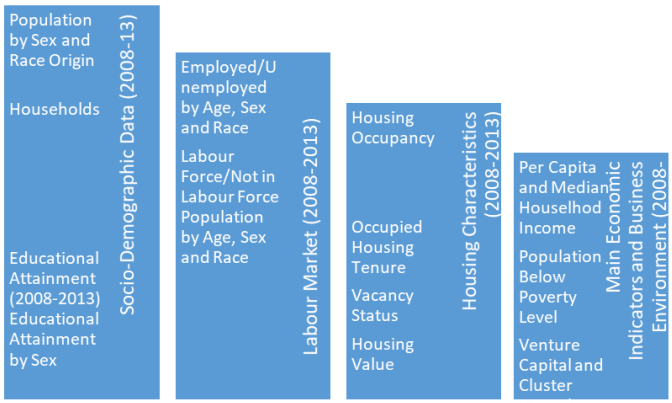
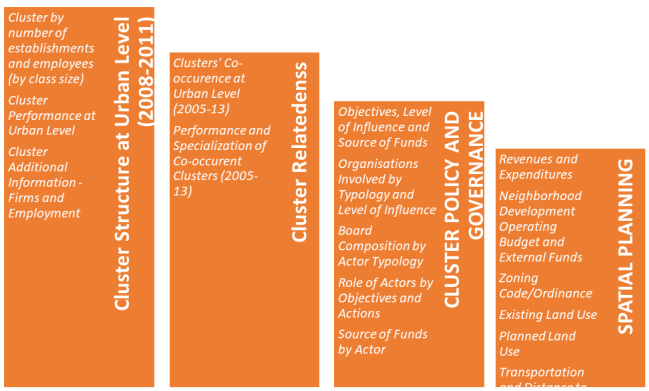
Appendix A Clusters' Multi-Scalar Inquiry Process



(**a**). Cluster configuration and morphology: Boston MSA/County level



(**b**). Cluster morphology and socio-economic context indicators: City level



(**c**). Clusters and the urban fabric: Integration of cluster structure, relatedeness, policy and governance, and spatial planning (urban level)

Appendix B Target Areas' Analysis (CSM Data Processing)

Analytical Tool	Macro Category/Category	Indicator	Data Source	Geographical Unit	Years
Survey (socio-economic and spatial data)	Socio-demographic	Population by sex and race origin	Census Bureau	Census Tract	2010–2011–2013
	Education	Educational attainment by sex and degree			
	Labor market	Employment, unemployment, labor force, not in labor force by age (25–44), sex and race origins			
	Housing	Housing occupancy, occupied housing tenure, vacant housing units			
	Real estate	Property typology, property value (assessed and market value)	City of Boston and City of Cambridge public open database and Zillow.com	Parcel block/ward	2014–2015–2016
	Transportation and infrastructure	Infrastructures, services, accessibility, parking, distance from the main transportation hubs	City of Boston and City of Cambridge public open database		2013–2016
	Public facilities	Open spaces, parks, community services, public libraries, schools, school yards, religious, social services, government facilities, clinic, commercial recreation, hospitals, museums, fire and emergency, police stations			2016
	Innovation	College/universities; start-ups in the area; research centers (public and private); innovation centers; research labs	Techscene.at available information; City of Boston and City of Cambridge	Census Tract (adapted from the website data visualization)	2016

Analytical Tool	Macro Category/Category	Indicator	Data Source	Geographical Unit	Years
Interview form	Mission, Goals, Strategy		Stakeholder interview	Stakeholders selected in initiatives located within target areas	2016
	Spatial Strategy				
	Governance				
	Results and impacts of the policy initiative				
Online questionnaire	Place Driver	Proximity and attractiveness	Online questionnaire	Innovation spaces within target areas	2016
	Knowledge Driver	Services and features			
		Innovation and competitiveness			
	Innovation Driver	Company sectors, typology, and characteristics			

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