Application of the Triple Helix Model in the Creation and Evolution of Areas of Innovation

Josep Miquel Pique, Francesc Miralles and Jasmina Berbegal-Mirabent

Abstract This study aims to contribute to the understanding of the revitalization projects of metropolitan areas and the evolution of ecosystems of innovation. Using a case method approach, this work explores four Brazilian urban revitalization cases and dives into the evolution of the *22@Barcelona* innovation district and the San Francisco-Silicon Valley ecosystem. From these cases, several implications can be drawn. On the one hand, from an academic point of view, both the Quintuple Helix model and the Knowledge Based Urban Development (KBUD) theory are found to provide an appropriate framework to map the revitalization processes analysed. On the other hand, policy makers in urban revitalization can benefit from this work by learning the lessons from the cities reviewed. We believe such cases can inspire other cities that want to transform old industrial areas (brownfield transformation) into socially conscious, creative and knowledge-based economy hubs. This study suggests the adoption of a holistic perspective that brings together the triple helix agents—universities, industry and government—while considering the local specificities in the urban, economic, social, and governance dimensions. We do so by theorizing the evolution of Areas of Innovation (AOIs) from inception to maturity.

Keywords Areas of innovation · Triple helix · Knowledge based urban development · Clusters of innovation · *22@Barcelona* · Silicon valley

J. M. Pique (✉) · F. Miralles
Innova Institute, La Salle—Ramon Llull University, Sant Joan de La Salle 42, 08022 Barcelona, Spain
e-mail: jmpique@salleURL.edu

F. Miralles
e-mail: fmiralles@salleURL.edu

J. Berbegal-Mirabent
Universitat Internacional de Catalunya, Immaculada 22, 08017 Barcelona, Spain
e-mail: jberbegal@uic.es

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1 Introduction

City planners face the challenge of playing a relevant role in the knowledge-based economy where face-to-face interactions, networking and trade remain vital [32]. The trend of urban planners is now to replace old manufacturers and industrial metropolitan areas with knowledge cities, which emerge from the balance between the production system and the urban cultural environment [54]. Cities that stimulate and rejuvenate various forms of knowledge serve as knowledge centres [30] and attract a creative and highly skilled workforce [25].

Science parks built in regenerated zones of inner cities have gained greatest momentum from a wide variety of stakeholders, ranging from policymakers to academics. Their role has been deemed as crucial for the evolution of innovation ecosystems of cities in the knowledge-based economy. Yet, this has implied that traditional science parks have been forced to evolve in order to play this role. Unlike traditional science parks, knowledge cities are urban enclaves that concentrate creative industries—including high technology, artistic and cultural sectors – which are integrated in a wider social context [53], while at the same time, provide socio-cultural amenities [61].

New cities hardly retain any of their former traditional, local and static nature [48]. In the inner cities, clusters of interlinked firms and organizations operate at world-class levels of competitiveness [49]. Companies take advantage of social agglomeration factors such as critical masses of skills and relationships, access to information, and the availability of specific infrastructures in a given field [27, 48, 55]. As a result of agglomeration effects, new economy metropolitan clusters emerged, comprising not only isolated firms but rather substantial ensembles of dynamic industries [27] that have been transformed into urban science parks or Areas of Innovation (AOIs) [35, 36].

Increasingly, knowledge-based and technology-intensive industries are taking the place of old industrial—and, in some cases, even residential—districts in the large urban agglomerations [27]. As clustering forces drive talented, innovative and creative people to concentrate in the most knowledge-intensive cities and regions [25], the new trend consists in promoting the creation of metropolitan clusters [11] that set up “new” versions of traditional science parks. Retention factors of talent are thus of utmost importance [2].

These new urban science parks combine technology—including computer graphics and imaging, software design, multimedia industries and graphic design industries that have been deeply influenced by technological development—with culture—represented by creative human capital and design functions—and the geographical location, more specifically, the innovative milieu of the inner city [27].

Although existing literature has focused on the evolution of traditional science parks, there is a lack of research exploring the drivers of the evolution, either organic or intended, that have transformed traditional suburban science parks into active areas of innovation (AOIs). The goal of this work is thus to shed new light on this issue and propose an enhanced framework that assists in the understanding of the evolution

of AOIs in cities, from inception to maturity, and to map how the role of the Triple Helix agents (university, industry and government) changes throughout the lifecycle of an AOI. The theoretical background is rooted in the conceptual frameworks of the Triple Helix model, the Knowledge Based Urban Development paradigm, the Clusters of Innovation and the lifecycle model of a new venture creation.

The remainder of this paper is organized as follows. Section 2 summarizes the theories used to frame our research. Section 3 describes the research strategy, which includes the research questions, the objectives, the scope and the methodology. Next, Sect. 4 presents the results of the different studies and discusses their implications. Lastly, in Sect. 5 the conclusions and futures research lines are put forward.

2 Theoretical Foundations

The theoretical foundations of this work come from different models and theories. To start with, the Triple Helix model [21], which focuses on the relationships between universities, government and industry. For the purpose of this research, this model is used as a framework that helps to better understand how ecosystems of innovation develop in cities. Second, to characterize how cities transform in the different dimensions—urban, economic, social and governance—the Urban Development approach [57, 58] is considered. Third, the Clusters of Innovation theory [16] is used to map the components of an ecosystem of innovation from the point of view of the interactions between start-ups, venture funds and corporates, contributing to the creation and development of high potential entrepreneurial ventures. Finally, as this work aims to advance the current knowledge on the evolution stages of AOIs, we use as an analogy the lifecycle of a new venture [26], which includes the traditional four stages: inception, launching, growing and maturity. The next subsections summarize the main theories mentioned above.

2.1 The Triple Helix Model

Etzkowitz and Leydesdorff [21] used the Triple Helix model (university-industry-government) to explain the development of knowledge-based economies. The model goes beyond linear systems based on policy innovation demand (market pull) or supply policies (technology push) and suggests reinforcing the emerging synergies between agents in a bottom-up perspective versus top-down government sponsored innovation initiatives. According to this model, ecosystems of innovation are composed of three types of agents:

– Universities (also including institutes of technology and research centres), which behave as magnets for international talent, stimulate the development of local talent, and are sources of scientific and technological knowledge for business.

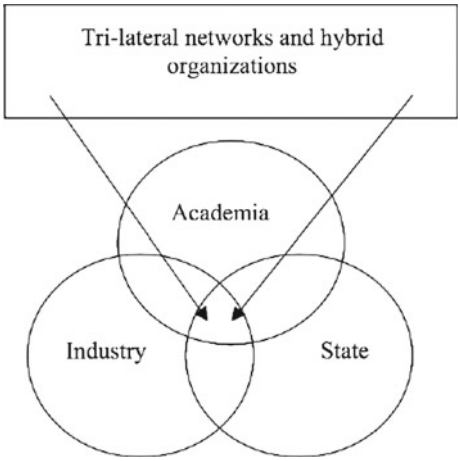

Fig. 1 The triple helix model of university-industry-government relations. *Source* Etzkowitz and Leydesdorff [21]

– Industries (large corporations, SMEs and start-ups), which are the key for the creation of economic value. Entrepreneurship is what translates the knowledge and talent of the individuals, teams and companies into innovation.
– Government (local, regional, national and international), which becomes the third party providing an active role in scientific, technological, business and land use policy making.

The Triple Helix model (see Fig. 1) is one of the most referenced models used to characterize an innovation ecosystem. The Triple Helix thesis postulates that the interaction among university-industry-government is the key to improve the conditions for innovation in a knowledge-based society: (a) industry operates as the centre of production; (b) government as the source of contractual relations that guarantee stable interaction and exchange; and (c) the university as a source of new knowledge and technology.

As the behaviour of each component in a system depends on the behaviour of the others, government's role in the Triple Helix model is interdependent on the role played by the university and the industry within the same system. Triple Helix agents play different roles in urban, economic and social development. While the university has traditionally been viewed as a support structure for innovation, providing trained people, research results, and knowledge to industry, in recent years it has increasingly become involved in firm formation, often based on new technologies originated thanks to academic research. It is therefore not surprising that in a knowledge-based society the university has been raised to an equivalent status, compared to previous institutional configurations where it had a secondary role. Rather than being subordinated to either industry or government, the university is emerging as an influential actor and equal partner [24].

A Triple Helix regime typically begins as university, industry and government enter into a reciprocal relationship with each other in which each of them attempts to enhance the performance of the other. Then, collaboration typically starts among

the institutional spheres more involved in innovation, taking place through their traditional roles. The increased interaction among university, industry and government as relatively equal partners, and the new developments in innovation strategies and practices that arise from this cooperation, are the core of the Triple Helix model. The creation of new organizational schemes to promote innovation such as incubators, science parks, and venture capital firms are other examples resulting from the interaction among the Triple Helix agents.

The next step of development of the Triple Helix is that, in addition to each agent performing its own tasks, they are also expected to "take the role of the other". This statement implies that, over time, each agent assumes some of the capabilities of the others while maintaining their primary role. Said differently, although each of the three helices continues with its traditional functions—teaching and basic research for universities, market operation and experimental development in the industry sphere, and multi-level decision making and rule setting in government—the helices interact and transform each other, thereby moving from single functions to multiple shared functions, and promoting the active circulation of people, ideas and policies among and within the three core spheres [6, 15, 24]. The three agents can act separately or in coordination by developing new knowledge, economic sectors, regions or cities. In promoting an ecosystem of innovation, players can assume the roles of the others, and hybrid structures that articulate joint actions may also be created [29].

The Quadruple Helix advocates for the addition of a fourth sphere, that is, the public and larger society [5]. By acknowledging the role of society in using, applying, and generating knowledge, this formulation explicitly introduces the democratization of knowledge production and innovation, as well as the impact of culture and creativity. Culture encompasses diversity in terms of values, lifestyles, and multiculturalism, but also in terms of multilevel local, regional, national, global, and *glocal* approaches. This diversity promotes creativity, a key component for new innovations and knowledge to spur [39].

Building upon the Quadruple Helix, the Quintuple Helix adds the natural environment as the fifth sphere for knowledge and innovation models, thereby positioning sustainable development and social ecology as a component equivalent to the other four helices for knowledge production and innovation [7]. Since socioecological concerns are incorporated as key drivers of innovation, this model supports the development of innovations oriented towards both problem-solving and sustainable development, and informed by multilateral interactions with the four other helices [39].

In this study we rely on the Triple Helix model to explore the role of the three agents in the promotion of urban, social [19] and governance development of cities.

2.2 Urban Development

Cities have always been considered as centres for economic and social development, and knowledge has become a key factor driving urban development [31]. In

the rapidly growing knowledge economy, talent and communities are crucial for economic and urban spatial transformation [50]. Cities have become "knowledge community precincts" [8, 58], that is, spaces for knowledge generation and for hosting knowledge communities [61]. More precisely, such precincts are initiated with the lead of the government, but with the support from either industry or/and academia, following the Triple Helix model. Central urban locations are the home for such precincts and benefit from the socio-cultural environment of the city. Knowledge community precincts have also been analysed in seven asset-bases [61]: (1) symbolic assets, (2) social assets, (3) human assets, (4) heritage and cultural assets, (5) natural environmental and infrastructural assets, (6) financial assets (7) knowledge assets and (8) relational assets.

Cities play an important role in the new economy where personal networking is of paramount importance [32]. The trend of urban planners is to transform old urban industrial zones into knowledge cities, which emerge as a balance between working and living [59]. Cities that stimulate different forms of knowledge serve as knowledge centres [30] and attract creative and highly skilled talent [25]. In the recent years some scholars have also included the artistic, cultural and social approach into this research field and have focused on analysing *creative cities* and *creative industries* for local development [4, 33, 53, 54].

The association of the terms "knowledge" and "city" (as in "knowledge city") combines the clusterization of activities related with science, technology and innovation in urban areas, which operate as engines for economic development [9]. Universities, industry and government are promoting knowledge-based activities for urban development as innovation districts [42]. Cities like Barcelona, Melbourne and Singapore are examples of this development [60].

During the last decade, scholarly articles dealing on urban development issues have notably grown. However, the investigations combining the topics of knowledge creation/diffusion and innovation spaces [62] are scarce. According to Bontje et al. [1, p. 1], "*the economic future of cities and city-regions increasingly depends on the capacity to attract, generate, retain and foster creativity, knowledge and innovation*". This paradigm, namely Knowledge-Based Urban Development (KBUD), has been first introduced during the last years of the 20th century as a result of the impact of the global knowledge economy on urban localities and societies [57, 58]. In 1995, Richard Knight argued the need for a new approach to explain the development of cities given the knowledge-based development [30]. He defined KBUD as "*the transformation of knowledge resources into local development*" [30, pp. 225–226].

Several models have been proposed for the conceptualisation of KBUD [51], yet, they all include: (1) social and cultural development (e.g., housing, community facilities, education, social capital and knowledge workers); (2) economic development (e.g., R&D centres, knowledge based companies and start-ups), (3) environment and urban development (e.g. green areas, green infrastructures—mobility, energy, waste, water—and green building); and (4) governance development (e.g. public and/or private bodies that manage the urban transformation and the process of participation of the citizens).

Knowledge assets and strategies have been found as the central concepts in the research domain of knowledge cities [20]. Researchers have identified knowledge and creative talent, universities, IT infrastructures, real estate development, and citizen decision-making as essential assets for the cities of knowledge. Universities and research centres are critical as they are the backbone of a knowledge based economy. In this sense, some authors emphasised the importance of Triple Helix partnership and the addition of the society in the Quadruple Helix to build knowledge cities [34], and even the environment in the Quintuple Helix model. In broader terms, knowledge assets in knowledge cities might also be considered the combination of both hard (tangible) and soft (intangible) assets [61].

In the urban development context, assets are defined as attributes of city-regions [56]. They are vital for the dynamics of urban life and crucial for the sustainability of the environment, economy and society. Therefore, the key local assets of a city-region—as the starting point of any transformation—are related with the success of development strategies. Managing both the tangible (i.e., physical infrastructure and buildings such as transport, property and utilities) and intangible assets (i.e., knowledge, collaboration and creativity) contributes to the competitiveness of cities (Fig. 2).

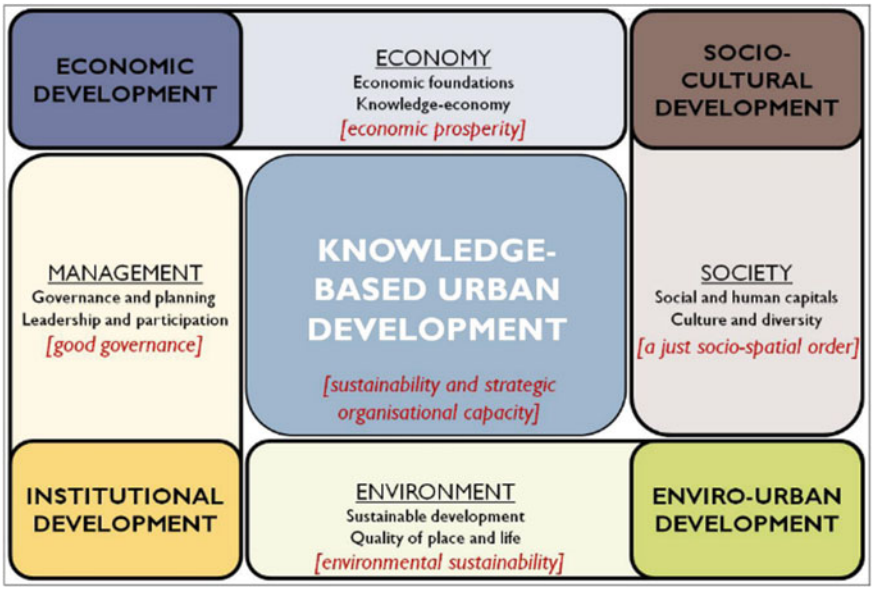

Fig. 2 Knowledge-based urban development model. *Source* Sarimin and Yigitcanlar [51]

2.3 Clusters of Innovation

Clusters of Innovation (COI) are global economic "hot spots" where new technologies germinate at an astounding rate and where pools of capital, expertise, and talent foster the development of new industries and new ways of doing business [18]. A COI is similar to, but somewhat different from, the well-established understanding of a business cluster [26]. In a COI, the entrepreneurial process is a mechanism for continuous and rapid innovation, technology commercialization, business model experimentation and new market development, and the process is encouraged by a dense venture capital cluster and the related facility for the creation of well structured, funded and connected start-ups. In these environments, start-ups benefit from being co-located with other providers, including lawyers, bankers, venture capitalists and a myriad of consultants who are well versed in the needs of start-ups and small technology companies [52].

The emergence of clusters in new industries that do not benefit from agglomeration externalities indicates the presence of several factors that characterize a COI [14], namely: (1) new firm creation as a rapid and frequent mechanism for innovation, technology commercialization, business model experimentation and new market development; (2) staged risk taking and commitment of resources; (3) rapid market testing and validation or failure; (4) tolerance of failure; (5) continuous recycling of people, money, ideas and business models; (6) intra- and inter-firm mobility of resources; (7) shared identities and values; (8) alignment of incentives and goals; and (9) a global perspective.

In 2009, Engel and Del-Palacio extended Porter's definition of industrial agglomeration to delineate a Global Cluster of Innovation framework that describes business clusters defined not primarily by industry specialization but by the stage of development and innovation of the cluster's components. While industry concentrations do exist, they are not definitive. It is rather the nature and the behaviour of the components that is distinctive—the rapid emergence of new firms commercializing new technologies, creating new markets, and addressing global markets [18] (Fig. 3).

2.4 The Lifecycle of a New Venture

The evolution of an ecosystem of innovation can be mapped in 4 phases following the analogy of the lifecycle of a new venture: inception, launching, growing and maturity [26]. Four steps were also proposed in the evolution of regional innovation ecosystems [22], including the development of the idea of a new regional model, the starting of new activities, the consolidation and adjustment and the self-sustaining growth of the ecosystem.

In contrast to biological evolution—which arises from mutations and natural selection—co-evolution occurs through a conscious intervention of every agent or with the creation of new hybrid organizations as a mix in terms of governance of universities,

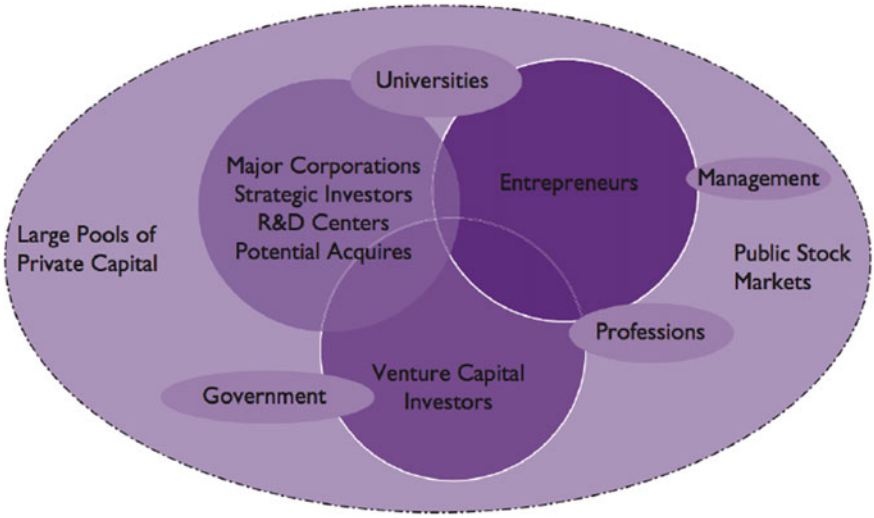

Fig. 3 Clusters of innovation theory. *Source* Engel [17]

industry and government—such as clusters or science parks [38]. Knowledge-based economic development can be traced to specific actors, typically operating in collaboration with each other. The institutional functions most appropriate to succeed can also be implemented from academic, industrial and governmental spheres. When one sphere is lacking, part of a knowledge based-strategy will substitute that actor and fill the gap [24].

Each phase will require the contribution of the Triple Helix agents—universities, industry and government—for urban, economic and social development to take place. In this study we aim to characterise, at each stage, the role played by each of the Triple Helix agents, and more importantly, how this contribution is shaping the subsequent stage, that is, boosting or hindering the evolution. The roles adopted by Triple Helix agents can change from phase to phase. Also, the roles might be connected with other's functions in the same phase but also in the forthcoming ones. For instance, in the urban dimension the government's regulation of the land in the inception stage will allow, in the subsequent phases, the investment of real estate companies in buildings and the use of the offices by start-ups.

In countries that—to a less or further extent—rely on central planning, it has become accepted that government programmes have an important role to play, not only from the national level (top-down) but also from the local level (bottom-up), often in collaboration with other organizations from the civil society (Fig. 4).

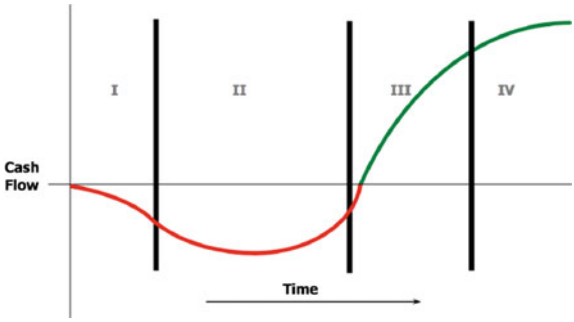

Fig. 4 Lifecycle of new venture model. *Source* Engel, from "The Innovative Organisation", session held in June, 2017, Berkeley, CA

3 Research Strategy

3.1 Research Objectives and Scope

Three are the main research questions that this work aims at answering:

(1) How do ecosystems of innovation evolve?
(2) Does the Triple Helix model (university-industry-government) help to understand the KBUD in the urban, economic, social, and governance dimensions?
(3) How does the role of the Triple Helix agents evolve in the different phases of the lifecycle of an AOI (inception, launching, growing and maturity)?

To address the above research questions, we have divided this research into four studies. Figure 5 graphically illustrates the research strategy followed, and the scope of each study.

In order to respond to the above questions, we rely in the theoretical frameworks revised in Sect. 2. Specifically, we use the Triple Helix model [5, 7, 21] to characterize the role of the university, the role of the industry, the role of the government, the role of the society (Quadruple Helix) and the role of the environment (Quintuple Helix). We use the Knowledge Based Urban Development paradigm [51] to investigate different areas of development: social and cultural, economic, environment and urban and governance. The Clusters of Innovation model [16] is helpful for the analysis of the mobility of people, capital and technology. Lastly, we use the different stages of the lifecycle of a new venture [22, 26]—namely, inception, launching, growing and maturity—to map how Areas of Innovation evolve the evolution of an Area of Innovation.

The first study, *Modelling the Ecosystems of Innovation* [45], tries to give a response to research questions (1) and (2). It is focused on a holistic model of Areas of Innovation in Cities, analysing the urban, economic, social, and governance dimensions of urban revitalizations. In this study we posit that the creation of innovation districts, scientific parks, urban clusters and smart cities has become a common tool for urban revitalisation. Usually, it has been applied in former industrial neighbourhoods in need of regeneration (brownfield), as it is the case of *22@Barcelona*. In

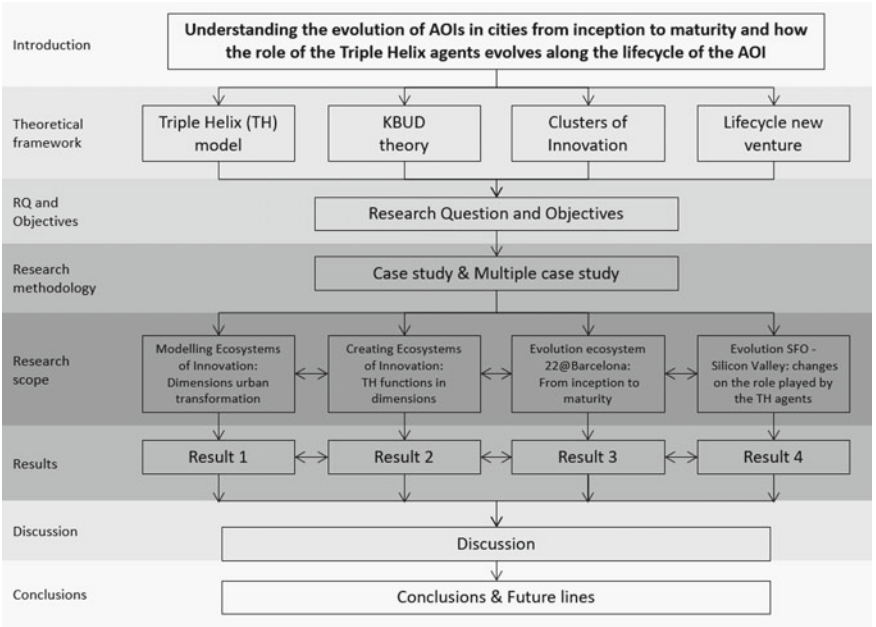

Fig. 5 Research scheme

other cases, projects are starting from scratch (greenfield) as in Skolkovo Technopark. The top-down approach to this type of urban development requires not only a clear methodology but also an in-depth knowledge of the context as well as of the stakeholders that participate in the transformation. Factors for success and failure related to the transformation of an area have been widely studied and documented [37, 40]. Yet, the mechanisms through which how cities and urban environments can promote the engagement and attachment of talented people in the nurture of the knowledge economy remains little explored. It becomes thus essential to provide mechanisms and tools to develop a dense network of relations that not only stimulates talent but also transforms it into added value creation. Aiming at fulfilling this goal, this study proposes a holistic model for Areas of Innovation in cities. Several variables will be taken into account on the effect this type of development might have as a driver for change in the city.

The second study, *Urban Revitalization: Creating Ecosystems of Innovation* [46], is focused on the role of the Triple Helix agents (university, industry and government) in every dimension of the urban transformation, and also aims at answering research questions (1) and (2). In this case, we argue that the revitalization of cities impacts on the urban, economic, social and governance dimensions [39, 51]. In this context, Triple Helix agents [21] can play different roles at each dimension. This study examines the revitalization of cities under the perspective of the Triple Helix model applied at Urban Development. To do this, four Brazilian cases in the process of revitalization of urban areas are analysed: *Porto Digital* (Recife), *Porto Maravilha*

(Rio de Janeiro), *4º Distrito* (Porto Alegre) and *Centro Sapiens* (Florianópolis). The *22@Barcelona* is included as a control case. Started in 2000 the *22@Barcelona* has now become a world reference of districts of innovation [28, 41]. It also exemplifies how the Triple Helix agents can cooperate in the Urban Transformation [23, 43]. Although each city and district is unique, regeneration of old districts share similar dimensions that can be extracted from a Triple Helix perspective. This study is guided to allow: (1) theoretical learning regarding the Knowledge Based Urban Development and the role of the Triple Helix agents; (2) the understanding of the role of Triple Helix agents in the *22@Barcelona*; and (3) an analysis on the Brazilian projects that, through a series of interventions of the Triple Helix agents, are recovering the strength of their cities.

The third study, titled *Evolution of ecosystems of innovation: the 22@Barcelona Case* [47] is simultaneously addressing the three research questions. In this case we adopt a case-oriented approach. Specifically, we examine the *22@Barcelona* innovation district, a case of a sound effort in building an Area of Innovation promoted in the metropolitan area of Barcelona that flourished from a traditional industrial district regenerated in an inner district of the city. The goal of this study is to better understand the evolution of Areas of Innovation, from inception to maturity, and investigate how, the role of the Triple Helix agents changes over their lifecycle. The *22@Barcelona* case is currently a model for 'innovation districts' in cities [10, 13, 42]. Also international stakeholders such as the International Association of Science Parks and Areas of Innovation (IASP) consider *22@Barcelona* as a reference source for policy transferability and experience-based knowledge. More than 354 delegations from all continents visited *22@Barcelona* from 2011 until 2015 according to the data from the Barcelona City Council.

Last but not least, the forth study explores the three research questions and is focused on the *Evolution of San Francisco - Silicon Valley ecosystem* [3]. In this study we argue that Silicon Valley has been at the top of ecosystems of innovation for so many years that many voices are now arising trying to identify why it will soon fail. But Silicon Valley seems to always recover and find a way to improve and tune its ecosystem in a more efficient way. This study aims at identifying and characterising the changes experienced by the Triple Helix agents in a strong entrepreneurial environment such as Silicon Valley. Also, the study tries to identify if the changes experienced by one of the agents trigger the evolution of the others. To do so, a timeframe—from 2006 to 2016—is considered. The focus is thus on how the role played by universities, industries and the government has changed during the past 10 years in Silicon Valley, paying special attention to their impact on start-ups creation.

3.2 Methodology

In the Foreword of the book "*Case Study Research: Design and Methods*" [63], Donald Campbell asserted that "*the core of the scientific method is not experimentation* per se *but rather the strategy connoted by the phrase 'plausible rival hypothesis*".

Case studies are extensively used in social science research [63], including the traditional disciplines (psychology, sociology, political science, anthropology, history and economics) as well as practice-oriented fields such as urban planning, public administrations, public policy, management science, social work and education.

The case study is one of several ways of conducting research in social sciences. Case studies are the preferred strategy when "how" or "why" [63] questions are being posed, when the investigators have little control over events, and when the focus is on a contemporary phenomenon within some real-life context. Case studies are found even in economics, in which the structure of a given industry of the economy or a city or a region may be investigated by using the case study method. In all these situations, the distinctive need for case studies arises out of the desire to understand complex social phenomena. In brief, the case study method allows retaining the holistic and meaningful characteristics of real-life events such as life cycles, organizational processes, neighbourhood change and the maturation of industries. That's the situation of the four studies that integrate this work. More specifically, we use single and multiple-case studies, combining both qualitative and quantitative information.

4 Discussion

From the results of the four studies, several implications can be drawn. This section groups the main implications into for domains: (1) cities as platform of the knowledge based economy; (2) city revitalization needs urban, economic and social transformation; (3) Triple Helix agents develop different functions in city transformation; and (4) Triple Helix agents change the role in the lifecycle of an Area of Innovation.

4.1 Cities, the Platform of the Knowledge Based Economy

Cities are the platform of the knowledge based economy because they are the platforms of talent, the real raw material of the new economy. Cities must provide a good place for working and living if they want to attract, retain and create talent [39]. On the other hand, cities are also a goal of innovation. For this reason, they can be a place for learning new applications. Policy makers, universities and industry can use the city as a lab to learn locally in order to compete globally.

The Quadruple Helix model includes the demand side of innovation. Citizens are the beneficiaries of the innovation, but also they could play a key role in the process of innovation [44]. Cities that want to develop Areas of Innovation will need to develop hard factors and soft factors for urban, economic and social transformation.

Both greenfield and brownfield developments should create an ecology of innovation that will include all the agents of the ecosystem (universities, industries and government). The starting point may be different, but the vision must be clear in

the direction of the knowledge based economy and society. Cities should understand the challenges to achieve this vision, and develop actions to address the urban, economic and social challenges, taking advantage of the capabilities of the agents of the ecosystem [45].

4.2 City Revitalization Needs Urban, Economic and Social Transformation

We can summarize the lessons obtained from the Brazilian cases [46]:

- Holistic approach: The urban revitalization needs an integral approach, including the (1) infrastructure and urban dimension, (2) businesses and economic dimension, (3) talent and social dimension, and (4) governance dimension.
- Urban transformation: Each project needs (1) an urban plan, (2) an infrastructure plan, and (3) a legal framework that allows the use of the land for knowledge based activities, and the attraction of real estate investors for retrofitting old buildings and creating new office and public spaces. *22@Barcelona* and the Brazilian cases have special laws for urban planning and infrastructures plan.
- Economic transformation: Innovation districts need smart specializations. This implies selecting what sectors (clusters) to be developed and what agenda of technologies is needed for the value chains of innovation.
- Social transformation: Talent is a key asset of the knowledge based economy and society. Innovation districts must develop a strategy for talent creation, development, attraction and retention, and provide enjoyable spaces where to live and work.
- Governance: The Triple Helix agents play a key role in the transformation, and should create hybrid organizations (public private partnership platforms) in order to share the vision to achieve in the innovation district, and to add actions to be developed in all the dimensions of the project.

4.3 Triple Helix Agents Develop Different Functions in City Transformation

Areas of Innovation need urban, economic and social transformation. The role of each agent of the Triple Helix model (Government, Universities and Industry) is different depending on the dimension of the transformation [3, 46, 47]:

- Government, in the local, regional (state) and national (federal) levels plays a key role in the transformation. In the urban dimension, it defines the uses of the land, the infrastructures plan, green spaces and the incentive for real-estate developers. In the economic dimension it invests in research and technology, promote attraction of

companies and the creation of new start-ups, promote clusters and create conditions for pilots. In the social dimension, it creates the conditions for living and working, including housing and schools.
– University is the source of talent and technology. The university is a key tool impacting at all the dimensions. In the urban dimension, they develop land and buildings as anchor institutions (for research, teaching, incubation and residences). In the economic dimension, they provide science, technology, labs and entrepreneurs to the ecosystem. In the social dimension, provides fresh talent to the district and experienced staff that will be also living in the district.
– Industry represents all the companies—of different sizes in sectors—in the area. In the urban dimension, on the one hand, through real state, develop and build new building and retrofit old ones for new proposals; utilities companies provide the key infrastructures; end users use the buildings and provide the return of investment. In the economic transformation dimension, large corporations, SMEs and new start-ups are clustered with universities and institutions, creating jobs and turnover. Lastly, in the social dimension, the industry provides professionals to the district as citizens, and allows talent to be involved in companies with internship and jobs.

4.4 Triple Helix Agents Change the Role in the Lifecycle of an Area of Innovation

The case of *22@Barcelona* provides evidence that, in each phase, each agent works in a different way, and that all agents are necessary to fulfil all the phases. A co-evolution process is therefore developed, interacting government, universities and industry. All agents need the others to evolve, and hybrid organizations as clusters are coordinating expectations and actions. Main roles that should be performed at each stage are summarised below [47]:

– Inception: A clear leadership of the government is needed to create an AOI (in some cases the Mayor of the city, in others regional and national policies). The involvement of the universities and association of companies are key factors to generate the vision and trust in the project. Without clear rules of the uses of the land and clear vision about the type of AOI will be difficult to advance in all the transformation.
– Launching: The AOI will need basic infrastructures for starting, and the first buildings to settle the first users. Also, tractor companies and universities will be necessary for stimulating others to come. The AOI will need full time managers for promoting the place and organizing the landing of organizations and investors.
– Growing: Investors will need clear pieces of land or buildings to invest or build. A cluster strategy should be developed in the district. The creation of start-ups will be one of the sources of growing and innovation. Synergies among the tenants in the district should be developed. In the social dimension, international professionals

will need landing aid and the creation of communities and networks of people will generate synergies and sense of belonging.
– Maturity: The AOI must evaluate the opportunities to expand the area around the original district, or transferring the experience to other zones of the city. The AOI should be a hub of innovation connecting with other parks and areas, creating superclusters of international networks. In the social dimension, the AOI will include the whole society being involved. In terms of governance, the leadership of the area should be in the hands of the associations of companies and social entities.

5 Concluding Remarks

5.1 Conclusions

This work aims to contribute to the understanding of the revitalization projects of metropolitan areas and the evolution of ecosystems of innovation.

Adopting a case study approach, in this work we have explored four Brazilian urban revitalizations, the evolution of *22@Barcelona* Innovation District and San Francisco-Silicon Valley Ecosystem. Several are the lessons learned.

First, we have been able to characterize and map the role of the different agents of the Triple Helix (government, universities and industry). Also, from the analysis it can be inferred that role differs depending on the dimension of the transformation. Specifically, from the government's standpoint, the case illustrates that this stakeholder should add and impact with projects in the same area mixing local, regional, national, and in some cases international bodies (like the case of the European Union or international organizations). The government plays key roles in urban planning, infrastructures regulation and urban services. In turn, these, attract companies, promote entrepreneurship, develop sectorial programs and invest in research, innovation, entrepreneurship and sophisticated demand. Public-Private Partnerships are needed to organize and add all public and private contributions. In the case of *22@Barcelona*, the City Council played a key role in public and private leadership. From the standpoint of universities, we have seen that these institutions perform the role of the entrepreneurial university as defined by Clark [12]. Universities provide talent from education, technology from research, and knowledge-based entrepreneurs from university incubators. Universities are key pillars of the knowledge-based economy. Universities also transform the urban dimension with their buildings in the city. They are anchors and magnets of knowledge-based companies and service companies. They impact on the community providing fresh and young talent that will be mixed with the neighbourhoods, transforming the life of the streets. In the case of *22@Barcelona*, universities are the lighthouses of urban, economic and social transformation. Lastly, in the case of the industry, companies are located in the Area of Innovation in order to offer professionals a place for working. Companies can take

advantage of the outputs of the universities, hire talent, use labs, absorb technology, and interact with the new knowledge-based start-ups. Also, companies provide experience, market technologies and focus on the real needs to Universities. They can cluster with other companies, start-ups and institutions. In the urban dimension, they are the tenants of the building owners, and pay the bill of the investment of the real estate developers. *22@Barcelona* developed a comprehensive cluster strategy, attracting investors and promoting entrepreneurship.

Second, from the above analysis, it can be distilled that every member of the Triple Helix works in all the dimensions from different perspectives, but all the members are needed in order to produce an urban, economic and social transformation. Hybrid organizations can be also created for joining efforts and activities. In the *22@Barcelona*, such organisations are exemplified by the Cluster programs and the Public-Private-Platforms partnerships. Likewise, governance platforms are needed to organize and coordinate agents and functions. In the case of *22@Barcelona*, Horizontal (22@Network) and Vertical (Clusters) were used to orchestrate the ecosystem of Innovation.

Third, we have been able to test the adequacy of applying the evolution model of an Area of Innovation using the phases of a new venture. In this sense, the *22@Barcelona* case is very illustrative, as it reveals that in each phase, each agent works in a different way, being however, all of them necessary to accomplish the ultimate goal. In this respect, a co-evolution process is required, with government, universities and industry interacting. Hence, all agents need the others to evolve, and hybrid organizations are necessary to coordinate expectations and actions. Particularly, from an in-depth analysis of the different phases, we can conclude that, in an inception stage, a clear leadership from the government is needed to create an Area of Innovation (in some cases the Mayor of the City, in others, regional and national policies). The involvement of universities and the association of companies are key factors to generate the vision and trust in the project. Without clear rules of the uses of the land and clear vision of the kind of Area of Innovation to be built, it will be difficult to advance in all the transformation. In the launching phase, the Area of Innovation needs basic infrastructures for starting, and the first buildings to settle the first users. Also, tractor companies and universities are paramount to stimulating newcomers. The Area of Innovation will need full time managers for promoting the place and organizing the landing of organizations and investors. In the growing stage, investors need clear pieces of land or buildings to invest or build. This means that the development of a cluster strategy is paramount. The creation of start-ups is one of the sources of growth and innovation as well as the establishment of synergies among the tenants in the district. In the social dimension, international professionals will need landing aid and the creation of communities and networks of people will generate synergies and a sense of belonging. Lastly, during maturity, the Area of Innovation must evaluate to expand the area around the original district and/or transfer the experience to other zones of the city. The Area of Innovation should be conceived as a hub of innovation connecting with other parks and areas, creating superclusters of international networks.

Fourth, it is worth signalling that in each phase, the Triple Helix agents work for the next phase. That is, the government defines the use of the land, allowing universities and companies to locate in the Area of Innovation. In return, universities develop the academic offer, providing talent to the companies. Also, universities should promote entrepreneurship, as a way to generate new start-ups that government and investors can fund in order to provide new innovations at the ecosystem. Big Corporations can buy start-ups as a way to absorb innovation. Operating like this, the horizontal value chain of the urban, economic and social dimension is vertically connected to the governance of universities, industry and government. In the case of San Francisco—Silicon Valley, Universities are getting closer to industry and the Big Corporations engage sooner with start-ups.

Fifth, the ecosystems of innovation evolve, but only if each Triple Helix agent co-evolves its role when others adopt new functions. In the specific case of *22@Barcelona* we have seen that for the case of urban transformation, the first effort came from the Government, investing in infrastructures. In a mature moment, the real estate took this role and invested in new buildings instead of the government. In the economical dimension, when the culture of entrepreneurship was needed, public programs were launched to provide financial aid to start-ups, while in a mature stage, business angels and venture capital firms led the investments. Lastly, in the social dimension, in the inception stage changing the traditional mindset of the neighbourhood was crucial, while in a mature stage the culture of innovation and entrepreneurship was instilled in schools. In the specific case of San Francisco-Silicon Valley, from the analysis of data collected during the interviews, we can conclude that the role of the Triple Helix agents evolved with time. The main changes identified during the study are (1) raise of accelerator programs as new player in the ecosystem; (2) early engagement of some corporations with start-ups; (3) geographical expansion of Silicon Valley, now including San Francisco; (4) increasing commitment of universities with capital funds; and (5) raise of micro-multinationals due to talent shortage and fierce competition in the area. Other changes have helped to increase the efficiency of an already highly innovative ecosystem.

Overall, we posit that *22@Barcelona* is a good example to illustrate that every agent of the Triple Helix has its internal agenda. Universities play a long-term vision, government has the elections timeline in its agenda, and industry pays salaries every month and shows the results on an annual basis. Aligning vision agendas at short, middle and long term is paramount, at the governance level, in order to make the ecosystem evolve in a synergic way as the *22@Barcelona* one has done.

In the case of San Francisco-Silicon Valley, through the changes identified in this study, we can conclude that the role of Triple Helix agents has evolved over time in Silicon Valley. Since the Triple Helix model is used to characterize an Ecosystem of Innovation, we can extrapolate that the Ecosystems of Innovation also evolves over time.

5.2 Limitations and Future Lines

Although this work provides useful insights into the analysis of ecosystems of innovation in urban areas, we identified some limitations that clearly represent future research lines. Concerning the methodological approach, it is worth highlighting the limited number of cases covered. We encourage future studies to corroborate the model of Areas of Innovation presented with quantitative data validating the effectivity of the model as a tool to analyse the impact of the interventions of the Triple Helix agents in all the dimensions of the transformation and the lifecycle of the Area of Innovation.

As for the theoretical foundations, this research is grounded in the Triple Helix Model in order to understand the role of the universities, industry and government developing urban ecosystems of innovation. While the model seems appropriate, future studies might consider adding other perspectives (Regional Innovation Ecosystems) and theories (Open Innovation) to better understand how the different agents interact and evolve.

It is also important noting that this work has focused on the analysis of Areas of Innovation in urban areas. A recommendation for further studies relates to exploring the usefulness of our model in other settings, that is, changing the unit of analysis. For instance, it would be interesting analysing how the model proposed here applies to regions (adopting a more "macro" approach). Likewise, the model can also be applied to non-urban areas that want to develop ecosystems of innovation. Cases like Atlanpole in France or Richardson Telecom Corridor in USA are Areas of Innovation that work beyond the city as epicentre of the ecosystem of innovation are just some examples. This scenario opens new challenges on governance, urban, economic and social development.

Lastly, this study has mainly focused on brownfield cases, that is, transforming districts or parts of the city with previous activities. Further research could explore how to apply this model in unused zone development, such as areas without any urban legacy (greenfield transformation). The Yachay City of Knowledge in Ecuador is an example that might benefit from the application of this research to its specific context.

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