Understanding the urban development and the evolution of the Ecosystems of Innovation

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DOCTORAL THESIS

Title	Understanding the urban development and the evolution of the Ecosystems of Innovation
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DOCTORAL THESIS

Understanding the urban development and the evolution of the Ecosystems of Innovation

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ABSTRACT

This PhD dissertation is a compendium of publications in the field of Ecosystems of Innovation. These articles are based on the conceptual frameworks of the Triple Helix model, Knowledge Based Urban Development paradigm, Clusters of Innovation and the Lifecycle Model of a New Venture.

This thesis aims to contribute to the understanding of the revitalization projects of metropolitan areas and the evolution of the Ecosystems of Innovation. Using a case method approach, this work has explored four Brazilian urban revitalizations, the evolution of 22@Barcelona Innovation District and the evolution of San Francisco-Silicon Valley Ecosystem. From these cases, several implications can be drawn. From the academic point of view, the Quintuple Helix model and the Knowledge Based Urban Development (KBUD) theory provide an appropriate framework to describe the revitalization processes that have been analysed. From the perspective of policy makers in urban revitalization, this work 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 proposing a holistic perspective of the role of the Universities, Industry and Government that includes local specificities in the revitalization processes in the urban, economic, social and governance dimension and a new perspective for theorizing the evolution of Areas of Innovation (AOIs) from inception to maturity.

Keywords

Science Parks; Areas of Innovation; Innovation Districts; Triple Helix; Knowledge Based Urban Development; Clusters of Innovation; Lifecycle; 22@Barcelona; Silicon Valley; Brazilian cities; Entrepreneurship; Start-ups.

PREFACE

In 2008, after the presentation of my DEA[1], I wrote a paper with Prof. Francesc Solé Parellada (UPC), Prof. Henry Etzkowitz (Triple Helix) and Itxaso del Palacio (UPC) entitled "*Science Parks as Global Entrepreneurship Platforms*" accepted and presented at the *IASP World Conference* celebrated in Johannesburg. The paper (Pique et al., 2008) analysed the role of science parks as entrepreneurship promoters because there were no clear evidences of what exactly science parks provide and how they were supporting new firm development (Ferguson and Olofsson, 2004). The goal of that research was to identify the main factors boosting technological entrepreneurship and venture growth in a science park. The analysis was based on the Triple Helix model as an innovation system (Etzkowitz and Leydesdorff, 2000)—university, government and networks among industries—and consisted in a step-by-step analysis, investigating the importance of these three agents, and how their support was varying from one stage to another (inception, launching, growing and maturity) of the new venture development (Freeman and Engel, 2007).

The analysis was based on an own previous research and several field studies in the Bay Area of San Francisco and in the Barcelona Area (see e.g. Etzkowitz et al., 2006; Pique et al., 2004; Pique et al., 2005). At this stage the exhaustive literature review that was performed was of paramount importance in order to select the 5 critical variables characterising the global-born-companies' business development process. Resulting from this study, a model using both the new venture development stages (Freeman and Engel, 2007) and the Triple Helix model was proposed. With the above information, in the next step six born-global-companies in Barcelona and in San Francisco were examined in depth, including interviews with the founders in order to validate the proposed model. The interviews confirmed the initial intuition that Triple Helix agents play different roles in the lifecycle of a new venture (from inception to maturity) and that university and government support is especially important at the first stage of inception and launching. During the subsequent stages of growth and maturity, the primary support moves to inter-firm networks. Taken as a whole, this study contributed to identify the main factors supporting technology start-ups during each specific stage of venture development. Furthermore, the study also provided evidence of the relative importance of the agents as support providers and how this support takes place. Governments and policymakers might find these results useful in order to elaborate more accurate policies aimed at boosting technology entrepreneurship initiatives to spur.

On the other hand, from November 2007 until September 2015, I worked at the Barcelona City Council developing first the *22@ District of Innovation* as CEO of the Public Company, and after that as the CEO of the Office of Economic Growth developing the Economic Strategy of the City in Strategic Sectors. This experience, combined with the reception of hundreds of international delegations visiting 22@ and the City of Barcelona, the presentation of the 22@Barcelona in dozens of international events, and the exercise of

[1] Advanced Studies Diploma – Ramon Llull University, December 17, 2007.

transferring the experience of 22@Barcelona to others cities of the world, stimulated me to go a step further and study the evolution of the role of the Triple Helix agents developing Ecosystems of Innovation.

In 2015, I became the president of the International Association of Science Parks and Areas of Innovation (IASP). I have attended international workshops and conferences worldwide and I have been invited three times to the Annual conference organised by the Network of Science and Technology Parks of Brazil (ANPROTEC). All these experiences allowed me to visit and analyse the new movement of innovation districts in Recife, Rio de Janeiro, Porto Alegre and Florianópolis.

Taking advantage of the works and experience of San Francisco - Silicon Valley as an archetype of an organic Ecosystem of Innovation, the experience of 22@ as District of Innovation promoted by the Government, and the new movement of Areas of Innovation in cities, we decided to focus this thesis on this topic, aiming at contributing to a better understanding of the revitalization projects of metropolitan areas and the evolution of the Ecosystems of Innovation. As such, this work revolves round three main questions: (1) How do ecosystems of innovation evolve?; (2) What agents and actions are needed in the knowledge-based urban development?; (3) Is it possible to divide this evolution in phases?

To answer these questions, this research is divided into four main studies. The first one focuses on a holistic model of Areas of Innovation in cities, analysing the urban, economic, social and governance dimensions of urban revitalizations. The second one concentrates on the role of the Triple Helix agents (university, industry and government) in every dimension of the urban transformation. The third study examines on the evolution of ecosystems of innovation taking advantage of 22@Barcelona Case. The last one, analyses the evolution of the ecosystem of innovation of San Francisco - Silicon Valley. For every study, we have written a publication, and the four papers fulfil this Thesis for Compendium.

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1. INTRODUCTION

City planners cannot avoid facing the challenge of playing a relevant role in the knowledge-based economy where face-to-face interaction, networking and trade remain vital (Landry, 2000). The tendency 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 (Scott, 2006). Cities that stimulate and rejuvenate various forms of knowledge serve as knowledge centres (Knight, 1995) and attract a creative and highly skilled workforce (Florida, 2008).

Science parks built in regenerated zones of inner cities have generated important attention from a wide range of stakeholders, from policymakers to researchers in the field of innovation ecosystems. 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 host significant concentrations of creative industries, including high technology, artistic and cultural sectors which are integrated in a wider social context (Scott, 2000), while at the same time, provide socio-cultural amenities (Yigitcanlar and Dur, 2013).

New cities hardly retain any of their former traditional, local and static nature (Porter, 1995). In the inner cities, clusters of interlinked firms and organizations operate at world-class levels of competitiveness (Porter, 1998). Companies take advantage of social agglomeration factors such as critical masses of skills and relationships, access to information, and the availability of specific infrastructure in a given field (Utterback and Afuah, 1998; Hutton, 2004; Porter, 1995). As a result of agglomeration effects, new economy metropolitan clusters comprise not just isolated firms but rather substantial ensembles of dynamic industries (Hutton, 2004) that have been transformed into urban science parks or Areas of Innovation (AOIs) (Luger and Goldstein, 1991; Massey, Quintas and Wield, 1992).

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 (Hutton, 2004). As clustering forces drive talented, innovative and creative people to concentrate in the most knowledge-intensive cities and regions (Florida, 2008), in the new economy the tendency is to attract the talent by promoting the creation of new economy metropolitan clusters (Chica and Marmolejo, 2016) that set up "new" versions of traditional science parks. Retention factors of talent are thus needed (Bontje, Musterd and Sleutjes, 2017).

These new 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 place, more specifically, the innovative milieu of the inner city (Hutton, 2004).

Although existing literature has focused on the evolution of traditional science parks, there is a lack of research clarifying those factors that explain the evolution, either organic or intended, from traditional

suburban science parks to AOIs that participate in creating cities for the knowledge-based economy. The goal of this work is thus to shed additional light to propose an enhanced framework that assists in the understanding of the evolution of the AOIs in cities, from inception to maturity, and 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, Knowledge Based Urban Development paradigm, Clusters of Innovation and the Lifecycle model of a New Venture creation.

This thesis is developed as compendium of publications and is structured in 10 sections. Section 1 introduces the research idea and the purpose of the thesis. Section 2 analyses the theoretical background. Section 3 presents the research strategy with research questions, objectives, scope and methodology. Sections 4, 5, 6 and 7 develop the four main studies with the results and the compendium of publications. Section 8 evaluates the ethical aspects; Section 9 incorporates discussion and implications. Section 10 includes the conclusions and futures research lines.

The contribution of the author of this thesis as compendium of publications has been as follows:

Publication 1: Pique, J. and Miralles, F. (2017) 'Areas of Innovation in cities: Holistic modelling of urban, economic and social transformation'. Proceedings of 6th *International Academic Conference on Social Sciences,* Barcelona, 27-28 July, pp. 9-13.

Under the supervision of F. Miralles, the PhD candidate has contributed defining the goal the study, analysing the state of the art, defining the methodology, collecting the data, elaborating the results, writing the paper and presenting it at the Conference.

Publication 2: Pique, J.M., Miralles, F., Teixeira, C.S., Gaspar, J.V. and Ramos Filho, J.R.B. (2018b) 'Application of the Triple Helix Model in the revitalization of Cities: The case of Brazil'. *International Journal of Knowledge-Based Development,* in press

Under the supervision of F. Miralles, the PhD candidate has contributed defining the goal the study, analysing the state of the art, defining the methodology, providing information of the control case 22@Barcelona, coordinating the study fields, elaborating the results and writing the paper.

Publication 3: Pique, J.M., Miralles, F. and Berbegal-Mirabent, J. (2018a) 'Areas of Innovation in Cities: The evolution of 22@Barcelona'. *International Journal of Knowledge-Based Development,* in press.

Under the supervision of F. Miralles and J. Berbegal-Mirabent, the PhD candidate has contributed defining the goal the study, analysing the state of the art, defining the methodology, collecting the data, elaborating the results and writing the paper.

Publication 4: Botey, M., Pique, J.M. and Miralles, F. (2018) 'The evolution of Silicon Valley's Innovation Ecosystem: From 2006 to 2016'. In: *XXXV IASP World Conference on Science and Technology Parks*. Isfahan (Iran). Forthcoming.

Under the supervision of F. Miralles, the PhD candidate has contributed defining the goal the study, analysing the state of the art, defining the methodology, coordinating the study field, participating in the discussion of the results, writing the paper and presenting it at the Conference.

2. THEORETICAL FRAMEWORK

The theoretical foundations of this work come from different models and theories. To start with, the Triple Helix model (Etzkowitz and Leydesdorff, 2000) which focuses on the relationships between universities, government and industry. This model is used in this thesis as a framework that helps to better understand how ecosystems of innovation develop in cities. Second, to understand how cities transform in the different dimensions—urban, economic, social and governance—the Urban Development approach (Yigitcanlar et al., 2008a; 2008b) is considered. Third, the Clusters of Innovation theory (Engel and Del-Palacio, 2009) is used to understand the components of ecosystem of innovation from the point of view of the interaction between start-ups, venture funds and corporates, contributing to the creation and development of high potential entrepreneurial ventures. Finally, this work aims to shed some light on the evolution stages of AOIs. To this end, taking as an analogy the lifecycle of a new venture (Freeman and Engel, 2007), a four phases framework is proposed, mapping the lifecycle of an AOI (inception, launching, growing and maturity).

2.1. THE TRIPLE HELIX MODEL

Etzkowitz and Leydesdorff (2000) use 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.

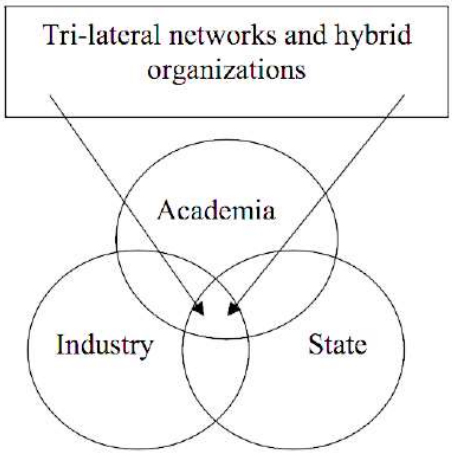
The central idea expressed by the Triple Helix model is that ecosystems of innovation are composed of three types of agents:

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

The university has traditionally been viewed as a support structure for innovation, providing trained people, research results, and knowledge to industry. Recently the university has increasingly become involved in the formation of firms, often based on new technologies originated thanks to academic research. The Triple Helix raised the university to an equivalent status in a knowledge-based society, unlike previous institutional configurations where it had a secondary status. Rather than being subordinated to either industry or government, the university is emerging as an influential actor and equal partner in a "Triple Helix" of university-industry-government relations (Etzkowitz, 2008).

Figure 1. The Triple Helix model of university-industry-government relations.



Source: Etzkowitz and Leydesdorff (2000)

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.

A Triple Helix regime typically begins as university, industry and government enter into a reciprocal relationship with each other in which each attempts to enhance the performance of the other. Then, collaboration typically starts among the institutional spheres most involved with 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 of economic and social development. The creation of new organizational formats to promote innovation such as incubators, science parks, and venture capital firms are another result from the interaction among the Triple Helix agents to promote innovation and, at the same time, they are themselves an example of the Triple Helix collaboration.

The next step of development of the Triple Helix is that, in addition to performing its traditional tasks each Triple Helix agent "takes the role of the other". This statement relates to the fact that, over time, each agent assumes some of the capabilities of the other while maintaining its primary role.

Although each of the three helices continues with its traditional functions—teaching and basic research at universities, market operation and experimental development in the industry sphere, and multi-level

decision making and rule setting in government—in the most developed forms of the Triple Helix model 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 (Carayannis and Campbell, 2011; Dzisah and Etzkowitz, 2008; Etzkowitz, 2008). The three agents can act separately or can coordinate by developing new knowledge, economic sectors, regions or cities. In promoting an ecosystem of innovation, players can assume the roles of the others, and permanent hybrid structures that articulate joint actions may also be created (Kim, Kim and Yang, 2012).

The Quadruple Helix can add a fourth sphere, that is, the public and larger society (Carayannis and Campbell, 2009). By acknowledging the role of the public in using, applying, and also generating knowledge, this formulation explicitly introduces the democratization of knowledge production and innovation, as well as the impact of culture and creativity. Culture encompasses both diversity in terms of values, lifestyles, and multiculturalism, and 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 (Nikina and Pique, 2016).

As an another driver of innovation, the Quintuple Helix adds the natural environment as a 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 (Carayannis et al., 2012). Since socioecological concerns are incorporated as a key driver of innovation, this model is positioned to support the development of innovations simultaneously oriented towards problem solving and sustainable development and informed by multilateral interactions with the four other helices (Nikina and Pique, 2016).

As summary, the Triple Helix model of university-industry-government relations (Etzkowitz, 1993, 1996; Etzkowitz and Leydesdorff, 1995, 2000) serves as both an illustration of and a roadmap for moving from linear knowledge flows to non-linear and interactive modes of innovation. The Quadruple Helix incorporates the viewpoints of civil society and media and culture-based publics while the ecologically sensitive Quintuple Helix adds the perspective of the natural environment (Carayannis and Campbell, 2009, 2010, 2011; Carayannis et al., 2012).

The Triple Helix model has been used for developing ecosystems of innovation, but beyond the economic development, this thesis aims to explore the role of the three agents in the promotion of urban, social (Esmaeilpoorarabi, Yigitcanlar and Guaralda, 2016) and governance development of cities.

2.2. URBAN DEVELOPMENT

Cities have always been centres for economic and social development, and knowledge has become a key factor driving urban development (Knight, 2008). In the rapidly growing knowledge economy, talent and communities are crucial for economic and urban spatial transformation (Powell and Snellman, 2004). Cities have become the localities of "knowledge community precincts" (Carrillo, 2006; Yigitcanlar, Velibeyoglu

and Baum, 2008b), that is, spaces for knowledge generation and places for knowledge communities (Yigitcanlar and Dur, 2013). More specifically, such precincts are initiated with the lead of government, but with the support from either industry or/and academy following the Triple Helix model. Central urban locations are the home for such precincts in order to benefit from the socio-cultural environment of the city in this place. Knowledge community precincts have also been analysed in seven asset-bases (Yigitcanlar and Dur, 2013): (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 (Landry, 2000). The tendency of urban planners is to transform old urban industrial zones into knowledge cities, which emerge as a balance between working and living (Yigitcanlar, Velibeyoglu and Martinez-Fernandez, 2008). Cities that stimulate forms of knowledge serve as knowledge centres (Knight, 1995) and attract creative and highly skilled talent (Florida, 2008). 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 (Scott, 2000, 2006; Lazzeretti, 2007; Cabrita, Machado and Cabrita, 2013).

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, operating as engines of economic development (Carrillo et al., 2014). Universities, industry and government are promoting knowledge-based activities for urban development as innovation districts (Pareja-Eastaway and Pique, 2011). Cities like Barcelona, Melbourne and Singapore are examples of this development (Yigitcanlar, 2011).

During the last decade, scholarly articles dealing urban development issues have notably grown. However, there have been very limited investigations combining the topics of knowledge creation/diffusion and innovation spaces (Yigitcanlar et al., 2016). According to Bontje et al. (2011, 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 (Yigitcanlar et al., 2008a; 2008b). In 1995, Richard Knight argued the need for a new approach to explain the development of cities given the knowledge-based development (Knight, 1995). He defined KBUD as “*the transformation of knowledge resources into local development*” (Knight, 1995, pp. 225-226).

Several models have been proposed for the conceptualisation of KBUD (Sarimin and Yigitcanlar, 2012), 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 (Edvardsson, Yigitcanlar and Pancholi, 2016). Researchers have identified knowledge and creative talent, universities, IT Infrastructures, real estate development, and citizen decision-making as essential knowledge assets for the cities of knowledge. Universities and research centres are critical assets for the knowledge cities 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 (Leydesdorff, 2012), 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 (Yigitcanlar and Dur, 2013).

In the urban development context, assets are defined as attributes of city-regions (Velibeyoglu and Yigitcanlar, 2010). 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.

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. A COI is similar to, but somewhat different from, the well-established understanding of a business cluster (Freeman and Engel, 2007). 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 (Saxenian, 2007).

The emergence of clusters in new industries that do not benefit from agglomeration externalities indicates the presence of several factors that characterize a COI, 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 (Del-Palacio, 2009).

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 constituents. 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 (Engel, 2015).

2.4. THE LIFECYCLE MODEL OF A NEW VENTURE

The evolution of an ecosystem of innovation can be mapped in 4 phases following the analogy of the lifecycle model of a new venture: inception, launching, growing and maturity (Freeman and Engel, 2007). Four steps were also proposed in the evolution of regional innovation ecosystems (Etzkowitz and Klofsten, 2005), 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, industry and government—such as clusters or science parks (Nelson, 1994). 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 (Etzkowitz, 2008).

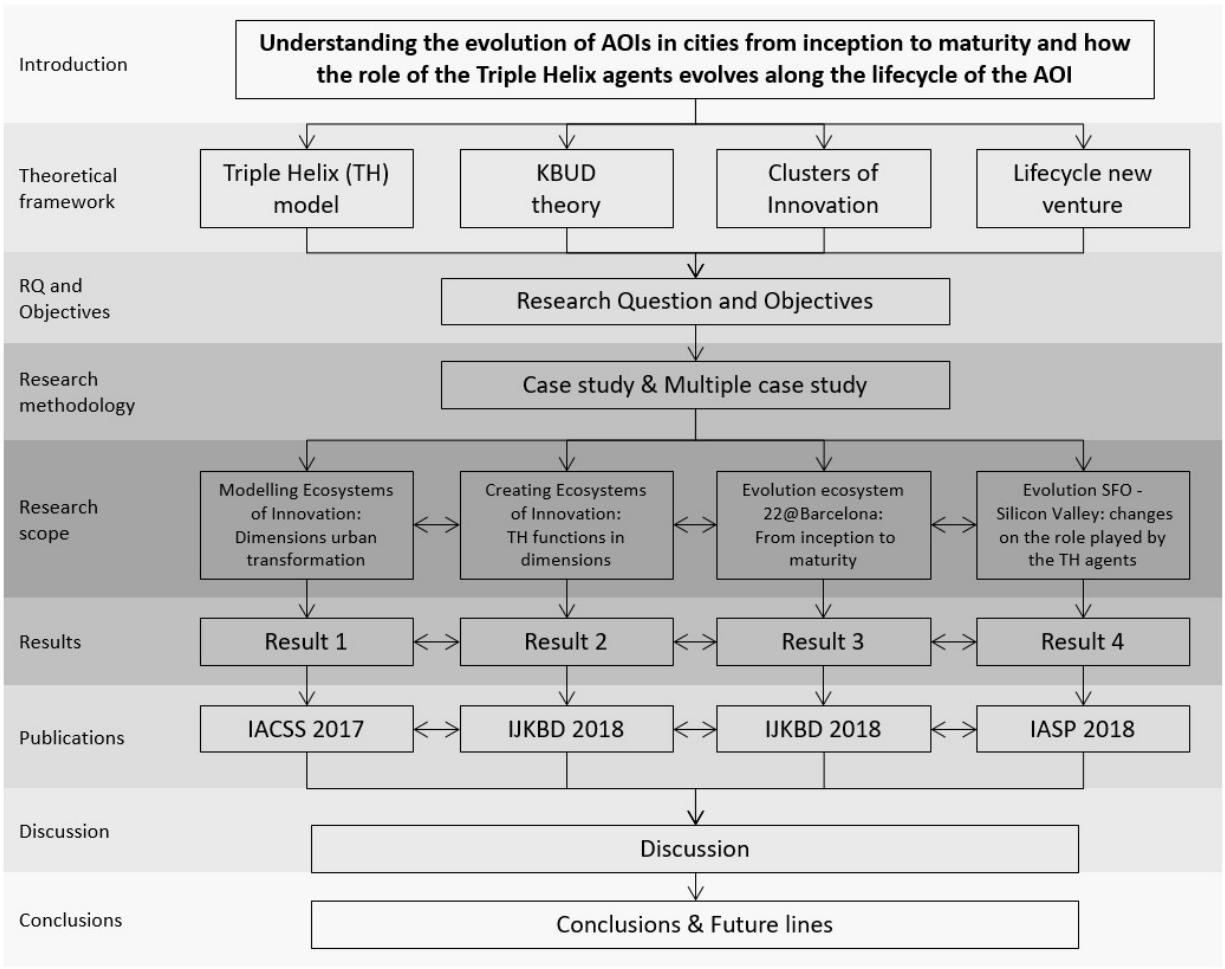
Each phase will require the contribution of the Triple Helix agents—universities, industry and government—for urban, economic and social development to take place. In terms of evolution, in every phase, this thesis aims at characterising the role played by each of the Triple Helix agents, and more importantly, how this contribution is shaping the subsequent phase, that is, boosting or hindering the evolution. The roles adopted by Triple Helix agents can change from phase to phase. Also, the functions of each of the agents 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.

3. RESEARCH STRATEGY

The research strategy follows this scheme: (1) justification of the research, (2) theoretical framework, (3) research questions and objectives, (4) research methodology, (5) research scope, (6) results and publications, (7) discussion and (8) conclusions and future lines. Figure 2 graphically illustrates this process.

Figure 2. Research scheme.



3.1. RESEARCH QUESTION

After the review of the literature, the research questions that emerged were:

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)?

3.2. RESEARCH OBJECTIVES

From the Triple Helix model (Etzkowitz and Leydesdorff, 2000; Carayannis and Campbell, 2009; (Carayannis, Barth and Campbell, 2012) we will analyse:

- The role of the university
- The role of the industry
- The role of the government
- The role of the society (Quadruple Helix)
- The role of the environment (Quintuple Helix)

From the Knowledge Based Urban Development paradigm (Sarimin and Yigitcanlar, 2012) we will analyse:

- Social and cultural development
- Economic development
- Environment and Urban development
- Governance development

From the Clusters of Innovation model (Engel and Del-Palacio, 2009) we will analyse:

- People
- Capital
- Technology

From the Lifecycle of a new venture (Freeman and Engel, 2007; Etzkowitz and Klofsten, 2005) applied to the evolution of an Area of Innovation we will analyse:

- Inception
- Launching
- Growing
- Maturity

3.3. RESEARCH SCOPE

This thesis as compendium of publications is divided in four main studies.

- The first study, *Modelling the Ecosystems of Innovation* (Pique and Miralles, 2017), is focused on a holistic model of Areas of Innovation in Cities, analysing the urban, economic, social and governance dimensions of urban revitalizations:
    - This study tries to give a response to Research Questions 1) and 2)

- The second study, *Urban Revitalization: Creating Ecosystems of Innovation* (Pique, Miralles, Teixeira et al., 2018b), is focused on the role of the Triple Helix agents (university, industry and government) in every dimension of the urban transformation:
    - This study proposes to answer Research Questions 1) and 2)
- The third study is focused on the *Evolution of ecosystems of innovation: the 22@Barcelona Case* (Pique, Miralles and Berbegal-Mirabent, 2018a):
    - This study provides an answer to Research Questions 1), 2) and 3)
- The forth study is focused on the *Evolution of San Francisco - Silicon Valley ecosystem* (Botey, Pique and Miralles, 2018):
    - This study answers Research Questions 1), 2) and 3)

Modelling the ecosystems of innovation

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 other cases, the 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 (Moulaert and Sekia, 2003; Padmore and Gibson 1998).

Yet, how can cities and urban environments promote the engagement and attachment of talented people in the nurture of the knowledge economy? 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.

This first study about *Modelling the Ecosystems of Innovation* (Pique and Miralles, 2017) has been submitted, accepted and published (Publication 1) in the proceedings of the *International Academic Conference on Social Science* (2017).

Urban revitalization: Creating ecosystems of innovation

The revitalization of cities impacts on the urban, economic, social and governance dimensions (Sarimin and Yigitcanlar, 2012; Nikina and Pique, 2016). In this context, Triple Helix agents (Etzkowitz and Leydesdorff, 2000) 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 (Katz and Wagner, 2014; Pancholi, Yigitcanlar and Guaralda, 2015). It also exemplifies how the Triple Helix agents can cooperate in the Urban Transformation (Etzkowitz, Sole and Pique, 2007; Pareja-Eastaway and Pique, 2014).

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.

This second study entitled *Urban revitalization: creating new ecosystems of innovation* (Pique, Miralles, Teixeira et al., 2018b) *has* been submitted and accepted (Publication 2) in the *International Journal of Knowledge-Based Urban Development* (2018).

Evolution of ecosystems of innovation: 22@Barcelona case

For the purpose of this study, a case-oriented research is used. Specifically, the 22@Barcelona 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 (Pareja-Eastaway and Pique, 2011; Cohendet et al. 2011; Casellas and Pallarès, 2010). 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.

This third study entitled as *Evolution of Ecosystems of Innovation: 22@Barcelona Case* (Pique, Miralles and Berbegal-Mirabent, 2018a) has been submitted and accepted (Publication 3) in the *International Journal of Knowledge-Based Urban Development* (2018).

Evolution of San Francisco-Silicon Valley ecosystem

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 research (fourth 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.

This study entitled as the *Evolution of San Francisco – Silicon Valley ecosystem* (Botey, Pique and Miralles, 2018) has been submitted and accepted (Publication 4) at the *XXXV IASP Word Conference on Science and Technology Parks* (2018). The full paper has been included in the proceedings of the conference.

3.4. RESEARCH MODEL AND METHODOLOGY

In the Foreword of the book "*Case Study Research: Design and Methods*" (Yin, 1984, p. 7), 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 (Yin, 1984), 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 but one of several ways of doing research in social sciences. Alternative methods might include experiments, surveys, histories, and the analysis of archival information. Each strategy has its advantages and disadvantages, depending on three conditions (Yin, 1984):

a) the type of research question
b) the control an investigator has over actual behavioural events
c) the focus on contemporary as opposed to historical phenomena

Case studies are the preferred strategy when "how" or "why" (Yin, 1984) 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. That's the situation of the 4 studies of this thesis.

As a research strategy, the case study is used in many situations to contribute to our knowledge of individual, group, organizational, social, political, and related phenomena. 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. In this thesis (1) several Areas of Innovation in cities have been analysed in the urban, economic, social and governance dimensions, (2) the role of organizations (universities, industry and government) have been studied in the dimensions and phases of the lifecycle of the Areas of Innovation.

The rationale for the book *Case Study Research* (Yin, 1984) is that case studies have been increasingly used as a research tool and provide the path to design and conduct single or multiple-case studies to investigate a research issue. In this thesis single and multiple-case studies have been analysed.

As a summary, for the purpose of this thesis (including the four different studies it comprises), the chosen methodology is the case study (and multiple-case study), as the main purpose is to analyse a specific set of cases that are relevant within the context of the study. A combination of both qualitative and quantitative information will be used.

4. MODELLING THE ECOSYSTEMS OF INNOVATION

As we announced, this research is divided into four main studies. Each study is presented in one chapter linked to each of the four publications of the Thesis for Compendium. Chapter 4 is focused on a holistic model of AOIs in cities, analysing the urban, economic, social and governance dimensions of urban revitalizations and is linked to Publication 1. Chapter 5 is focused on the role of the Triple Helix (university, government and industry) in every dimension of the urban transformation and is linked to Publication 2. Chapter 5 is focused on the evolution of ecosystems of innovation taking advantage of 22@Barcelona case and is linked to Publication 3. Chapter 6 is focused on the evolution the ecosystem of innovation of San Francisco - Silicon Valley and is linked to Publication 4.

4.1. GOAL

The creation of Areas of Innovation in cities have been a common tool for urban revitalisation. Innovation districts, scientific parks, urban clusters and smart cities have been applied in former urban industrial zones in need of regeneration (22@Barcelona case), and in other cases the projects are starting from scratch (Skolkovo case). This type of urban development needs a clear understanding of the dimensions of the transformation (urban, economic, social and governance). The top-down approach to this type of urban development requires a clear methodology and also a deep knowledge of the context and actors that participate along the process.

The aim of this study is to propose a holistic model for the development of Areas of Innovation in cities. Several factors are considered, aiming at investigating their effect on this type of development.

4.2. SPECIFIC CONTEXT

After the third wave of globalisation that took place in the 20th century, comparative (and competitive) advantages of cities and countries currently rely on new forms of production based on knowledge and talent. Rather than typical factor endowments associated with lower costs, countries—and particularly cities—aim to attract highly qualified people from all over the world at the same time as enhancing their own fertile soil through education and skills development.

The dichotomy between companies and people emerges as a key issue in the new economy. Unlike in the past, not just companies but also people and talent are critical elements for increasing economic growth. Therefore, ideas, creativity and, in summary, new inputs for the value chain becomes essential for the new arena of urban competition.

As a result, not only hard factors (infrastructures, transport, and connectivity, among others) typically involved in attracting companies, but also soft ones (atmosphere, leisure activities and tolerance, among others) are essential for attracting individuals, and turn traditional cities into nodes of the knowledge economy.

But, to what extent are those creative and talented workers involved in the production of new innovative processes and products? How can cities and urban environments promote the engagement and attachment of talented people in the nurture of the knowledge economy? It becomes 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.

Economic activity is necessarily associated with a particular geographic area. It is instrumental to locate innovation. However, a geographical area is more than just a business location. It is interaction space and residence, generating synergies between people, institutions and policies. In recent years, a growing interest has developed to know which mechanisms should be used to create innovation (Bélissent, 2010; Zygiaris, 2013). The approaches are diverse, ranging from academia to local agents who want to improve their capacity to generate high added value.

In this framework the International Association of Science Parks and Areas of Innovation (IASP), defines an "Areas of Innovation" as a place designed and curated to attract entrepreneurial-minded people, skilled talent, knowledge-intensive businesses and investments, by developing and combining a set of infrastructural, institutional, scientific, technological, educational and social assets, together with value added service, thus enhancing sustainable economic development and prosperity with and for the community.

4.3. STATE OF THE ART

Talent as a basis for the new economy

Among others, clustering of companies and technologies has been identified as one of the most effective strategies to group synergies and increase dynamism in the creation of economic value. However, these strategies do not work properly when talking about talent. As Cannon (2008, p. 40) points out, "*the clustering of talent—especially entrepreneurial talent and knowledge workers—is different. Talent moves because it can move and cluster because it makes sense especially if the connectivity advantages come into play*".

The enhancement of a specific area with the aim of creating innovation requires identifying a local context with the potential to embrace challenges and able to generate a new way to connect with the rest of the city. Awareness about the effectiveness of new tools for connectivity is vital to understand how talent can be attracted and retained. The capacity to transform the existing environment to attract companies and talent is a policy challenge: cities design development strategies and roadmaps towards innovation in certain districts in the light of other experiences. However, major strategic lines of action require a process of adaptation and validation for each context and specific situation. Transferring models does not guarantee the success of the intervention.

Cities tend to assemble talent from all over the world, benefiting from the interaction of different people, from different backgrounds and with different abilities in a single project or endeavour. The role of the city

is crucial in developing a particular image to appeal and hook knowledge workers. Following Pareja-Eastaway and Pique (2010, p. 185), we argue that "*there is a direct correlation between the ability of a city to gather highly skilled people and the region's potential for innovation and economic growth. Generating ideas and their processing as innovative tools applied to business does not depend on classical items of business location anymore: the very personality of the city becomes crucial in creating an attraction for certain groups that provide new capacities and growth potentials for the region*".

Science and technology parks have an important role in the knowledge economy. We are already witnessing the evolution of the traditional models into new ones, that is, the Areas of Innovation. This model was analysed by Luiz Sanz (2001) as 'Learning Village'. Three main elements were identified: (i) businesses, (ii) educational centres and (iii) residential areas. The three elements are still at the centre of the study, as they include the key concept behind AOIs: a place for working and living in the knowledge based economy and society.

Citizens as the fourth pillar (Quadruple Helix)

The definition and function of the Triple Helix thesis combines industry, government and universities in the same environment arguing their capacity to provide a framework for action of the knowledge-based economy (Etzkowitz and Leydesdorff, 1995). The Quadruple Helix adds the 'market' as a fourth element. In this sense, demand becomes a key factor for innovation development. Stakeholders can act separately or coordinate actions through the development of new knowledge, new economic sectors or regions (e.g., promoting innovation ecologies, players assuming the roles of others, and the creation of hybrid structures that allow permanent joint initiatives).

On the other hand, the importance of adequate educational facilities is crucial to ensure the production of talent in the area. The presence of both public and private schools of high quality—such as universities—ensures the availability of a highly-skilled workforce and attracts businesses to these places.

As mentioned above, the increase of global competition and cheaper sources of high-quality technological solutions means that companies can no longer rely on maintaining a competitive advantage based on 'traditional' drivers of price and quality. They must seek alternative sources of competitive advantage. Nowadays companies are undertaking major transformations in their innovation processes and business models in order to deliver more valuable products and services to the market. Open business models, a greater focus on understanding latent consumer needs, and more direct involvement of users in various stages of the innovation process are, among others, examples of these new strategies.

Several authors have acknowledged the need to develop a new model that includes the user perspective in innovation development (Yawson, 2009; Eriksson et al., 2005; Lundvall et al., 2002; Thomke and von Hippel, 2002; Schienstock and Hämäläinen, 2001). User-driven innovation is therefore seen as an essential success factor both for private firms and public sector organizations. Nowadays, the concept of "user-driver innovation" has shifted from a perspective where the consumer simply adds value to already existing products (developed by companies) to a different approach in which consumers are involved in the

production process during the process of product conception, development and market introduction (Wise and Hoegenhaven, 2008).

Besides direct consumer involvement in the creation of positive innovation externalities in the company or along the value chain, there are other side effects related to the user as an inextricable element of the demand side of the market. As Pique and Majo (2011) summarise, the creation of 'sophisticated demand' has clear benefits in at least four distinct areas: the city itself, its citizens, its business network, and its scientific and technological environment. Better products and services compel companies to include the core of innovation in new services and products in increasingly competitive environments.

Cities as the platform for the knowledge economy

Urban changes are constrained by global transformations that have changed patterns of production and renewal of the industrial economies. The urban space has been adapted to the dominant mode of production: the trading town, the industrial city or the Fordist city are good examples of this. The most recent change in the relationship between capitalist development and urbanization is associated with an increased post-Fordism, primarily related with the knowledge economy or the creative economy. The cognitive cultural capitalism (Scott, 2008) conceives a city based on neoliberal policies characterized by central business districts, elegant shopping and entertainment areas and revitalized port areas that meet the requirements for industrial renewal and, at the same time, attract talent and tourists to the city. This is the scene in which global competition and global flows of values pose new challenges for policy and governance in urban communities, increasing the intensity of innovation and postmodern cultural trends.

Economic globalisation has made local governments much more concerned than in the past about the global aspects of local economic development. In a sense, cities are becoming global networks of city-orientation with the strategic task of adjusting urban communities under the conditions of the global economy. Municipal governments can do so by increasing their competitiveness influencing the general context in which this competition between cities takes place. Local governments need to increase their capacity to govern and to design favourable governmental structures. Therefore, the creation of successful responses to the globalised interurban competition is essentially a problem of strategic positioning and governance (Anttiroiko, 2009).

The ability of cities to effectively attract external resources—particularly where high value-added activities are concerned—largely determines their position in the global urban hierarchy, which reflects and determines its overall appeal and capacity in the globalized environment. This reinforces the need for basic urban policies involving local people and capable of balancing development policies with the adoption of an integrated vision.

Ecosystems of innovation arise in this context as keystones in the global-local synthesis. They attract external resources, enhance existing ones and create favourable conditions for global competitiveness. Thus, in the processes of renewal and urban revitalization that claim to stimulate innovation, we see the

convergence of the improvement and upgrading of physical infrastructure on the one hand and, on the other hand, investment in human capital development and social improvement.

Cites are the place for creativity, innovation, and growth where organically talent finds economic opportunities (Florida, 2003). The creation of innovation districts has become usual tools and discourses associated to urban revitalization. Usually, it has been applied in former industrial neighbourhoods in need of regeneration (Pique and Pareja-Eastaway, 2013)

4.4. METHODOLOGY

For the purpose of this research we will use the case study method and analyse a specific set of cases (22@Barcelona and Skolkovo Technopark) that are relevant within the context of study.

22@Barcelona is a brownfield transformation case and Skolkovo Technopark is a greenfield transformation case. Both are members of the IASP (International Association of Science Parks and Areas of Innovation) and are 2 global references in size and results of the transformation. In order to understand the urban transformation, we analyse the 2 cases in the urban, economic, social and governance dimensions. A combination of both qualitative and quantitative data has been used for developing the Holistic Model of Areas of Innovation.

4.5. RESULTS

A holistic model of Areas of Innovation in cities

Urban regeneration involves the participation of the community, companies, institutions and policies to improve the quality of life of citizens. However, policies have focused on different aspects to renovate or renew, leading to different strategies—physical vs social regeneration—. Integral approaches to regeneration are meant to combine both physical intervention but also social policies in order to improve the quality of life of citizens (Roberts and Sykes, 2000). Later on, this focus has been predominant in the regeneration of cities and districts. An all-embedding intervention improving not only infrastructures or public spaces but also provisioned with intangible elements to the community to increase its quality of life have been implemented around.

Certain cities will offer a better set of attributes for businesses and economic activity than others; these simultaneously include tangible assets—in the form of easily measurable physical elements (i.e. highways, airports)—but also more abstract elements such as image, quality of governance and social and cultural features (Begg, 2002).

Infrastructures and urban development

The historical development of cities has a huge influence on their current situation. The association of a city to a determined economic profile does not emerge immediately. To a large extent, the past determines the present. Consecutive economic transformations inexorably leave their legacy in the territory.

The availability of good infrastructure and transport connections as well as centres of higher education, the availability of capital and labour with the necessary qualifications, together with an institutional context that favours the location of business through programs and specific actions such as fiscal exemptions or land at a below market price are the factors that have been traditionally considered as determinants for the economic location of business.

The opportunity to develop a smart city strategy for either green or brownfield districts is a strategic decision to include in the holistic approach.

Companies and economic development

Traditionally, huge importance has been given to the advantages of agglomeration economies, the economies of scale and clustering as promoters of economic growth. Industrial clusters have been analysed and identified as relevant players in the analysis of innovation and the definition of political support to industrial activity (Porter, 1990). Industrial clusters are defined as geographic concentrations of companies of the same sector or sectors related along the value chain that collaborate or compete and have also links with other factors (such as universities). According to Porter, clusters reflect a top-down approach to promote a certain region, which basically consists of grouping different stakeholders (universities, technology and research centres, business, management and financial resources both private and public) interested in working together in an economic sector.

Talent and social development

Talent and social development underline the importance given to providing the territory with specific equipment and urban attributes that appeal to people. Since talent has become the engine of the new economy—which is based on creativity and knowledge—aspects referring to the geographical territory have become more important than location factors for economic activity. Quality of life, ‘atmosphere’ and tolerance are just some of these elements that should be boosted.

Personal or professional networks—either implicit or explicit—become the connectors between stakeholders who participate in different parts of the economic activity. In fact, network factors are an alternative formulation to the classical location factors, closely related to the aspect of connectivity that offers a good provision of infrastructures. In addition, they also include those aspects that point out to the individual path of people and its attachment with the territory.

Governance

Areas of Innovation are created by a model of dynamic innovation based on the concept of the Triple Helix, which enhances the confluence of public administration, universities and companies in order to develop synergies between these strategic partners to increase the competitiveness of the production system and assist in the creation, growth and consolidation of employment. Collaborative relationships form the basis of the development of the Triple Helix. This interaction results from the synergies created in the territory among stakeholders rather than from a ‘prescription’ from the authorities. Furthermore, the different

stakeholders involved might assume different roles, providing opportunities for innovation. Vertical and horizontal governance are necessary to articulate clusters (strategic sectors) and the Areas of Innovation (holistic approach). The incorporation of citizens' needs and city challenges in the quadruple helix is another strategic decision to make when developing a governance model.

4.6. PUBLICATION 1

The results of this investigation were presented at a conference. The full reference is as follows:

> Pique, J. and Miralles, F. (2017) 'Areas of Innovation in cities: Holistic modelling of urban, economic and social transformation'. Proceedings of 6th *International Academic Conference on Social Sciences,* Barcelona, 27-28 July, pp. 9-13. ISBN: 978-9941-27-444-2.

5. URBAN REVITALIZATION: CREATING ECOSYSTEMS OF INNOVATION

5.1. GOAL

A new trend in urban projects has risen around a common problem: old urban spaces are losing most of their productive capabilities and becoming obsolete. In most cases, these spaces are revitalized by transforming them into knowledge based development areas. The aim of this study is to understand how these transformation projects are developed.

After reviewing the theoretical framework of the Triple Helix model and the Knowledge Based Urban Development, several Brazilian cities that are in the process of urban revitalization are examined. Specifically, four cases are scrutinized in this multiple-case study: the *Porto Digital* initiative, which performs an important role in the City of Recife's renewal; the *Porto Maravilha* project, already regarded as the major Rio de Janeiro Olympics legacy for revitalizing the port; the *4º Distrito*, which seeks to transform part of the old industrial region of Porto Alegre; and the *Centro Sapiens*, created to give the eastern sector of the historic centre of Florianópolis a new purpose. This research provides new evidence on how Brazilian cities are adapting the Triple Helix model, and developing the innovation districts adjusted to their realities.

5.2. SPECIFIC CONTEXT

In the recent decades, a new trend in urban projects has risen around a common problem: old urban spaces are losing most of their productive capabilities and becoming obsolete, and consequently, are being considered as ghettos of urban, social and environmental degradation (Roberts and Sykes, 2000). When such areas are subject to a series of actions that allow improvements in productivity, the emergence of a new purpose and value, and an improvement of the area and its surroundings, a process of urban transformation occurs (Katz and Wagner, 2014).

However, the revitalization of metropolitan areas is still a new issue and the scientific work describing such environments is mellowed by the existing literature: Knowledge Cities (Carrillo, 2006), Urban Knowledge Precincts (Yigitcanlar et al., 2008) and Knowledge Based Urban Development (Yigitcanlar et al., 2008a; Carrillo et al., 2014). Authors like Pareja-Eastaway and Pique (2011) propose that the urban revitalization concept should be understood as an act of developing strategies to promote an inclusive and integrative process, which spurs initiatives to reverse the physical degradation of urban spaces, improving the quality of the environment as a whole. This process may be considered as a way to face the challenge of development according to sustainability principles, valuing the local culture and, especially, the physical patrimony (Zancheti, 2006).

The urban transformation can take advantage on path dependency (Pareja-Eastaway el al., 2007) and should consider the potential of the existing patrimony, its accessibility, the symbolism of the urban areas, its

vacant spaces, its discontinuities, its internal limits to growth and to economic expansion. In addition, it is worth considering the expansion of popular conscience, the consolidation of community and environmental movements, as well as the emerging of a new paradigm of sustainable development (Del Rio, 2001).

The revitalization of cities affects urban, economic, social and governance dimensions (Sarimin and Yigitcanlar, 2012; Nikina and Pique, 2016). Triple Helix agents can play different roles in each dimension.

This study aims at better understanding the revitalization process of cities under the perspective of the Triple Helix model applied at urban development. To do so, analyse 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 added as a control case (Katz and Wagner, 2014; Pancholi, Yigitcanlar and Guaralda, 2015; Etzkowitz, Sole and Pique, 2007; Pareja-Eastaway and Pique, 2014).

The findings suggest that an extended perspective is necessary to understand knowledge based development initiatives in the revitalization of old urban areas. In addition to the Triple Helix model and the Knowledge Based Urban Development theory, a holistic approach, including local specificities and components from the society and environment related to the Quadruple and Quintuple Helix, is needed in order to design and implement these revitalization processes.

5.3. STATE OF THE ART

The connection of Urban Development of Cities and the Triple Helix is a field that has not been deeply analysed. Yet, some studies have loosely connected cities and Triple Helix. The Triple Helix model enables the study of the knowledge-based of an urban economy in terms of society support for the evolution of cities as key components of ecosystems of innovation (Leydesdorff and Deakin, 2011). Cities can be considered as densities in networks among relevant dynamics, as the intellectual capital of universities, the industry of wealth creation, and the participation of the society in the democratic government. The effects of these interactions can generate spaces and dynamics within cities where knowledge can also be exploited. The density of the relations among the three spheres—universities, government and industry—enables cities to crystallize in the form of innovative ecosystems.

This double approach—the Triple Helix model and the knowledge based urban transformation—has been previously used in the 22@Barcelona project (Pareja-Eastaway and Pique, 2011). For this reason, the 22@Barcelona will be used as a control case. Specifically, the 22@Barcelona is an archetype of a district of innovation (Pareja-Eastaway and Pique, 2011) as it has transformed the city through the participation of the Triple Helix agents combining urban, economic and social dimensions. Living spaces combine with working spaces, thus, creating value propositions for both talent and companies (Chica and Marmolejo, 2016).

For this study, we will take into account the role of the Triple Helix agents (universities, industry and government), the Quadruple Helix (social/market), the Quintuple Helix (environment) and its application in the urban, economic, social and governance transformation of the cities.

5.4. METHODOLOGY

This research adopts the form of a multiple case study (Yin, 1984; Godoy, 1995; Vergara, 2000), since (1) analyses "how" is the process of the revitalization of urban spaces, (2) the authors do not have control over the districts analysed, and (3) it is a contemporary phenomenon with real-life context. Data have been gathered from the websites that report the status of the above mentioned cities as well as from other official documents. Also, research and review articles on urban revitalization have been analysed and complemented with field interviews with the key stakeholders of each Brazilian project. This information has been then linked to urban, economic, social and governance transformation, identifying the roles of the Triple Helix agents.

The projects under analysis have been compared to 22@Barcelona innovation district, which according to several authors (Pareja-Eastaway and Pique, 2011; Katz and Wagner, 2014; Amaral, 2014) has transformed the old industrial neighbourhood of *Poblenou* into an innovative environment. All the Brazilian cases that have been chosen are districts in process of revitalization of urban areas: the *Porto Digital* (in the City of Recife), the *Porto Maravilha* (in the City of Rio de Janeiro), the *4º Distrito* (in the City of Porto Alegre) and the *Centro Sapiens* (in the City of Florianópolis).

5.5. RESULTS

This work contributes to the understanding on how knowledge-based initiative can help urban development projects. Two main literature research strands have been used to shed new light on this topic: the Triple Helix model and the Knowledge Based Urban Development theory. To this end, a multiple case study of four cities in Brazil has been performed (see Table 1 for a brief comparison of the cases). Additionally, the 22@Barcelona case has been used as a control case. All Brazilian cases have been described and compared to the 22@Barcelona project.

Table 1. Projects analysed.

	Porto Digital	***Porto Maravilha***	***4º Distrito***	***Centro Sapiens***	***22@Barcelona****
Launch year	2000	2009	2013	2015	2000
City	Recife	Rio de Janeiro	Porto Alegre	Florianópolis	Barcelona
Law	Lei Municipal 17.244/2006 (City Law) with 5 modifications	Lei Municipal Complementar nº 102/2009 (City Law)	Lei Municipal Complementar nº 785/2015 (City Law)	No. The law exempting the IPTU for start-ups is in process in the city	MPGM 22@Barcelona Urban Plan (2000)
Goals	Urban revitalization and development	Urban repurposing	Urban revitalization	To create an environment to foster enterprises and the creative economy	Urban regeneration
Coverage	149 hectares, encompassing the Old Recife historic neighbourhood and the Santo Amaro neighbourhood	5 million square meters by the Rio de Janeiro Port area	870,95 hectares all the *4º Distrito*. Around 100 hectares Distrito C.	The eastern portion of downtown Florianópolis. Encompasses 4,3 million square meters	200 hectares of Poblenou (Sant Martí District)

Source: Self-devised (*control case).

Relevant data referring to the 22@Barcelona is shown in Table 2.

Table 2. Quintuple Helix in urban, economic, social and governance dimensions at 22@Barcelona.

	University	**Government**	**Industry**	**Society**	**Environment**
Governance	Participation in clusters. Participation in 22@Network.	Promoting and participation in clusters. Promoting and participation in 22@Network.	Participation in clusters. Participation in 22@Network.	Transparency and participation of citizens.	Regulation clean infrastructures plan (Waste, Energy,Mobility, Water). Carbon footprint reduction policy.
Social	New young talent in the district Students' dorms. Open space and resources for social activities (Auditoriums, Libraries,...). Digital district program for neighbours.	Social housing policy. Schools and Public services. Vocations and professional orientation: Porta 22.	Living Lab: Space for pilots in the district Internships: staying in company. Welcome international talent: 22@Network.	Scalability of the pilot at the rest of the district and the city.	Waste management, Energy management, Public mobility and water uses.
Economic	Research and technology centre. Promotion of entrepreneurship. Providing talent.	Clusters policy. Promotion of the district and branding.	Clustering companies and institutions (ICT, Media, Health, Energy and Design). Activity of the big firms, SME and start-ups.	Living Lab: Space for pilots in the district with participation of the citizens.	Cluster on (clean) energy industries related to waste recycling, Water management, Energy efficiency and Public mobility.
Urban	New location of buildings in the district: UPF, UPC, UB. New university residences. Knowledge infrastructures.	New location in the district: Incubator Almogavers, OAE, Public bodies. Incentives for investment (22a ->22@). Infrastructures plan.	Location in the district: buildings for large firms, SME and new. Real estate developers. Utility companies.	Social housing. Pubic space (streets and plazas). Identity.	No pollution Activities. Creation of green areas (10% of 22@). Clean infrastructures.

The discussion of this work is sustained in the double perspective of the conceptual framework: the Triple Helix model and the Knowledge Based Urban Development theory. This double perspective allows explaining all cases of revitalization projects that have been considered. See Table 3 for a summary of the urban, economic, social, and governance dimensions, as well as the concepts that explain each of the dimensions for each city.

Table 3. Urban, economic, social and governance dimensions at the Brazilian cases.

	Recife	Rio de Janeiro	Porto Alegre	Florianopolis
Governance	*Núcleo de Gestão do Porto Digital*. With representation of Universities, Industry and the Local and Regional Government (Triple Helix).	Consorted Urban Operation (OUC) of the Rio de Janeiro Port region at the Special Urban Interest Area (AEIU). Coordinated by the City Council and its Offices, with the participation of local owners, residents, users and investors.	*UrbsNova* (a Social Innovation Agency). Non profit association with companies participation. There is not still an institutional Governance with the Local Government and Universities.	Local universities (UFSC, UDESC, IFSC), Non-profit Foundations (Sapiens Park and CERTI Foundation). Management committee with diverse activities in the ecosystem.
Social	No housing in the district. Amenities (Bars, Restaurants, Bookstores, Cinemas, Libraries). Leisure activities on Sunday.	Social Programs: Porto Maravilha Culture.	Relationship between artists, entrepreneurs and the social urban environment.	Program "*Viva a Cidade*".
Economic	SME Companies. Entrepreneurship and Innovation. Venture Capital.	Local Economy boosting. Creation of Jobs.	Science and Technology. Entrepreneurship and Innovation. Economic Conversion.	Entrepreneurs and investors. Co-creation Lab.
Urban	Urban revitalization. Recovering buildings and historic patrimony. Open Urban Laboratory.	Urban requalification. Attraction of real estate investments to build new residential, commercial and service units. Alteration of the traffic flow. Repurposing the areas informally occupied.	Urban requalification. Attraction of real estate investments to build new residential, commercial and service units. Recovering historic patrimony.	Urban revitalization. Recovering historic patrimony. Tax exemption for Real Estate. Reduction of Tax over services.

Table 4 summarizes the role of the Triple Helix in each Brazilian project. Additionally, to enrich the discussion, both the Quadruple and the Quintuple Helix model have been applied to the cities under analysis.

Table 4. Quintuple Helix at Brazilian cases.

	Recife	**Rio de Janeiro**	**Porto Alegre**	**Florianopolis**
University	Participation of C.E.S.A.R., Federal University of Pernambuco (UFPE) and SENAI.	No explicit participation of Universities.	Participation of PUC University and Federal University of Rio Grande do Sul (UFRGS).	Participation of Federal University of Santa Catarina (UFSC), Santa Catarina State University (UDESC) and Federal Institute of Santa Catarina (IFSC).
Government	Participation of Stage Government of Pernambuco and City Council of Recife.	Participation of City Council of Rio de Janeiro, State of Rio de Janeiro and Federal Government of Brazil.	Participation of the City Council of Porto Alegre.	Participation of City Council of Florianopolis Participation of Non-profit Foundations (Sapiens Park and CERTI Foundation).
Industry	FOCUS; Knowledge and Innovation, Creative economy. Digital and Media.	FOCUS: Urban repurposing as an incentive to innovation.	FOCUS: Creative economy, knowledge economy, experience economy, Education, Health.	FOCUS: Creative economy.
Society	Participation of the citizens in the Open Urban Lab.	Neighbourhood impact assessment improving the existing residential units.	Participation of the society with URBSNOVA.	Urban traits - Urban culture of the city.
Environment	No explicit involvement of Environmental Sustainability.			

In the case of 22@Barcelona, as a Control Case, we had clear evidences in all the dimensions about the role of the environment as a challenge:

- Governance: Regulation clean infrastructures plan (Waste, Energy, Mobility, Water). Carbon footprint reduction policy.
- Social: Waste management, Energy management, Public mobility and water uses.
- Economic: Cluster on (clean) energy, industries related to waste recycling, Water management,
- Energy efficiency and Public mobility
- Urban: No pollution Activities. Creation of green areas (10% of 22@). Clean infrastructures.

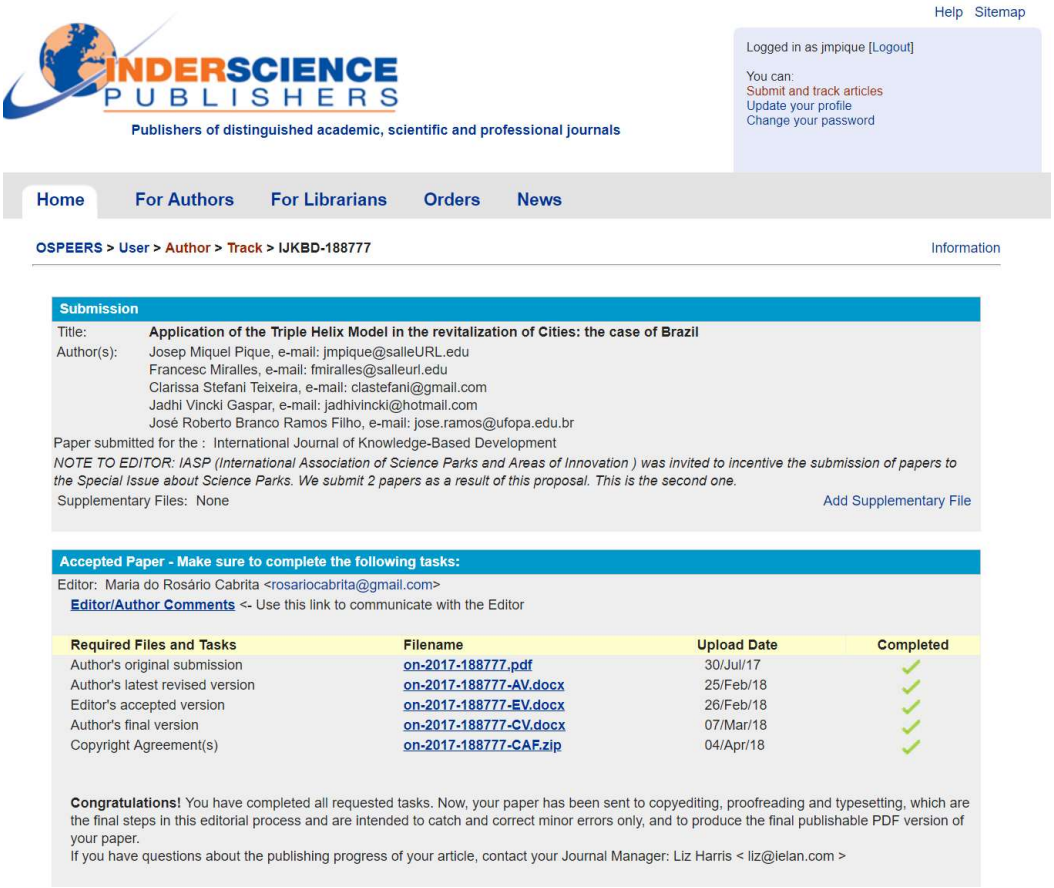
In the analysis of the Brazilian cases (see Pique et al., 2018b), we did not find any evidence about strategies related with the environment.

5.6. PUBLICATION 2

This study has been accepted for publication in the International Journal of Knowledge-Based Development. As it can be seen in Figure 3, the paper is now under the publication process. For the full reference, refer to:

> Pique, J.M., Miralles, F., Teixeira, C.S., Gaspar, J.V. and Ramos Filho, J.R.B. (2018b) 'Application of the Triple Helix Model in the revitalization of Cities: The case of Brazil'. *International Journal of Knowledge-Based Development,* in press.

Figure 3. Screenshot of the online platform of IJKBD journal.



6. EVOLUTION OF ECOSYSTEMS OF INNOVATION: THE 22@BARCELONA CASE

6.1. GOAL

Areas of Innovation (AOIs) are on the agenda of urban planners in the revitalization of inner cities. The knowledge-based economy provides the opportunity to base these revitalization efforts in creating AOIs as an evolution of the old industrial districts. Although many theoretical insights have been proposed to understand different perspectives of this process, there is a lack of a comprehensive model that describes the evolution steps this process entails.

Grounded in some of the most widely spread conceptual frameworks in this research field—Triple Helix model, Knowledge Based Urban Development paradigm, Clusters of Innovation framework, co-evolutionary theory, Learning Region theory and lifecycle of a new venture—as a reference, this work contributes to the existing literature by proposing a comprehensive model that maps the evolution of AOIs. The proposed model integrates previous theoretical insights that have been used to study the revitalization of inner cities with an evolutionary perspective.

Using a case study approach, this work focuses on the 22@Barcelona case—an AOI that transformed an old industrial district into a knowledge-based one—to examine how AOIs evolve and based on this, elaborate a more general model.

The academic value of this work stems from shedding new light on a new perspective for theorizing the evolution of AOIs from inception to maturity. Urban planners can benefit from this work by getting additional clues about the planning revitalization efforts in inner cities.

6.2. SPECIFIC CONTEXT

Although the Triple Helix approach has been examined from multiple perspectives, scholars are still searching for new frameworks that shed some light on how ecosystems of innovation evolve. Thus, by exploring other conceptual frameworks such Knowledge Based Urban Development, Clusters of Innovation, co-evolutionary theory, Learning Region theory and lifecycle of a new venture, the aim of this study is to provide new insights about the evolution process of innovative ecosystems, that is, the steps cities need to follow in order to move from a traditional science parks and become an AOI.

This research benefits from the results of past studies dealing with cluster organizations (see e.g. Porter 1990, 1998) and with the location of knowledge-based clusters in the inner cities (see e.g. Porter, 1997; Leibovitz, 2004; Gospodini, 2006). Recently, some scholars have also considered the artistic, cultural and social lens when studying this topic. The natural consequence is the rise of a different but related literature on creative cities (see e.g. Scott, 2000, 2006; Lazzeretti and Nencioni, 2005), industrial districts (Becattini,

1986, 1990), knowledge cities (see e.g. O'Mara, 2005), Knowledge Based Urban Developments (Carrillo et al., 2014) and innovation districts (Katz and Wagner, 2014).

6.3. STATE OF THE ART

During the last twenty years many studies have analysed how cities are adapting to the global economy. Ranging from general overviews of development and organization of inner cities (Sassen, 1991, 1998, 2002; Knight, 1995; Gospodini, 2006) to more specific subjects such as gentrification effects (Atkinson, 2004), sustainable development (Hall, 1997), urban environment and health (McMichael, 2000), urban regeneration policies (Marcotullio, 2003; Atkinson, 2004; Thomson et al., 2006), and cities' competitiveness (Brotchie et al., 1995; Jensen-Butler et al., 1997; Lever, 1999; Strambach, 2002), among others. Special attention has been paid to the development of the new economy in the inner cities (Hutton, 2000, 2004), urban knowledge parks (Bugliarello, 2004), creative and knowledge cities (Lever, 2002; Florida, 2003; Costa et al., 2008; Pratt, 2008) and knowledge based urban developments (Carrillo et al., 2014).

New cities hardly retain any of their former traditional, local and static nature (Porter, 1995). In the inner cities, clusters of interlinked firms and organizations operate at world-class levels of competitiveness (Porter, 1998). Companies take advantage of social agglomeration factors such as critical masses of skills and relationships, access to information, and the availability of specific infrastructure in a given field (Utterback and Afuah, 1998; Hutton, 2004; Porter, 1995). As a result of agglomeration effects, new economy metropolitan clusters comprise not just isolated firms but rather substantial ensembles of dynamic industries (Hutton, 2004) that have been transformed into urban science parks or AOIs (Luger and Goldstein, 1991; Massey, Quintas and Wield, 1992).

Increasingly, knowledge-based and technology-intensive industries are substituting old industrial—and, in some cases, even residential—districts in large urban agglomerations (Hutton, 2004). As clustering forces drive talented, innovative and creative people to concentrate in the most knowledge-intensive cities and regions (Florida, 2008), the trend of the new economy is to attract the talent by promoting the creation of new economy metropolitan clusters (Chica and Marmolejo, 2016) that set up "new" versions of traditional science parks. The survival of such cluster will require specific policies to retain talent (Bontje, Musterd and Sleutjes, 2017).

These new science parks—innovative milieus in inner cities—combine technology, including computer graphics and imaging, software design, multimedia industries and graphic design industries that have been deeply influenced by technological development. Culture is represented by creative human capital and design functions (Hutton, 2004).

6.4. METHODOLOGY

For the purpose of this study, a case-oriented research was conducted. The focus was on the case of 22@Barcelona, an example of a sound effort in building an AOI promoted in the metropolitan area of Barcelona and that flourished from a traditional science park regenerated into an inner district of the city.

Complementary cases as the Boston's Innovation District, *Porto Digital* in Recife, *Yachay* in Ecuador, Skolkovo in Moscow, the *Quartier de l'Innovation* in Montreal and Kendall Square in Cambridge (MA) have been used to complement the insights obtained from the 22@Barcelona case. All these projects are promoting AOIs that develop the knowledge-based economy and combine working with living spaces (Yigitcanlar, Velibeyoglu and Martinez-Fernandez, 2008). To do so, their transformation is multidimensional (environmental, economic and social) and combine hard with soft factors (Esmaeilpoorarabi, Yigitcanlar and Guaralda, 2016).

This research provides a new perspective for AOIs in cities. The key learning is that during the evolution process of AOIs, Triple Helix agents play different roles in the dimensions of the transformation (urban, economic, social and governance) and co-evolve in the phases of lifecycle (inception, launching, growing and maturity).

6.5. RESULTS

Proposing a lifecycle approach for Areas of Innovation

An AOI needs urban, economic and social transformation. This transformation results from various contributions from universities, the industry and the government, and needs to be analysed from its inception to its mature stage (Pancholi, Yigitcanlar and Guaralda, 2015).

Taking as a simile the lifecycle of a new venture (Freeman and Engel, 2007) and based on the cases analysed, this section describes this transformation process, exploring in an individual fashion the different stages of development of an AOI: inception, launch, growth and maturity (Table 5). By adopting this approach, it is also possible to map the role and relevance of the Triple Helix agents (Table 5, first row) at each stage. It also allows for describing the evolution of an AOI in its different dimensions (urban, economic and social).

Our findings reveal that at each stage, it is of paramount importance to align hard and also soft factors in order to contribute to the mobility of the key resources—people, technology and capital (Engel and Del-Palacio, 2009)—. Implications are discussed in terms of location decisions and the urban transformation of the region.

Table 5. Lifecycle of Areas of Innovation.

	Definition	**Launching**	**Growth**	**Maturity**
Triple Helix configuration*				
Key role	Government and Universities.	Adding tractor companies.	Assignment of leadership in business associations and clusters.	Explicit leadership from companies, talent and related networks.
Talent and social transformation	Promoters.	Managers of the AOI.	Communities and networks.	International networks. Local social networks.
Companies and economic transformation	Involvement of Key Institutions: Universities, Government and Associations of Companies.	Tractor Companies. Location of research and technology centres. Incubation and landing services.	Attraction of companies. Creation of companies Clusterization. Open innovation Management.	Growth models. Decentralization and internationalisation. Super clusters. Megaregions. Network of networks of research and innovation.
Infrastructures and urban transformation	Planning.	Utilities. Consulting. Real estate Developers.	Investors. Real estate. Developers.	Territorial growth. Exporting the model.

* The blue circle denotes the government. In grey, universities and research centres. Lastly, industry and firms are shown in green. The size of the circles denotes the relevance of the different agents at that particular stage.

Inception

From an institutional perspective, the enhancement of a specific area with the aim of creating an urban innovation ecosystem requires identifying a local context that ensures that talent, technology and capital will be able to loosely flow (Etzkowitz and Leydesdorff, 2000). The location should also act as a space for interaction and residence. Nevertheless, each region shows specific identity features, such as culture, a distinctive educational system or a specific knowledge transfer policy, which shape the development of the region and determine its own learning capabilities (Doloreux, 2002). The transformation of the existing environment into an AOI is thus a complex issue.

In the definition stage, major strategic decisions on where to settle the innovation ecosystem are taken. Once the location is chosen, a feasibility study of urban, economic and social development is critical in order to evaluate the economic viability of the project. Given the idiosyncrasies of each region, the conceptualization of AOIs and the form they might adopt differ from one case to another. Because of these differences, it is difficult to converge on a homogenous policy design. Nevertheless, from the study of current examples, it is possible to identify two opposed creation strategies. Differences lie in the desire to create something new or to exploit something already existing by undertaking a formalization process. Accordingly, we distinguish between directed (inorganic) and spontaneous (organic) planning strategies.

The directed planning strategy evidences a deliberate creation scheme for concentrating innovative activities. Urban or metropolitan planned actions are driven towards bringing together highly valued activities through infrastructure planning, usually guided by the intervention of industrial policy. The underlying idea is to create something new from scratch in an attempt to provide the territory with a more dynamic environment. The 22@ district in Barcelona, the Boston's Innovation District, and Porto Digital in Recife illustrate this strategy (Nikina and Pique, 2016). Powered by local authorities, these districts were originally industrial areas that had traditionally been very active, but over the years had been abandoned (brownfields). Aiming at creating value-added activities that boost the economic dynamism of the city, local authorities drove a transformation process that entailed an entire re-make and reinvention of underexploited infrastructures and spaces, giving them a completely different purpose and usage. Other projects following this strategy are Yachay in Ecuador and Skolkovo in Moscow (Nikina and Pique, 2016), which started new developments of AOIs from greenfields.

On the contrary, the spontaneous planning strategy is the result of an unplanned spatial concentration of innovative activity originated by the sum of independent initiatives coming from actors located in a particular area under the umbrella of anchor institutions. In this case, the AOI is created as a result of institutionalizing an endogenous dynamic environment that has organically emerged. While at the beginning basic services are provided for the coverage of the daily activities, as the movement of resources (people, technology and capital) increases, there is a need for urbanizing the environment and providing the place with the appropriate spaces and infrastructures that transform the area into a living lab, including housing and real state opportunities, as well as recreation services. Aiming at improving the externalities and the interrelations between the different stakeholders located in the same geographical enclave, the AOI is then formalized. The Silicon Valley and the *Quartier de l'Innovation* in Montreal are perhaps the most iconic examples of this strategy.

In the case of 22@Barcelona, the City Council was the main stakeholders for defining and promoting the district (directed planned strategy). An urban plan defined the urban uses of the land, promoting a mix of activities for working and living. Also, a 22@ special infrastructures plan was included, defining the quality of the public services.

Launching

The planning of the land and the development of basic infrastructure lay the foundations for the installation of the first tenants. Anchor institutions such as universities, hospitals, or major corporations adopt a leading role, acting as innovation catalysts, particularly, in the launching stage. Anchor institutions are envisioned as important providers of knowledge and expertise. As such, they cluster and connect with start-ups, business incubators, and accelerators, in the pursuit of an innovation ecosystem that aligns research interests with business needs and social welfare. A good example of an AOI that has been built around anchor institutions is the Kendall Square in Cambridge (with the Massachusetts Institute of Technology and the Mass General Hospital acting as anchor institutions) (Nikina and Pique, 2016).

Anchor institutions are necessary but not sufficient. At this stage, the innovation community needs to make use of its own resources, leverage core competencies, interact with similar communities, and experiment innovation by taking risks and a global perspective. Such an agenda of intentions helps develop the behaviours that would create value and enhance the innovation potential of the area. A top-down government and institutional action combined with a bottom-up emergent performance of entrepreneurs and investors can help in building the structures that enable such a culture of collaboration.

Alongside with reference buildings and incubators, housing and the social dimension must be considered to retain talent and attract investments. An AOI should have a well-defined physical personality and stimulate work and social environments. The historical development of the city may have a huge influence at this stage. The acceptance of a specific growth model neither emerges nor is fully implemented immediately. Consecutive economic transformations inexorably leave their legacy in the territory. Therefore, economic, social and institutional path dependency hinders or boosts the development of an AOI.

In the case of 22@, real estate developers and utilities were attracted. The first anchor companies and institutions were settled and the 22@Barcelona agency was created for managing the transformation. Likewise, incubators were created to boost the creation of new start-ups.

Growth

This stage incorporates all the elements of the ecology of innovation, and mainly focuses on attracting businesses and investors, creating new ventures, and promoting business clustering and networking. At this stage, the AOI is well developed in urban planning and the infrastructures are implemented. The challenge is to attract on the one hand real estate investors that will build buildings for allowing the landing of the future tenants, and on the other hand stimulate companies to choose the AOI as the right place to be for growing.

In parallel, it is also paramount to create a new generation of start-ups, offering them facilities and special programs to grow. Entrepreneurial competitions focused on the AOI's sectors, training programs, networking and specialized investment will be the magnet for attracting young talent.

The cluster strategy will need appropriate governance. The establishment of public-private-partnership (PPP) platforms aggregating universities, industry and government working together in common projects and promoting the best synergies between big corporations and new entrepreneurs and investors is a key step before the maturity process. In the case of 22@Barcelona, a cluster strategy was developed, promoting the clusters of IT, media, tech-media, clean energy and design. For each cluster, a PPP was created in order to manage the vertical clusters.

Horizontal links are also necessary, connecting professionals and companies in a transversal way and allowing a better integration of the international talent and the new companies located in the area. In the 22@Barcelona case, the 22@Network was created to promote these interactions and foster the engagement of the companies in the district with the project.

Maturity

This stage focuses all its efforts on the development of activities that maximize the ecology of innovation and the connection with other international hubs of innovation. The global connections will be the key expression of the maturity of the AOI.

Following the Global Networks of COI framework (Engel and Del-Palacio, 2009) the adoption of a global perspective serves to enlarge the economies of scale. Mobility and unbundled interactions with other AOIs contribute to cross-fertilization and give firms a global advantage based on orchestrating diverse networks to exploit new opportunities and gain access to international assets and resources. These connections are created by mobile people and their personal relationships, which create linkages (weak ties, durable bonds and covalent bonds) that allow for the formal and informal exchanges of value. Because of these international connections, at this stage the AOI expands geographically to neighbouring areas. It might also become an international reference model for other areas.

In the social sphere, there is a clear focus on the integration of the international community installed in the area. The AOI assumes the leadership in talent management, particularly in attracting and retaining international talent combined with actions to specifically create and develop local talent.

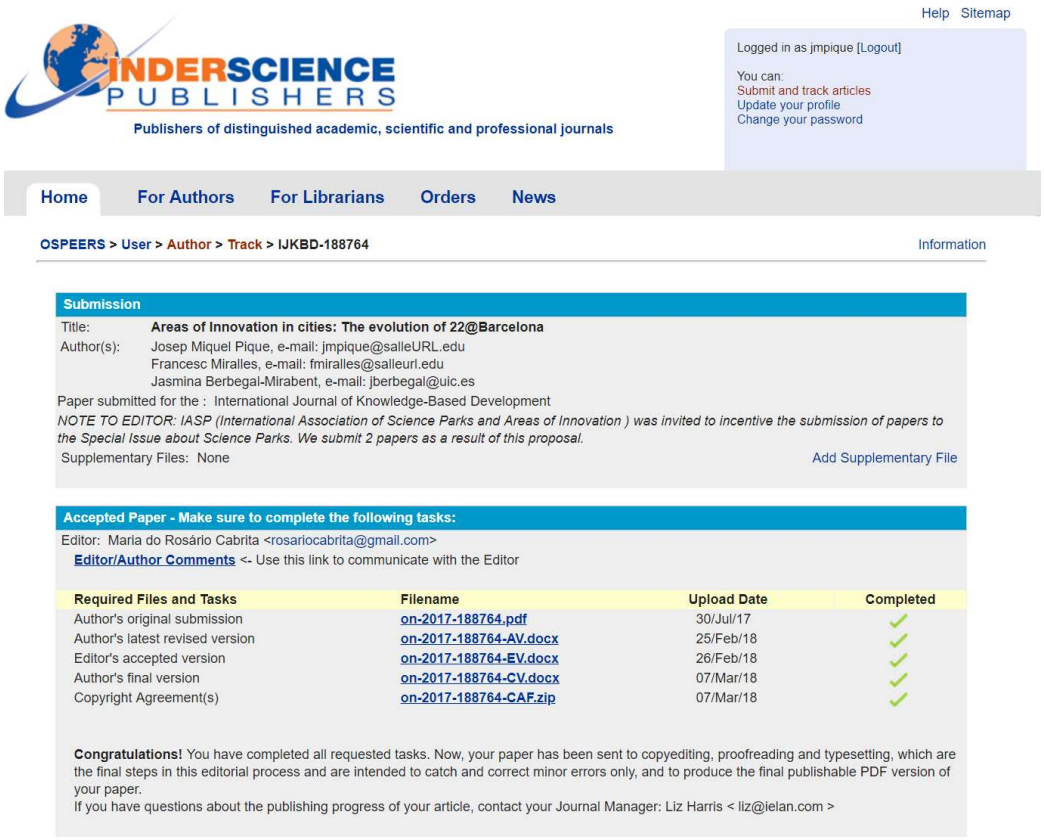
The mobility of technology, capital and people inside an AOI and with other external AOIs is exemplified with the case of the Israel/Silicon Valley Super Cluster of Innovation (Engel and Del-Palacio, 2011). For the specific case of 22@, global alliances were created, including partnerships with the IASP, the European Network of Living Labs (ENOLL) and the Global Network of Clusters (TCI). 22@ has also started exporting its model to other districts of the city and other cities such as Medellin.

6.6. PUBLICATION 3

This work has been accepted to be published in the International Journal of Knowledge-Based Development. Figure 4 proves this. The full reference is as follows:

> Pique, J.M., Miralles, F. and Berbegal-Mirabent, J. (2018a) 'Areas of Innovation in Cities: The evolution of 22@Barcelona'. *International Journal of Knowledge-Based Development,* in press.

Figure 4. Screenshot of the online platform of IJKBD journal.



7. EVOLUTION OF SAN FRANCISCO-SILICON VALLEY ECOSYSTEM

7.1. GOAL

Silicon Valley innovation ecosystem keeps finding ways to improve and become more efficient. This study aims to understand *how* and *why* Silicon Valley evolves by identifying changes on the role played by the Triple Helix agents. Two points of time are compared: 2006 and 2016. We also aim to identify if changes in one of the agents triggers the evolution of the others.

Considering start-ups as the unit of analysis (the recipients of all the changes occurring in the innovation ecosystem), we posit that Triple Helix agents change have a different impact at each stage of start-ups' development process. Also, we argue that over time (2006 compared to 2016) the role played by the different agents at each stage has also experienced significant changes. Interviews with key informants validate our initial intuitions. The overarching conclusion is that not only the role of the Triple Helix agents evolves over time, but also does so the innovative ecosystem.

7.2. SPECIFIC CONTEXT

Silicon Valley innovation ecosystem has been analysed in numerous studies, papers and articles for years. This highly successful entrepreneurial region is the main reference for those—mainly governments but also universities and private institutions—willing to re-create a "Silicon Valley" in their homelands. Even though other ecosystems of innovation are trying to catch up, Silicon Valley always seems to be one step ahead. While it has been observed that weak-entrepreneurial ecosystems evolve—mainly in response to government incentives, regulations or funds—the evolution of strong-entrepreneurial ecosystems, such as Silicon Valley, and its effects to start-ups remains under investigated.

This work explores the evolution of Silicon Valley from 2006 to 2016 focusing on the effects that these potential changes have had in the start-ups. As a guide and baseline for this research, the information collected in 2006-07 by Del-Palacio (2009) will be used. In her study, Del-Palacio interviewed founders and CEOs to gather detailed data related to the support provided by the Triple Helix agents in each stage of the start-up development process in Silicon Valley.

Following her model, in this study six founders and ten key experts were interviewed to identify the main changes in the role of the Triple Helix agents and investigate if changes in one agent are linked to changes in the other ones.

The results of this research are expected to serve as a guideline for cities (or any other type of ecosystems of innovation) to evaluate their initiatives aimed at promoting technology entrepreneurship and at better responding to the changing needs of entrepreneurs and markets. Instead of copying what Silicon Valley

does now, other ecosystems should look at the different stages Silicon Valley has gone through and identify which practices may apply to each context based on its stage of development.

From 2006 to 2016 many changes occurred in Silicon Valley. Facebook opened to everyone older than 13 years old in 2006 and Apple launched the first iPhone in 2007 which is considered the start of the digitalization era. By 2009, Dropbox and Airbnb were already operating after being accelerated at YCombinator. That same year, Google Ventures and Uber were funded. In 2012, while Facebook was filling its IPO, San Francisco started to see the benefits of the Payroll Tax Exclusion launched in 2011 to redevelop the Central Market Street & Tenderloin areas when Twitter—that had recently raised $400M—decided to keep its office in the city. While all these were happening, what were Silicon Valley universities, government and industry doing to secure a new hype of successful entrepreneurs?

The theoretical foundations for this study are found on three widely accepted models: the Triple Helix model (Etzkowitz and Leydesdorff, 2000), the general business development model which divides the start-up process into four stages: inception, launch, growth and maturity (Freeman and Engel, 2007), and the Clusters of Innovation framework by Engel and Del-Palacio (2009).

The study has two main parts. In the first part—qualitative approach—we characterize our analysis as a case-study research. Next, the research questions are listed and the hypotheses are set forth. Then, we define the units of analysis and the variables, and explain how the interviews were conducted and how information was processed. The results of these interviews include the analysis assessing the role played by the government, the university and the industry in each stage of development. The second part—quantitative approach—focuses on identifying the current actions and activities performed by the Triple Helix agents. This analysis allows us to validate the findings on the qualitative approach. Specifically, we identified and compared the incentives (for public administration), type and source of investments (for industry) and new programs (for universities) established after 2006. We also considered other facts such as population, employment, housing or commute to better understand the region.

Finally, the findings are presented and compared to the ones in 2006. The results are presented in two forms: the changes and movements of the three agents of the Triple Helix compared to their roles in 2006, and a graphical illustration to better visualize the relative support of the three agents at each stage of business development (also compared to 2006).

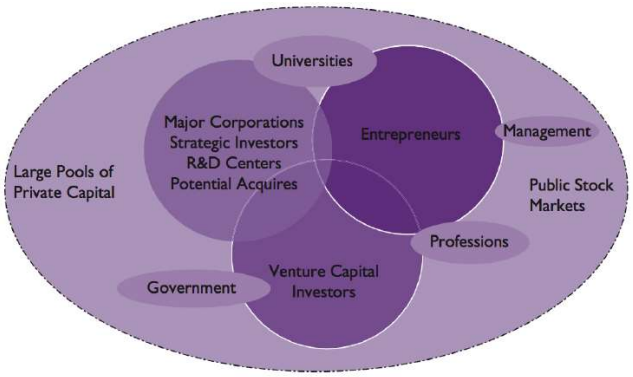
7.3. STATE OF THE ART

Following the model Del-Palacio (2009), this research is based on the same fundamental theories: the Triple Helix model and the theory of Clusters of Innovation. In addition, we introduce some general aspects related to the business development process and the investment stages related to each one (Freeman and Engel, 2007). This model helps to easily determine the development stage of the start-ups analysed in the qualitative approach. The following pages deal with the analysis of the COI components for the particular case of Silicon Valley and the different stages of investment and firm development.

COI components in Silicon Valley

According to Engel and Del-Palacio (2009), the key components that characterise a COI are (see Figure 5): entrepreneurs, venture capital investors, mature corporations and strategic investors, universities, government, R&D centres, and specialized service providers and management.

Figure 5. The innovation engine of Clusters of Innovation.



Source: Engel (2014)

For the specific case of Silicon Valley (Engel, 2015) these components materialise as follows:

Universities: In the early 1900s, the University of California at Berkeley, UC San Francisco and Stanford University—initially focused in practical disciplines such as agriculture, mining and mechanics—expanded to integrate business and education. Through their collaboration with private industry, the universities helped early high-tech firms flourish. Stanford Industrial Park (now Stanford Research Park) is an example of this strong collaboration with large corporations such as General Electric, IBM, Eastman Kodak, Lockheed, Varian, and Hewlett-Packard.

Government: The long-term US government spending in Silicon Valley can be considered crucial in the early development of the Silicon Valley. Since World War II the US military research programs, funded engineering efforts in universities (electronics at Stanford and high energy physics at UC Berkeley), national government laboratories, and private firms in Silicon Valley. The Bayh–Dole Act in 1980 changed the ownership of commercialization rights unlocking potential opportunities for universities, entrepreneurs and investors and starting a new wave of commercialization of government research.

Entrepreneurs: Silicon Valley workforce is not only highly educated but extremely innovative and entrepreneurial. Silicon Valley entrepreneurs seek big scale opportunities and are willing to use high price capital to unlock their potential. Start-ups, and the entrepreneurs that drive them, are often highlighted in popular culture, becoming cultural icons (Freeman and Engel, 2007).

Venture capital: Since their appearance after the first Silicon Valley based start-ups IPOs in 1956-58 (Varian, Hewlett-Packard and Ampex), venture capital investors have played a critical role in the inception and rapid growth of new ventures taking active involvement in governance, recruiting and compensation policies.

Mature corporations: Collaborations between mature corporations and start-ups can take many forms, from agreements to investments, partnerships, or acquisitions. Silicon Valley corporations take full advantage of their past as start-ups engaging early with new ventures.

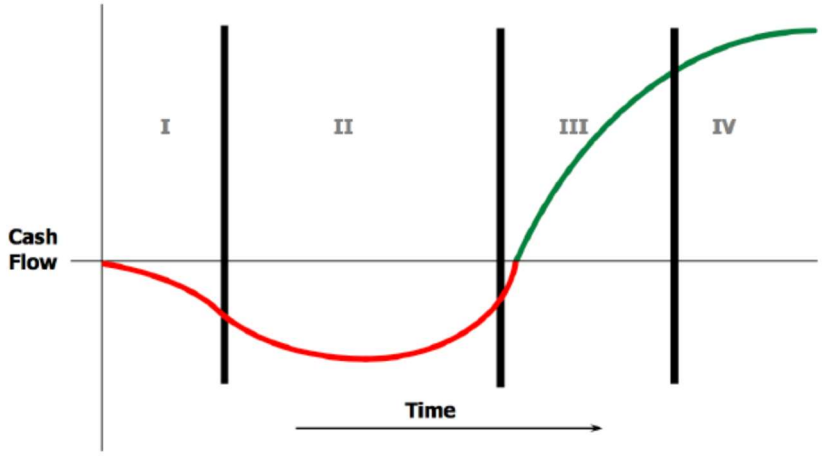
Industrial research centres: The growth of Silicon Valley also attracted a broad spectrum of research centres, from federally funded research labs (Lawrence Berkeley or Stanford Linear Accelerator), to R&D private centres (IBM, Xerox, Samsung or more recently Walmart or Baidu) and independent R&D centres, which spun out of universities such as the Stanford Research Institute (SRI). This tendency keeps providing the Valley with top technical talent and technologies.

Service providers and management: Lawyers, accountants, design professionals, recruiting firms, investment bankers, incubators and accelerators provide tailored professional services, while discounting or deferring their fees in exchange for a small share in the venture's eventual returns.

The entrepreneurial venture: Periods of development

As a company grows, it evolves and qualitative changes are typically observed in its internal organization. Companies' development is determined by financial events and the requirements or milestones needed to move to the next financial round. Start-ups are financed through a series of staged investments where each stage of investment is designed to carry the venture to a higher level of achievement and validation (Freeman and Engel, 2007). Staged investments help investors minimize risk while increasing the valuation of the firm. Figure 6 illustrates these stages. Moving from one stage to another one implies not only a great deal of good luck but much hard work on the part of entrepreneurs and investors alike. The scales for both dimensions vary substantially across industries, business models, and organizational forms. The vertical dashed lines represent notable financial milestones. These milestone drive changes in the organizational structure and management activities.

Figure 6. Evolution of the entrepreneurial venture.



Source: Engel, from "The Innovative Organisation" session held in June, 2017, Berkeley, CA.

- The *inception or pure entrepreneurship* stage (I), starts with a small founding event, which commits the founders' efforts to build a new business organization. During/prior to this time, start-ups tend

to be organic in structure, leadership resides with the inventors, business plans are developed, and resources are gathered. The search for capital occupies a substantial portion of the founders' time. The fund is used to define the concept, build the team, determine the customers, analyse competitors and build prototypes. The period ends when prototype versions of the product or service are sold to customers, generating income.

- The second period, called *launch* or *strategic focus* (II) commences when the company begins to generate revenues from sales. The team grows and focuses on improving the product/service based on customers' feedback. Start-ups seek its first round of institutional investment at this point. During this period, with the venture capitalist investment, organizational routines are developed and formalized, a board of directors is created, and an experienced management team is hired. All these actions lead to a dilutive effect on the equity position of the founders, often resisting loss of control and shifting from creativity to discipline. With continued success, product designs are finalized, marketing and sales efforts expanded, and business systems developed. As this process accelerates, cash flows turn positive at the end of this period.
- Once the scalability of the product is validated, the next step is the *growth* or the "*building of the systems*" (III). At this point the company is able to successfully compete with older rivals. This is a period of structural development, managerial skill expansion, and organizational routines. Stable relations with suppliers and customers are established while resources grow. Access to capital is required to fuel a continued and rapid growth, allowing the company to scale to a larger size.
- The last stage is the *maturity* or "*corporate management*" (IV). At this point, institutional investors usually want to get their money—including the returns on the investment—out. Often, the exit strategy consists of one major "*exit event*" such as an initial public offering (IPO) or a merger and acquisition (M&A). At this stage, the financial regulation and fiduciary responsibility falls on the board and officers of the company.

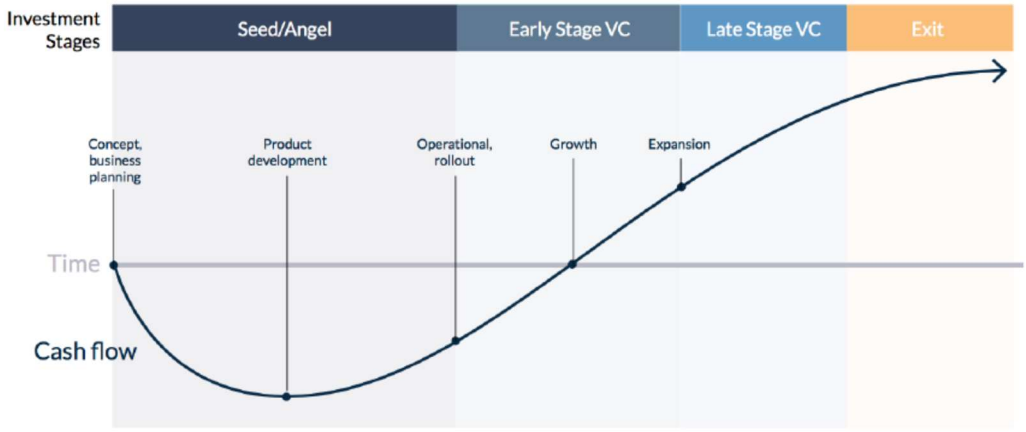
Investment stages

Venture capital is the earliest stage of private equity (PE) investment, typically when companies have little or no revenue. Companies that seek venture capital will often go through multiple financing rounds with different valuations. As the valuation and operating costs of the company grows, so does the investment received in the next investment rounds.

PriceWaterhouseCoopers & CBInsight have established a classification for investment stages (see Figure 7). Note that this classification refers to investment stages, not to start-up development process. It is also relevant to point out that when analysing the capital deployed as "*Early*", the company might be in either the launch or the growth stage according to the model described above in this section.

The next paragraphs try to establish a link between investment stages and the most frequent milestones venture capitalists expect to be achieved by the company at the end of each period.

Figure 7. Stages of investment related to cash flow.



Source: National Venture Capital Association – 2017 Yearbook, data provided by Pitchbook.

- The earliest stage of venture financing is known as the *seed* round and usually involves a smaller amount of equity and lower valuations. Seed-stage financings are often comparatively modest amounts of capital provided to entrepreneurs to finance the early development of a new product or service, support the market research, build the management team and/or develop the business plan. It is a pre-marketing stage and thus does not involve production for sale. Seed and Angel rounds are under Seed stage.

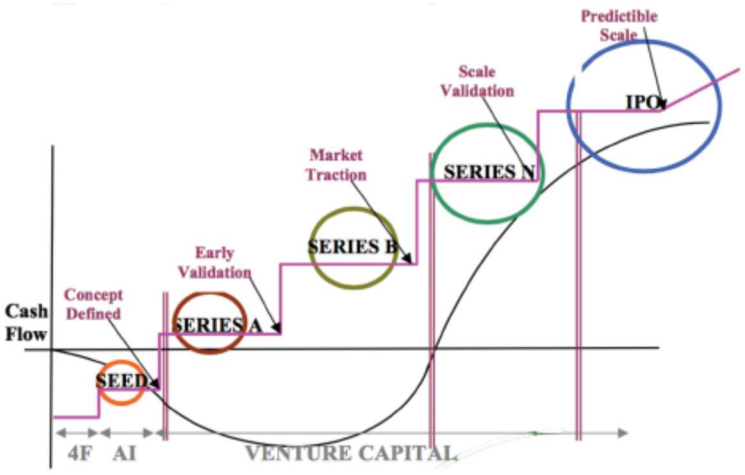
  A round is labelled as "angel" when there are no PE or VC firms involved in the company. As for seed, when the investors and/or press release state that a round is a seed financing, or it is for less than $500,000 and is the first round as reported by a government filing, it is classified as such. If angels are the only investors, then a round is only labelled as seed if it is explicitly stated. After the company has begun developing a prototype and a more comprehensive business plan, it will typically seek for additional capital through one or more early stage financings. Seed-stage VC funds will typically participate in later investment rounds with other equity players to support business expansion costs.

- In the next stage, the *early-stage*, companies are able to begin operations but are not yet at the stage of commercial manufacturing and sales. At this point, new business can consume vast amounts of cash. At this stage established VC firms and corporations may begin investing with seed-round investors also continue playing a role as well. VC firms often provide their portfolio companies with resources, connections and advice but have less hands-on involvement. Rounds are generally classified as Series A. A round can be classified as Series A either by the series of stock issued in the financing or by the age of the company, prior financing history, company status, participating investors, and more. The early stage can consist of different sub stages: start-up and first stage. The former provides start-ups with funds for product development and initial marketing; the latter—first-stage capital—is used to initiate commercial manufacturing and sales. Most first-stage companies have a product or service in testing or pilot production. In some cases, the product may be commercially available.

- The *expansion* or growth stage includes series B, C and others required to launch and grow the company. The company is probably still unprofitable at the beginning of this phase but is likely to be thinking of an exit mechanism at the end of it. Here, companies are producing and shipping products to customers and, although not required to be profitable, they are likely to have real feedback from the market. The capital will be used for their further expansion, marketing, working capital or development of an improved product.
- In the *late-stage*, rounds are generally classified as Series D or further. At this stage, capital is provided after commercial manufacturing and sales but before any initial public offering or for major expansion (e.g. expansion, product improvements, marketing campaigns). The product or service is in production and is commercially available. The company demonstrates significant revenue growth, but may or may not be showing a profit.
- The last stage is called *mezzanine* and this step implies going public, representing the bridge between expanding the company and the IPO. This stage is needed when a company plans to go public within six months to a year but needs more capital to sustain rapid growth in the interim. It can also involve restructuring major stockholder positions through secondary transactions. This happens when there are early investors who want to reduce or liquidate their positions or if management has changed and the stockholdings of the former management, their relatives and associates are being bought out to relieve a potential oversupply after going public.

Figure 8, developed by Del-Palacio (2009) graphically illustrates the link between each noticeable financial event—represented by the vertical lines—with the evolution of a start-up's cash flow and the business development stages.

Figure 8. New-venture funding stream: venture capital rounds, financing to milestones.



Source: Del-Palacio (2009).

7.4. METHODOLOGY

The purpose of this study is to investigate how and why Silicon Valley evolves by identifying changes on the role played by the Triple Helix agents. Given that this research aims at answering "how" and "why" questions, following epistemological criteria based on an interpretivism (Klein and Myers, 1999; Walsham, 1993) and a post-positivism (Popper, 1963; Philips and Burbules, 2000) method, a case study approach was used.

In our specific research, the case study seeks to understand:

- How have the university, industry and government's role changed during the start-up creation process in Silicon Valley during the last 10 years?
- Why have they changed?

Specifically, 6 case studies were arranged within a multiple-case design. Following Yin (1984) this approach is suitable when the investigators have little control over events, and the focus is posed on a contemporary phenomenon within a real-life context. This was our case. The scope of the analysis was limited to show the trends and changes of the IT sector. Biotech and MedTech companies were discarded since its development process and necessities are specific and different from other sectors. Given the nature of the two research questions, data were gathered from different sources as described below.

- Data referring to 2008 was obtained from the doctoral dissertation of del-Palacio (2009), who interviewed several start-up companies and conducted a detailed analysis of the innovation ecosystem at Silicon Valley.
- Data from 2017 we followed the same procedure as the one employed in del-Palacio (2009). Accordingly, six in-depth personal interviews with high-position founders or managers of the start-ups of interest were conducted in order to identify the support of and relationship established with universities, industries and government at each stage of business development.

Table 6 (Appendix 5) shows the main characteristics of the six start-ups. The list of interviewees was based on recommendations and connections. Interviews were very useful because they directly target the case-study topics and focus on causal inference (Yin 1984). The interviews were semi-structured, beginning with a set of open-ended questions and then allowing for free-form conversation.

According to Yin (1984), key informants are often considered critical for the success of a case study. Thus, as a part of the research, ten additional interviews with key informants from industry, universities and public administration were conducted during the same period (see Table 7 – Appendix 5). These interviews were also open-ended. The informants were asked about the facts of the matter allowing them to elaborate on his/her own insights into certain occurrences.

In order to triangulate data, a number of secondary documents were selected and reviewed dealing with the incentives (for public administration), type and source of investments (for industry) and new programs (for

universities) established after 2008. The ultimate purpose was to identify some hints on the changes occurred, while allowing us to corroborate or contradict the findings from the interviews. Additional information concerning population, employment, housing or commute was also collected to better understand the changes.

In order to analyse the changes in the role of each agent in each stage of business development we compared the results with those in del-Palacio (2009) referring to year 2008.

The interviews took place between March and July 2017. All interviews were recorded to ensure a more accurate attention to the interviewee and the conversation. Data collected were analysed on the basis of the Triple Helix model and the lifecycle model of business development.

The interviews comprised in-person conversations and phone calls ranging from 40 to 90 minutes that were structured as follows. First, we started the interview by summarizing the goals of the study. Second, we asked the interviewees to introduce themselves and to give a short explanation of their company and technology. A template was designed to gather all this data together for each of the start-ups under analysis (see Table 8 – Appendix 5). The third and most important part of the interview was the collection of the data needed for answering the research questions. This last part was conducted through direct questions about the team, the technology, the location, financing and the go-to-market strategy in each of the stages of the business development cycle (see Table 9 – Appendix 5). Finally, interviewees were asked about their perceptions about the evolution of the Silicon Valley for the past 10 years.

7.5. RESULTS

Evolution of the Triple Helix agents

From the analysis of the data collected in the interviews, we can conclude that the roles played by universities, industry and government are specific at each stage, and that, over time (2006 compared to 2016), these roles have slight changes. The following paragraphs deal with the main conclusions.

Government

As a general perspective, federal R&D funds have clearly declined and become more sophisticated since 2006. Now state funds require consortium agreements, and universities can access to specific programs to promote commercialization of science. Main changes include:

1. Investor: The government's role as an investor is steadily shrinking in Silicon Valley. Both start-ups (SBIR/STTR Funds) and universities (R&D Programs) are relying on private funds to develop their new technologies.

2. From customer to facilitator: We have witnessed a shift in the role adopted by the cities, moving from customers to facilitators. Cities are increasingly becoming technology platforms, allowing companies to emerge and consolidate, and showcase their new technologies in a real environment.
3. Policy maker: According to Silicon Valley Bank, U.S laws and regulations affect 1 in 4 start-ups in the US.

The main drivers for these changes are:

- Immigration: the collapse of the H1B Visa Program—defined to attract international talent—has caused a shortage of engineers forcing start-ups to move their engineering teams totally or partially abroad.
- The Tax Exclusion Program launched by the City of San Francisco, along with Millennials demands to live in a walkable city, has extended Silicon Valley—historically related to Santa Clara County—to the city.
- Housing regulations around San Francisco and Silicon Valley are not allowing enough construction to keep up with demand. This has raised the price of housing beyond a reasonable level, creating more separation between high-tech workers and the rest of the population.

Universities

Universities are still the main place where entrepreneurs meet and decide to start a business. For a long time, universities were not taking full advantage of this, losing an opportunity to increase their revenue. During this period, we have seen universities taking new roles and embracing their entrepreneurs:

1. Actively promoting entrepreneurship: Universities are actively supporting their entrepreneurs while they are students and after graduation. Through business plan/lean competitions, awards, cross-faculties programs or clubs, universities are providing soft-skills to future entrepreneurs. With incubator and accelerator programs they are also providing the necessary infrastructure to begin a venture.
2. Investor: A rise on university-backed VC Funds is clear in Silicon Valley and California in general, mainly as a result of a $250Million Fund from the University of California. Additionally, universities also invest in their start-ups through affiliated VC funds, student venture funds and accelerator programs.
3. Strengthening ties with VCs and investors: At least 9 VC funds in Silicon Valley are running a student program, which involves students as scouters of new ventures in their campuses.
4. Source of knowledge, not only in their traditional meaning: Universities—and academic staff in particular—have become a source of knowledge for investors that want to keep track on what is technologically disruptive and feasible.

5. Source of entrepreneurs: Financial and corporate investors are approaching university labs and technology transfer units to find high-tech start-ups. Technology transfer offices are also including creation of start-ups as a performance indicator.
6. Promoting commercialization of science: Programs such as i-corps are moving research closer to private companies, increasing the relationships with the private sector.

Industry

The main changes are the emergence of accelerator programs and the role that big tech corporations are taking in Silicon Valley. Other movements are:

Start-ups:

1. Start-ups have now easier access to technical and marketing (digital) resources, such as cloud or Adwords. Technological infrastructure is also cheaper. These two events lead to cheaper and easier beginning for start-ups compared with those starting in 2006.
2. Talent has become the most precious resource in Silicon Valley. It has always been relevant but for start-ups is becoming more challenging to attract and retain engineers in their Silicon Valley teams.
3. Due to the shortage of engineers, start-ups are forced to move their engineering teams totally or partially abroad.
4. Growth has become the toughest stage. Companies have more competition (more companies are funded in seed&early stages), hiring is more expensive, and investment is concentrated in less companies at this stage.
5. Start-ups are more technical.
6. Raise of micro-multinationals: Silicon Valley IT start-ups are establishing subsidiaries abroad sooner than 10 years ago.
7. Lack of an international market strategy: Decisions to open overseas offices were based on merely economics (recruitment) or personal reasons, not responding to market assessment or strategy.
8. Entrepreneurs start their businesses everywhere but tend to move to Silicon Valley to grow.
9. Stronger ties with expert knowledge via the formalization of advisory boards.
10. Entrepreneurs are younger now than 10 years ago.

Corporations:

11. New big tech companies are engaging sooner with start-ups, typically as an early costumer, investing through CVCs, accelerators, etc.
12. Some Silicon Valley investors question that early engagement of corporates might have a negative effect on the ecosystem.

Investment:

13. VC funds are more sophisticated, focusing in specific technologies and providing an array of other services to their companies.
14. *Business angels* are more organized and syndicated.
15. Incubators have disappeared in favour of accelerator programs which are considered an efficiency of the system.
16. Easier to get seed&early funds: With more resources concentrated on seed&early stage (*business angels*, corporations & accelerators) more start-ups are being funded.
17. Less risk in the later stages: VCs are concentrating their investments in later stages, with larger investments in fewer companies, playing "too big to fail".

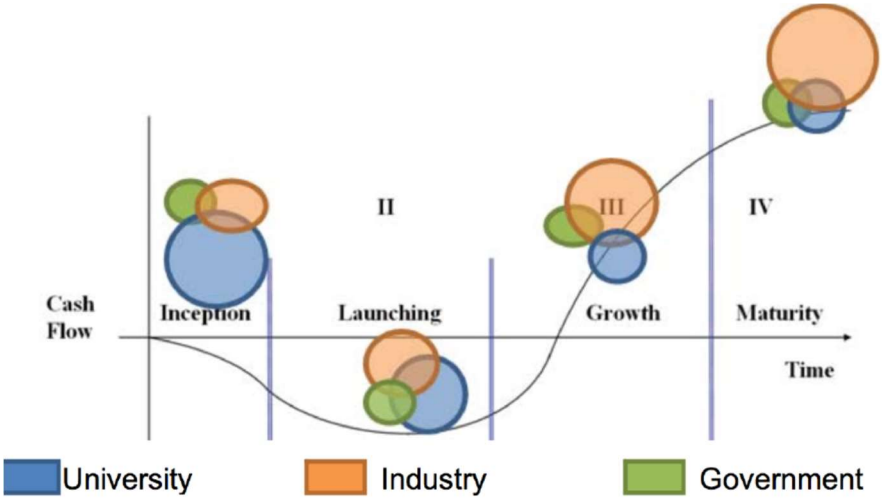
Evolution of the tracks with a Triple Helix perspective

In this section we will take a closer look at the changes identified above, and relate them to the different tracks and stages of development. A detailed analysis is presented. Furthermore, depending of the magnitude of the change, three levels will be assigned:

- No-change (=): When the agent is keeping the same role. Some changes in the performance or development can apply, but the expected results are the same.
- Incremental change (+): The agent is developing the same role with a different approach or perspective. This may lead to bigger influence of the agent in one specific track and/or stage development.
- Disruptive change (++): The emergence of a new agent, a new role or task developed by an agent not usually involved in that track and/or stage of development.

Figure 9 illustrates the relative support of the three agents at each stage of business development in 2006/2007 and Figure 10 does so for the current situation (in 2016/2017). As it can be seen, at the *inception* stage, universities' importance is sustained over time for starting up new ventures. However, a new industry agent has emerged: accelerators. *Business angels* have also intensified their (industry sphere). Government is trying to get closer to both universities and industry enlarging the collaboration area. Few changes are observed in the *launching* stage. Universities and industry are increasing their ties while government plays a relatively smaller role. As companies grow, their necessities change and regulations start to affect them. Thus, in the *growth* stage, public administration has acquired bigger prominence. They allow companies to showcase their solutions in cities and through policy regulations. At this stage, universities lose part of their influence but less than they did 10 years ago. Now, universities keep ties with their start-ups for a longer period through their VC funds.

Figure 9. Relative importance of the three Agents at the Triple Helix model for supporting the development of technology ventures in Silicon Valley in 2006/2007.

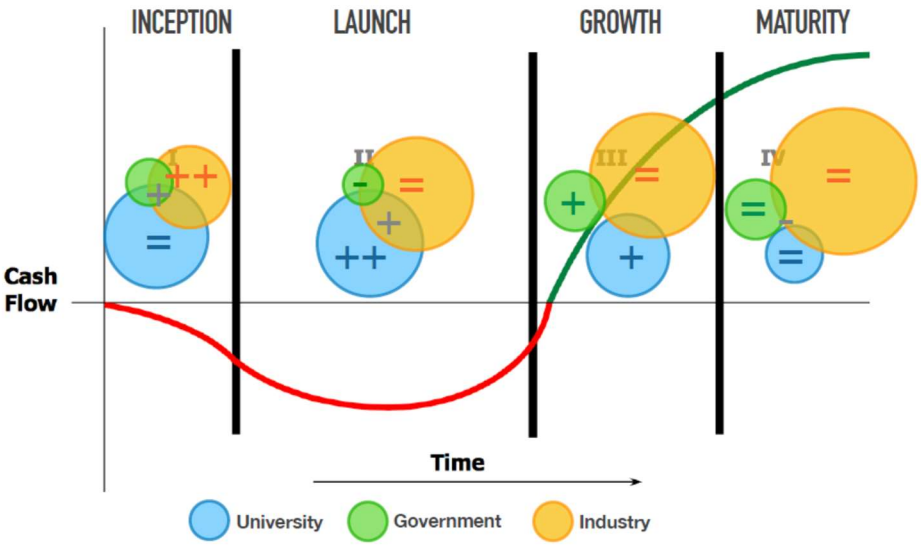


Source: Del-Palacio (2009).

Lastly, at *maturity*, industry remains as the most important agent. Administration keeps its role as a regulator while universities' influence diminishes. Less interaction between the three agents is identified compared with 10 years ago.

To sum up, when comparing the situation in 2006/2007 and 2016/2017, we observe that the support provided by the three agents has substantially increased. This proves the evolution of the Triple Helix agents; therefore, the evolution of the Ecosystem of Innovation.

Figure 10. Relative importance of the three Agents at the Triple Helix model for supporting the development of technology ventures in Silicon Valley in 2016/2017.

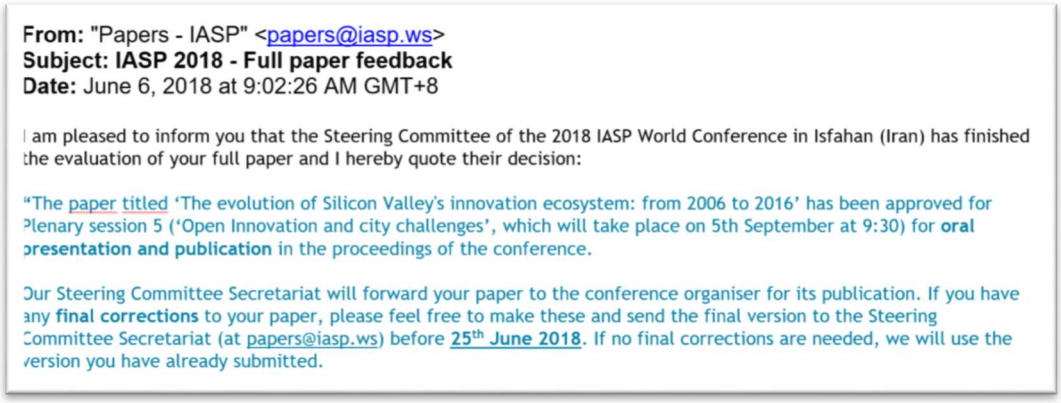


7.6. PUBLICATION 4

This paper was accepted and will be presented at the IASP World Conference (see Figure 11).

> Botey, M., Pique, J.M. and Miralles, F. (2018) 'The evolution of Silicon Valley's Innovation Ecosystem: From 2006 to 2016'. In: *XXXV IASP World Conference on Science and Technology Parks*. Isfahan (Iran). Forthcoming.

Figure 11. Publication 4 notice.



From: "Papers - IASP" <papers@iasp.ws>
Subject: IASP 2018 - Full paper feedback
Date: June 6, 2018 at 9:02:26 AM GMT+8

I am pleased to inform you that the Steering Committee of the 2018 IASP World Conference in Isfahan (Iran) has finished the evaluation of your full paper and I hereby quote their decision:

"The paper titled 'The evolution of Silicon Valley's innovation ecosystem: from 2006 to 2016' has been approved for Plenary session 5 ('Open Innovation and city challenges', which will take place on 5th September at 9:30) for **oral presentation and publication** in the proceedings of the conference.

Our Steering Committee Secretariat will forward your paper to the conference organiser for its publication. If you have any **final corrections** to your paper, please feel free to make these and send the final version to the Steering Committee Secretariat (at papers@iasp.ws) before **25th June 2018**. If no final corrections are needed, we will use the version you have already submitted.

8. ETHICAL ASPECTS

In order to evaluate the ethical aspects of this research, we have to clarify that the theoretical foundations of this work are taken from different perspectives. This approach allows a better understanding of the nature of the agents and data analysed.

This thesis does not include research on human embryo, foetus, children, patients, genetics, animals, military, or potential for terrorist abuse. The ethical aspects of this research are respectful and aligned with the principles of the Charter of Fundamental Rights of the European Union.

First of all, Triple Helix Theory, focused on understanding how Triple Helix agents (Universities, Industry and Government) contribute to the development of ecosystems of innovation in cities. Second, the understanding of Urban Development requires the analysis of the dimensions of the transformation (urban, economic, social and governance) in cities. Third, Clusters of Innovation theory, helps understanding the components of the Ecosystem of Innovation from the point of view of the interaction between start-ups, venture funds and corporates contributing the creation and development of high potential entrepreneurial ventures. Finally, the evolution stages of AOIs are based on the lifecycle of a new venture in order to propose four phases of lifecycle of an AOI (inception, launching, growing and maturity).

For the purpose of this thesis, we have used the case study method and analysed a specific set of cases that are relevant within the context of study. A combination of both qualitative and quantitative methods has been used. To this end, this research is divided in four main studies. In every study we have used appropriate units of analysis and data following the theories behind the works.

The first one is focus on a Holistic Model of Areas of Innovation of Cities, analysing the urban, economic, social and governance dimensions of urban revitalizations. This work uses the cases studies of 22@Barcelona (as brownfield transformation case) and Skolkovo (as greenfield transformation case), taking advantage of public data in order to organize and recognize the evidence of the urban, economic, social and governance dimension in the process of revitalization. All the data used is published in websites or memories of activities.

The second one focuses on the role of the Triple Helix (university, industry and government) in every dimension of the urban transformation. To do this, we have analysed four Brazilian cases in the process of revitalization of urban areas, the *Porto Digital* (in the City of Recife), the *Porto Maravilha* (in the City of Rio de Janeiro), *4º Distrito* (in the City of Porto Alegre) and the *Centro Sapiens* (in the City of Florianópolis). We have added the 22@Barcelona as a control case. Data have been gathered from the websites that report the status of the above mentioned venues as well as from official documents. Also, research and review articles on urban revitalization have been reviewed and complemented with field interviews with the key stakeholders of the projects.

The third study focuses on the evolution of ecosystems of innovation taking advantage of 22@Barcelona Case. This research provides a new perspective for AOIs in cities, understanding that along the evolution

of the Area of Innovation, all Triple Helix agents play different roles in the dimensions of the transformation (urban, economic, social and governance) and co-evolve in the phases of lifecycle (inception, launching, growing and maturity). For the purpose of this study, we use a case-oriented research, analysing data from the Report 22@Barcelona 2000-2015 and 22@Barcelona Business Census 2015. We have analysed data of urban, economic and social transformation. All this data is public.

The last study, analyses the evolution in the ecosystem of innovation of San Francisco - Silicon Valley. We aim to understand *how* and *why* Silicon Valley evolves by identifying changes on the role played by the Triple Helix agents (Universities, Government and Industry) from to 2006 to 2016. We also aim to identify if changes in one of the agents trigger evolution of the others. From the start-ups perspective, we identify—applying case-study methodologies—how the role of Triple Helix agents affects each stage of the start-up development process. A qualitative study is based on key interviews and a quantitative study is included in order to validate the findings from the interviews.

In terms of the ethics of the data collection process, it was ensured that the data collected were relevant and interesting for providing insightful evidence according to the purpose of this research. To analyse the evolution of the ecosystems of innovation in the urban, economic, social and governance dimension the data collection process was not invading any privacy or personal concerns, following the European Charter for Researchers guidelines.

Regarding the quality of the data gathered two main strategies were followed. On the one hand, to ensure that collected information was relevant (avoiding superfluous details). On the other hand, when doing the interviews, data collection process was in a balanced and non-intrusive base, ensuring that insights were not biased by the researcher (Creswell, 2009; Fayolle and Wright, 2014).

Another key issue was, during the interviews, to provide to each interviewee completed and clear information about the whole research and to address any possible concerns at the beginning and throughout the research process. Thus, at the beginning of each interview, the interviewees were informed about the aim of this research, the type of data to be collected and the procedure to do this (semi-structured interviews). Accordingly, interviewees were given an outline of the interview, and were informed about the type of data that was going to be collected through a template (Fayolle and Wright, 2014; Myers, 2009).

As conclusion, this research deals with the nature of data with no risk of ethical violation, due the origin of the data (public) and due the way of performing the interviews (the interviewees were informed of the aim of the research and the kind of data collected).

9. DISCUSSION AND CONTRIBUTION

With the results of the 4 studies, several implications can be drawn. This chapter discusses about (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.

9.1. DISCUSSION

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 (Nikina and Pique, 2016). 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 (Pique and Majo, 2012). 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 (Pique and Miralles, 2017).

City revitalization needs urban, economic and social transformation

We can summarize the lessons obtained from the Brazilian cases (Pique, Miralles, Teixeira et al., 2018b):

- **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 (1) what sectors (clusters) to be developed and (2) 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 (1) creation, (2) development, (3) attraction and (4) 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 (1) hybrid organizations (public private partnership platforms) in order to (2) share the vision to achieve in the innovation district, and to (3) add actions to be developed in all the dimensions of the project.

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 (Pique et al., 2018a; Pique et al., 2018b; Botey, Pique and Miralles, 2018):

- **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.

From the cases analysed, and in the light of the Triple Helix model and the KBUD paradigm, several conclusions can be drawn. First, cities that seek to prosper through an increase in competitiveness, creating means to develop and attract elements to form creative knowledge clusters like in Barcelona, cannot thrive if they overlook aspects related to its territory, agents and institutions. All cities, with their own configurations, agents, institutions, pasts and hopes for the future, are unique. In each city, government, university and industry participate in the urban, economic and social transformation (Pique, Miralles, Teixeira et al., 2018b).

Second, every project adapts and develops its transformations taking into account its region's path dependency, assets and opportunities (Pique, Miralles, Teixeira et al., 2018b). *Porto Digital* is performing an accelerated urban revitalization process encompassing economic transformation and the modernization of urban infrastructure, real estate and historic patrimony of the Old Recife's and Santo Amaro's neighbourhoods. *Porto Maravilha* is considered a positive legacy of the Rio de Janeiro 2016 Olympics and FIFA World Cup 2014, transforming the old port area into a new growth engine for the city. *4º Distrito* seeks to promote and boost economic reconversion, improve quality of life, and spur citizen awareness in the area, with emphasis on urban restructuring, environment awareness, and productive activities promotion in the City of Porto Alegre. *Centro Sapiens* is expected to promote a successful environment to boost the creative sector in Florianópolis. The project is contributing to the continuous development of the city with intense work to foster creative economy activities and the urban revitalization of the historic centre of Florianópolis.

As it can be inferred, all the above projects seek to revitalize their territories to promote creative and knowledge economy activities, in order to transform degraded, underutilized urban spaces, goals achieved by the 22@Barcelona project. Yet, all the projects had the local government as one of the main sponsors of the urban revitalization process. In some cases, leading, in others allowing and following the social or university movements.

Third, our analysis includes a perspective based on the Quadruple and Quintuple Helix model (Pique, Miralles and Berbegal-Mirabent, 2018a). On the one hand, the society is involved in different ways, 22@ is explicitly involved in the urban dimension (social housing and public space), economic (living lab) and social (programs for children, families and old people) and governance (participation and transparency). In the Brazilian cases, all the cases involve the society, with programs of participation and cultural activities related (Pique, Miralles, Teixeira et al., 2018b). Social housing is not present in all projects. On the other hand, the environment—that in 22@Barcelona is one of the axis of work, with clear clean infrastructures decided on the Infrastructures Plan—it is not explicitly evident in the Brazilian cases.

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 (Pique, Miralles and Berbegal-Mirabent, 2018a):

- **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.

At **each stage the roles of the Triple Helix agents shape the steps for the next phases** (Pique, Miralles and Berbegal-Mirabent, 2018a; Botey, Pique and Miralles, 2018). The government, defining the use of the land, is allowing universities and companies to be in the AOI. Universities, developing studies of engineering, are providing key talent at the knowledge based companies. Also, through the promotion of entrepreneurship, universities are generating new start-ups that government and investors can fund in order to provide new innovations at the ecosystem. Large corporations can buy start-ups as a way to absorb innovation. We have witnessed how the horizontal value chain of the urban, economic and social dimension is vertically connected with the governance of universities, industry and government.

Ecosystems of innovation evolve, and each **Tripe Helix agent co-evolve its roles when others adopt new functions** (Pique, Miralles and Berbegal-Mirabent, 2018a; Botey, Pique and Miralles, 2018). In the case of urban transformation, the first effort might come from the government, investing in infrastructures and the first buildings. In a mature stage, real estate developers will invest in new building and the government should not need to invest again in buildings. In the economical dimension, when the culture of entrepreneurship is needed, public programs are needed to finance start-ups. Also, at this stage *business angels* and venture capital firms can lead the investments. In the social dimension, during inception, it will

be necessary to transform the mind-set of the neighbourhood. In a mature moment, the culture of innovation and entrepreneurship in the schools will substitute some future public activities.

Each 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 in annuals basis. Aligning agendas at short, middle and long term visions, is a key issue in the governance performance, in order to evolve the ecosystem in a synergic way.

9.2. CONTRIBUTION

In order to emphasize all contributional aspects of our work, we can summarize:

1. City revitalization needs a Holistic Approach

   The conceptualisation of KBUD (Sarimin and Yigitcanlar, 2012) includes: (1) Social and cultural development; (2) economic development, (3) environment and urban development; and (4) governance development. From the 22@Barcelona Case and the Brazilian Cases we observe that 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 (Pique and Miralles, 2018; Pique, Miralles, Teixeira et al., 2018b).

2. Triple Helix Agents develop different functions in every dimension of the Areas of Innovation

   Etzkowitz and Leydesdorff (2000) use the Triple Helix model (university-industry-government) to explain the development of knowledge-based economies, but Areas of Innovation need urban, economic and social transformation. We observe that the role of each agent of the Triple Helix model (Government, Universities and Industry) is different depending on the dimension of the transformation (Pique et al., 2018a; Pique et al., 2018b; Botey, Pique and Miralles, 2018).

3. Triple Helix agents change the role in the lifecycle of an Area of Innovation

   The evolution of an ecosystem of innovation can be mapped in 4 phases following the analogy of the lifecycle model of a new venture: inception, launching, growing and maturity (Freeman and Engel, 2007). Four steps were also proposed in the evolution of regional innovation ecosystems (Etzkowitz and Klofsten, 2005). The case of 22@Barcelona provides evidence that, in each phase – from inception to maturity - 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. (Pique, Miralles and Berbegal-Mirabent, 2018a).

10. CONCLUSIONS, LIMITATIONS AND FUTURE LINES

10.1. CONCLUSIONS

This thesis aims to contribute to the understanding of the revitalization projects of metropolitan areas and the evolution of ecosystems of innovation. It has been based on the conceptual frameworks of the Triple Helix model, the Knowledge Based Urban Development paradigm, the theory of the Clusters of Innovation and the Lifecycle Model of a New Venture. Moreover, complementary insights from the Quadruple and Quintuple Helix Models have been proved to be useful to improve the understanding of these projects.

From the point of view of academic implications, the Quintuple Helix model and the KBUD theory have been found to be useful to describe the revitalization processes analysed. From the perspective of policy makers in urban revitalization, this work can inspire other cities that want to transform old industrial areas (brownfield transformation) into socially conscious, creative and knowledge based economy hubs. Furthermore, this study suggests a holistic perspective that includes local specificities in the revitalization processes.

Using a case method, this thesis has explored four Brazilian urban revitalizations, the evolution of 22@Barcelona Innovation District and San Francisco-Silicon Valley Ecosystem. Several conclusions can be drawn.

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 (1998). 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.

As a summary, we can conclude that with the four studies we have been able to answer the three research questions guiding this research:

1) The ecosystems of innovation evolve in urban, economic, social and governance dimensions, as we have investigated in *22@Barcelona* Case, San Francisco-Silicon Valley Case and Brazilian Cities multiple-case (*Porto Digital*, *Porto Maravilha*, *4º Distrito* and *Centro Sapiens*).

2) Triple Helix model (university-industry-government) provides a clear framework to understand the Knowledge Based Urban Development dimensions. Every agent plays different roles in every dimension of the transformation, as we have examined in the four studies. Complementary insights from the Quadruple and Quintuple Helix have been added to improve the understanding of these transformations.
3) The role of the Triple Helix agents evolves in the different phases of the lifecycle of an Area of Innovation from inception to maturity. Ecosystems of innovation evolve, but only if each Triple Helix agent co-evolves its role when others adopt new functions. Co-evolution process is required, with government, universities and industry interacting. Hybrid organizations are necessary to coordinate expectations and actions. The Triple Helix agents work for the next phase evolving functions in every phase. This Research Question have analysed in the *22@Barcelona* Case and San Francisco-Silicon Valley Case.

For each study, we have written a publication, and the four papers fulfil the requirements for a Thesis for Compendium.

10.2. LIMITATIONS AND FUTURE LINES

Although this thesis provides useful insights into the analysis of ecosystems of innovation in urban areas, we identified some limitations and restrictions for the extrapolation of the results that clearly represent future research lines.

First, we use a case study research method. This implies that although useful insights from other well-known cities (e.g. Boston, Porto Digital, Skolkovo) have been used, the study mainly refers to the specific case of Barcelona. It could be a limitation in terms of the number of cases studied. Future studies should consider corroborating the model of Areas of Innovation in other cities. Also, we encourage researchers to complement the study with quantitative data in order to validate the effectivity of the model presented.

Second, this research is grounded in the Triple Helix Model in order to understand the role of universities, industry and government developing urban ecosystems of innovation. While the model seems appropriate, we will find a restriction for the extrapolation when we don't have in an ecosystem one agents of the Triple Helix. Future studies might consider adding other perspectives (Regional Innovation Ecosystems) and theories (Open Innovation) to better understand how the different agents evolve and interact.

Third, this work has focused on the analysis of Areas of Innovation in urban areas. Even though this is not the purpose of this dissertation, a recommendation for further studies relates to exploring the usefulness of our model in other settings. 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 or in weak and emerging entrepreneurial ecosystems.

Fourth, this study has mainly focused on brownfield cases, that is, transforming districts or parts of the city with previous activities. This is a clear restriction in terms of extrapolation. Further research should 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.

Lastly, this study has not found evidences about the role of the Quintuple Helix (Environment) in the Brazilian Cases. We encourage future research in order to understand why the environment is not detected in developing countries like Brazil. This is relevant from the perspective that the cultural and social settings of developing countries are different from them of the developed countries, where the quintuple helix approach was proposed.

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APPENDIX 1 – PUBLICATION 1

Pique, J.M. and Miralles, F. (2017) 'Areas of Innovation in Cities: Holistic Modelling of Urban, Economic and Social transformation'. In: *The 6th International Academic Conference on Social Sciences.* Barcelona (Spain).

APPENDIX 2 – PUBLICATION 2

Pique, J.M., Miralles, F., Teixeira, C.S., Gaspar, J.V. and Ramos Filho, J.R.B. (2018b) 'Application of the Triple Helix Model in the revitalization of Cities: the case of Brazil'. *International Journal of Knowledge-Based Development,* in press.

APPENDIX 3 – PUBLICATION 3

Pique, J.M., Miralles, F. and Berbegal-Mirabent, J. (2018a) 'Areas of Innovation in Cities: The evolution of 22@Barcelona'. *International Journal of Knowledge-Based Development,* in press.

APPENDIX 4 – PUBLICATION 4

Botey, M., Pique, J.M. and Miralles, F. (2018) 'The Evolution of Silicon Valley's Innovation Ecosystem: From 2006 to 2016'. In: *XXXV IASP World Conference on Science and Technology Parks*. Isfahan (Iran). Forthcoming.

The Evolution of Silicon Valley's Innovation Ecosystem: From 2006 to 2016.

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ABSTRACT

Silicon Valley Innovation Ecosystem keeps finding ways to improve and become more efficient. We aim to understand *how* and *why* Silicon Valley evolves by identifying changes on the role played by the Triple Helix Agents (Universities, Government and Industry) from to 2006 to 2016. We also aim to identify if changes in one of the agents trigger evolution of the others.

From the startup perspective, we identify — applying case-study methodologies — how the role of Triple Helix Agents affects each stage of the startup development process. A qualitative study is based on key interviews and a quantitative study is included in order to validate the findings from the interviews.

By identifying the changes, we conclude that the role of the Triple Helix agents evolves over time and therefore the Innovative Ecosystem also evolves over time.

Keywords: Silicon Valley; Triple Helix; Clusters of Innovation; Evolution; Entrepreneurs; Startup; Corporates; Accelerators; Corporate Venture Capital.

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1. INTRODUCTION

Silicon Valley Innovation Ecosystem has been the topic of numerous studies, papers and articles for years. The highly successful entrepreneurial region is the main reference for those — mainly governments but also Universities and private institutions — willing to re-create a “Silicon Valley” in their homelands. Even though other innovation ecosystems are trying to catch up, Silicon Valley always seems to be one step ahead. While we have observed that weak-entrepreneurial ecosystems evolve — mainly in response to government incentives, regulations or funds — the evolution in strong-entrepreneurial ecosystems, such as Silicon Valley, and the effects in the startup development process remained unclear.

In this paper we study the evolution of the Silicon Valley Innovation Ecosystem from 2006 to 2016 focusing on the effects that these potential changes have in the startup. As a guide and baseline for our research, we will use the information collected in 2006-07 by del-Palacio (2009) for her PhD Thesis “The Capital For Small Technology Companies In Spain: Public Venture Capital To The Rescue?”. In her study, del-Palacio interviewed founders and CEOs to gather detailed data related to the support provided by University, Government and Industry (Triple Helix Agents; see 3.1.) in each stage of the startup development process (Inception, Launch, Growth, Maturity; see 3.3.) in Silicon Valley.

Following her model, we interviewed six founders and ten key experts to identify the main changes on the Triple Helix Agents role and try to determine if the evolution is driven by changes of one agent, forcing the rest to evolve.

As it was pointed out, almost all innovation ecosystems try to become ‘the new Silicon Valley’, different approaches with unalike results have been tried, from Singapore to Shenzhen, Chile or Barcelona. The results of this research may offer a guideline for other ecosystems to use in evaluating their initiatives for fostering technology entrepreneurship and to better respond to the changing needs of entrepreneurs and markets. Instead of copying what Silicon Valley does now, other ecosystems should look at the different stages Silicon Valley has gone through and identify which practices may apply to each innovative ecosystem based on its stage of development.

From 2006 to 2016, a lot has happen within the Silicon Valley. Facebook opened to everyone older than 13 years old in 2006 and Apple launched the first iPhone in 2007 which is considered the start of the digitalization era. By 2009, Dropbox and Airbnb were already operating after being accelerated at YCombinator. That same year, Google Ventures and Uber were funded. In 2012, while Facebook was filling its IPO, San Francisco started to see the benefits of the Payroll Tax Exclusion launched in 2011 to redevelop the Central Market Street & Tenderloin areas when Twitter — that had recently raised $400M — decided to keep its office in the city. While all these was happening, what were Silicon Valley Universities, Government and Industry doing to secure a new hype of successful entrepreneurs?

This paper begins with the state of the art; followed by a presentation of our research questions and approach; qualitative and quantitative information; data analysis and key findings; and finally, recommendations and areas for further consideration.

We based our analysis on three widely accepted models. The first is the Triple Helix (Etzkowitz, 2000) model, one of the most referenced models used to characterize an innovation ecosystem. The second is the general business development model which divides the startup process into four stages: inception, launch, growth and maturity (Freeman and Engel, 2007). Finally, we also use the Clusters of Innovation Components defined by Engel and del-Palacio (2009) to better understand the Silicon Valley Innovative Ecosystem.

The paper has two main parts. In the first part —qualitative approach — we characterize our analysis as a case-study research, we list the questions, set forth the hypotheses, define the units of the analysis and variables and explain how the interviews are conducted and how the results are interpreted. The results of this interviews include the analysis assessing the role played by the government, the university and the industry in each stage of development. The second part —quantitative approach — focuses on identifying the present actions and activities of the Triple Helix Agents, while allowing us to corroborate or contradict the findings on the qualitative approach. Specifically, we identified and compared the incentives (for public administration), type and source of investments (for industry) and new programs (for universities) established after 2006. We also considered other facts such as population, employment, housing or commute to better understand the region.

Finally, we present our findings, compare them to 2006 and draw our conclusions. The results of the analysis are presented in two forms: identifying changes and movements of the three agents of the Triple Helix compared to their roles in 2006; and a graphic to represent the relative support of the three agents in each stage of business development compared to 2006. We expect the agents to evolve, taking part of role of the others over time understanding how and why this happened.

2. GOALS

Silicon Valley has been at the top of Innovation Ecosystems for so many years now that many voices arise 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 way that its more efficient.

For Innovation Ecosystem *followers* it is easier: they study, analyze, compare, discuss and finally apply the “innovations” that were first implemented in Silicon Valley. But, *how and why Silicon Valley evolves without references?*

In this research, we aim to identify the changes on the role played by University, Government and Industry — the Triple Helix Agents — in a strong entrepreneurial environment such as Silicon Valley.

We also aim to identify if changes in one of the agents trigger evolution of the others.

To be able to do that, we established a timeframe: from 2006 to 2016; a unit of analysis: startups; and our research questions: (1) How have the University, Industry and Government’s role changed during the startup creation process in Silicon Valley during the last 10 years?; and (2) Why have they changed?

We will do our research from the startup perspective, asking entrepreneurs how Universities, Government and Industry affect their companies at each stage of the business development. The qualitative study will be backed up by key expert interviews. We will later proceed with the necessary quantitative study in order to corroborate or contradict the findings from the interviews. The quantitative study does not aim to be a collection of all the incentives, programs or regulation changes since 2006; since their existence does not prove their success. We have focused our research on those initiatives or programs identified by the interviewees.

The study will show trends and changes specifically on the IT sector. Biotech and MedTech companies were discarded from the beginning since its development process and necessities are specific and different from other sectors. Although hardware companies were not initially excluded, none was included in the analysis and therefore, we will not consider our results applicable to hardware startups neither.

3. STATE OF THE ART - FUNDAMENTAL THEORIES

We review relevant literature to define the academic framework of the study and to better delimit the present research. Following the model del-Palacio (2009) set in her thesis — "The Capital For Small Technology Companies In Spain: Public Venture Capital To The Rescue?", and with the aim to compare our research with the results she established in 2009 — this research will be based on the same fundamental theories: Triple Model Helix and Clusters of Innovation (COI).

The Triple Helix model, defines an innovation system as a system of three interconnected components: the university, the industry and the government. This model is used to support the quantitative and qualitative analysis. Later, we will compare the role played by the three agents in a strong entrepreneurial environment such as Silicon Valley in a 10-year period.

We also use the COI components established by Engel (2015) in "Global Clusters of Innovation: Lessons From Silicon Valley" to deeper analyze the Silicon Valley Innovation Ecosystem.

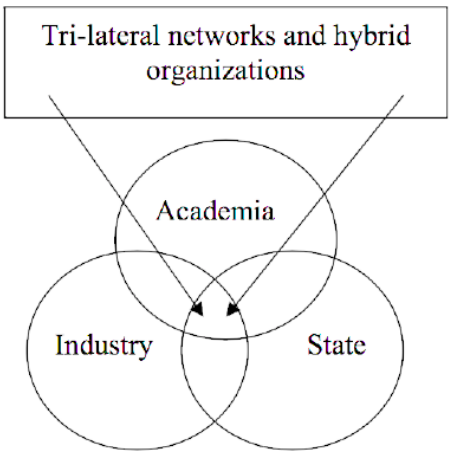
We will also introduce some general aspects related to the business development process and the investment stages related to each one (Freeman and Engel, 2007). We used this model to easily determine the development stage of the startups analyzed in the qualitative approach.

3.1. Triple Helix Model

The Triple Helix model, developed by Etzkowitz and Leydesdorff (2000) 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 center 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.

The university has traditionally been viewed as a support structure for innovation, providing trained persons, research results, and knowledge to industry. Recently the university has increasingly become involved in the formation of firms, often based on new technologies originating in academic research.

Figure 1 - The Triple Helix Model of University-Industry-Government Relations



Source: Etzkowitz and Leydesdorff, 2000

The Triple Helix raised the university to an equivalent status in a knowledge-based society, unlike previous institutional configurations where it had a secondary status. Rather than being subordinated to either industry or government, the university is emerging as an influential actor and equal partner in a "Triple Helix" of university-industry-government relations.

As the behavior of each component in a system depends on the behavior 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 (Pique et al., 2018b)

A Triple Helix regime typically begins as university, industry, and government enter into a reciprocal relationship with each other in which each attempts to enhance the performance of the other. Then, usually starts collaboration among the institutional spheres most involve with 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 of economic and social development.

The creation of new organizational formats to promote innovation such as the incubator, Science Park, and the venture capital firm are another result from the interaction among the Triple Helix Agents to promote innovation and are themselves an example of the Triple Helix collaboration.

The next step of development of the Triple Helix is that, in addition to performing its traditional tasks, each Triple Helix agent "takes the role of the other". This statement relates to the fact that, with time, each agent assumes some of the capabilities of the other while maintaining its primary role.

The case-study analysis that is developed in this research seeks to identify which new capabilities have assume each triple Helix Agent in a 10 years period in Silicon Valley. This approach have been applied in the evolution of other ecosystems of innovation as 22@Barcelona (Pique et al., 2018a).

3.2. 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. A Cluster of Innovation is similar to, but somewhat different from, the well-established understanding of a business cluster (Freeman and Engel, 2007).

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 startups. In these environments, startups 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 startups and small technology companies (Saxenian, 2006).

The emergence of clusters in new industries that do not benefit from agglomeration externalities indicates the presence of several factors that characterize a COI, 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

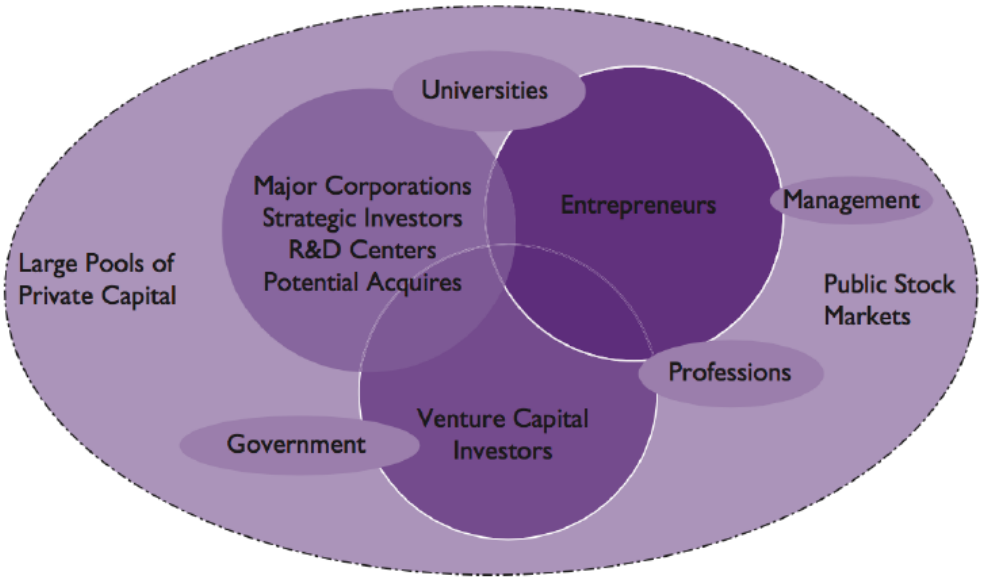
business models, (6) intra- and inter-firm mobility of resources, (7) shared identities and values, (8) alignment of incentives and goals and (9) a global perspective (del-Palacio, 2009).

In 2009, Engel and del-Palacio (2009) 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 constituents. While industry concentrations do exist, they are not definitive. It is rather the nature and the behavior of the components that is distinctive—the rapid emergence of new firms commercializing new technologies, creating new markets, and addressing global markets (Engel, 2015).

COI Components in Silicon Valley

According to Engel and del-Palacio (2009), the key components that identify the Silicon Valley aggregations are: entrepreneurs, venture capital investors, mature corporations and strategic investors, universities, government, R&D centers, and specialized service providers and management.

Figure 2 - The Innovation Engine of Clusters of Innovation



Source: Developed by Engel, 1995. Published in J.S. Engel, Global Clusters of Innovation: Entrepreneurial Engines of Economic Growth around the World (Northampton, MA: Edward Elgar Publishing Inc., 2014).

In the study from 2015 *Global Clusters of Innovation: Lessons From Silicon Valley,* Engel identified the main components of the COI in Silicon Valley as follows:

Three main components with an historic role:

I. Universities: In the early 1900s, the University of California at Berkeley, UC San Francisco and Stanford University, initially focused in practical disciplines such as agriculture, mining and mechanics, expanded to integrate business and education. Through their collaboration with private industry, the universities helped early high-tech firms flourish. Stanford Industrial Park (now Stanford Research Park) is an example of this strong collaboration with large corporations such as General Electric, IBM, Eastman Kodak, Lockheed, Varian, and Hewlett-Packard.

II. Government: The long-term US government spending in Silicon Valley can be considered crucial in the early development of the Silicon Valley. Since the World War II the US military research programs, funded engineering efforts in universities (electronics at Stanford and high energy physics at UC Berkeley), national government laboratories, and private firms in Silicon Valley. The Bayh–Dole Act from 1980 changed the ownership of commercialization rights unlocking potential opportunities for universities, entrepreneurs and investors and starting a new wave of commercialization of government research.

III. Entrepreneurs: Silicon Valley workforce is not only highly educated (see 6.4.1. for further details), but extremely innovative and entrepreneurial. Silicon Valley entrepreneurs seek big scale opportunities and are willing to use high price capital to unlock their potential. Startups, and the entrepreneurs that drive them, are often highlighted in popular culture and have become cultural icons. (Freeman and Engel, 2007).

Other significant COI components:

IV. Venture Capital: Since their appearance after the firsts Silicon Valley based startups IPOs in 1956-58 (Varian, Hewlett-Packard and Ampex), Venture Capital investors have played a critical role in the inception and rapid growth of new ventures taking active involvement in governance, recruiting, and compensation policies.

V. Mature Corporations: Collaborations between mature corporations and startups can take many forms, from agreements, to investments, partnerships, or acquisitions. Silicon Valley corporations take full advantage of their past as startups engaging early with new ventures.

VI. Industrial Research Centers: The growth of Silicon Valley also attracted a broad spectrum of research centers, from Federally funded research labs (Lawrence Berkeley or Stanford Linear Accelerator), to R&D Private Centers (IBM, Xerox, Samsung or more recently Walmart or Baidu) along with independent R&D Centers spun out of universities such as Stanford Research Institute (SRI). This tendency keeps providing the Valley with top technical talent and technologies.

VII. Service Providers and Management: lawyers, accountants, design professionals, recruiting firms, investment bankers, incubators, and accelerators provide tailored professional services, while discounting or deferring their fees in exchange for a small share in the venture's eventual returns.

In this research, we will identify changes on Universities, Government, Entrepreneurs, Venture Capital and Mature Corporations activities during the last 10 years. This information will allow us to detect the evolution of the Cluster of Innovation.

3.3. The Entrepreneurial Venture: Periods of Development

As the company grows, it evolves and qualitative changes are often observed in its internal organization. Companies' development is determined by financial events and the exigencies or milestones that need to be achieved to move to the next financial event. Startups are financed through a series of staged investments where each stage of investment is designed to carry the venture to a higher level of achievement and validation, called a milestone (Freeman and Engel, 2007). Staged investments help investors minimize risk while increasing the valuation of the firm.

The Figure 3 assumes a great deal of good luck and much hard work on the part of entrepreneurs and investors alike. The scales for both dimensions vary substantially across industries, business models, and organizational forms. The vertical dashed lines represent notable financial events.

These events drive changes in organizational structure and management activities

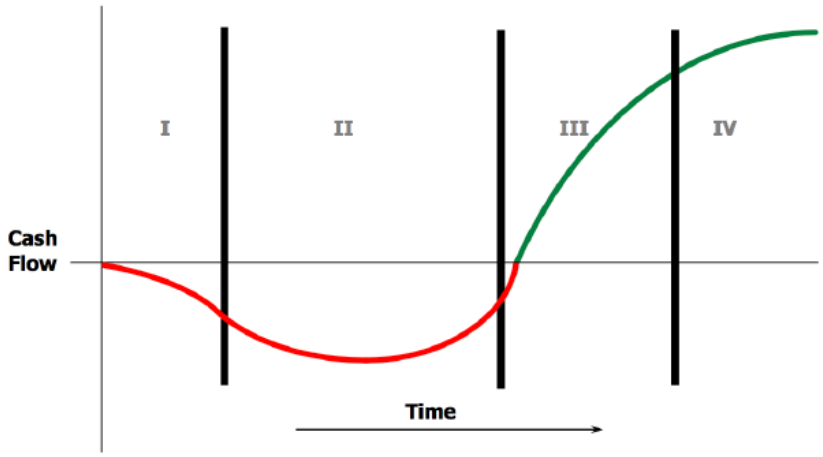
I. Inception or Pure Entrepreneurship: the process starts with a small founding event, which commits the founders' efforts to build a new business organization. *During/Prior to* this time, startups tend to be organic in structure; leadership resides with the inventors; business plans are developed and resources are gathered. The search of capital occupies a substantial portion of the founders' time. The fund is used to define the concept, build the team, determine the customers, analyze competitors and build prototypes. The period ends when prototype versions of the product or service are sold to customers, generating income.

II. Launch or Strategic Focus: The second period commences when the company begins to generate revenues from sales. The team grows and focuses on improving the product/service based on customers' feedback. Startups seeks its first round of institutional investment at this point. During this period, with the Venture capitalist investment, organizational routines are developed and formalized, a board of directors is created, and a experienced management team is hired. All these events leads to a dilutive effect on the equity position of the founders, often resisting loss of control and shifting from creativity to discipline. With continued success, product designs are finalized, marketing and sales efforts expanded, and business systems developed. As this process accelerates, cash flows turn positive ending this period.

III. Growth or Building Systems: Once the scalability of the product is validated, the company is able to successfully compete with older rivals. This is a period of structural development, managerial skill expansion, organizational routines and roles and build stable relations with suppliers and customers while growing the resources. Access to capital is required to fuel continued rapid growth, and to be ready to scale to large size.

IV. Maturity or Corporate Management: At this point, institutional investors usually want to get their money— including their returns on the successful investment—out. Often the exit strategy consists of one major "exit event" such as an IPO (Initial Public Offering) or an M&A (Merger and Acquisition) where the company is acquired. At this time, the full weight of financial regulation and fiduciary responsibility falls on the board and officers of the company.

Figure 3 - Evolution of the Entrepreneurial Venture



Source: Engel, from "The Innovative Organization" session held in June, 2017. Berkeley, CA

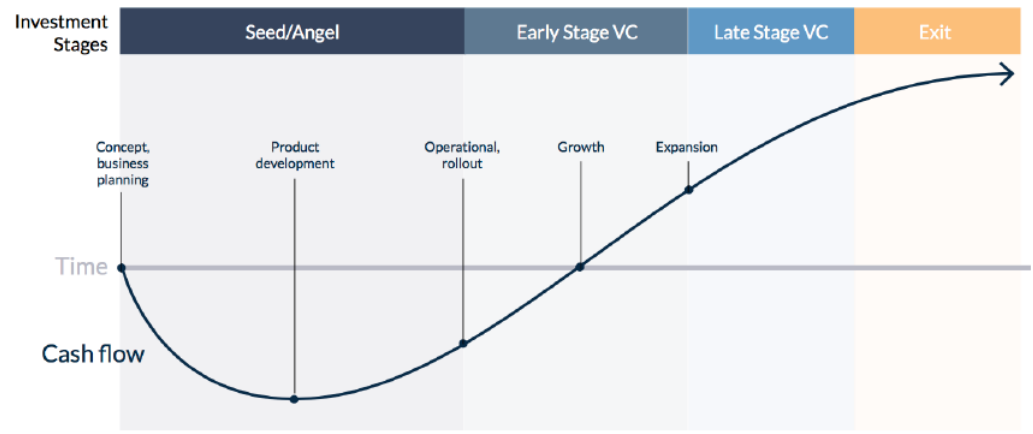
3.4. Investment Stages

Venture capital is the earliest stages of PE investment, typically when companies have little or no revenue. Companies that seek venture capital will often go through multiple financing rounds with different valuations. As the valuation and operating costs of the company should be theoretically be growing with every financing, each round tends to be bigger than the last.

We will now define investment stages following the PriceWaterhouseCoopers & CBInsight classifications. This classification is used for investment stages, not for startup development process. Note that when analyzing the capital deployed as Early, the company might be in either launch or growth stage according to the model expose above.

To clarify the scenery, we link every investment stage to the most frequent milestones venture capitalists expect to be achieved at the end of each investment period.

Figure 4 - Stages of Investment related to cash flow



Source: National Venture Capital Association - 2017 Yearbook, data provided by Pitchbook

I. Seed

The earliest stage of venture financing is known as the seed round, which usually involves a smaller amount of equity and lower valuations. Seed-stage financings are often comparatively modest amounts of capital provided to entrepreneurs to finance the early development of a new product or service. These early financings may be directed toward product development, market research, building a management team and/or developing a business plan. It is a pre-marketing stage and thus does not involve production for sale. Seed and Angel rounds are under Seed stage.

A round is labeled as angel when there are no PE or VC firms involved in the company to date and one cannot determine if any PE or VC firms are participating or if its stated as one by the company or investors press release. As for seed, when the investors and/or press release state that a round is a seed financing, or it is for less than $500,000 and is the first round as reported by a government filing, it is classified as such. If angels are the only investors, then a round is only marked as seed if it is explicitly stated.

After the company has begun to develop a prototype and a more comprehensive business plan, it will often seek additional capital through one or more early stage financings. Seed-stage VC funds will typically participate in later investment rounds with other equity players to finance business expansion costs.

II. Early-stage

For companies that are able to begin operations but are not yet at the stage of commercial manufacturing and sales. At this point, new business can consume vast amounts of cash.

Early stage venture rounds is where more established VC firms and corporations may begin invest, with seed-round investors usually continuing to play a role as well. Venture capital firms often provide their portfolio companies with resources, connections and advice but have less hands-on involvement. Rounds are generally classified as Series A. A round can be classified as Series A either by the series of stock issued in the financing or by the age of the company, prior financing history, company status, participating investors, and more.

The early stage can consists of different sub stages: startup and first stage. Startup financing provides funds to companies for product development and initial marketing. Usually at this stage, companies that have not yet sold their product in the marketplace. First-stage capital is used to initiate commercial manufacturing and sales. Most first-stage companies have a product or service in testing or pilot production. In some cases, the product may be commercially available.

III. Expansion Stage

The expansion or growth stage includes series B, C and others required to launch and grow the company. The company is probably still unprofitable at the beginning of this phase (expansion stage) but is likely to be thinking of an exit mechanism at the end of the stage.

Here, companies are producing and shipping products to customers and, although not required to be profitable, are likely to have real feedback from the market. The capital will be used for further plant expansion, marketing, working capital or development of an improved product.

IV. Late-stage

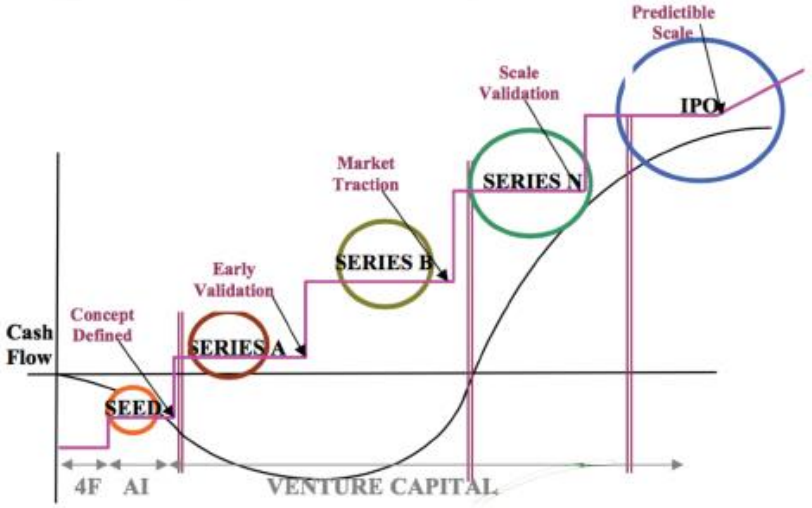
Rounds are generally classified as Series D or later. In this stage, capital is provided after commercial manufacturing and sales but before any initial public offering or for major expansion such as physical plant expansion, product improvement and marketing. The product or service is in production and is commercially available. The company demonstrates significant revenue growth, but may or may not be showing a profit.

V. Mezzanine (bridge)

Mezzanine Stage finances the step of going public and represents the bridge between expanding the company and the IPO. This stage is needed when a company plans to go public within six months to a year but needs more capital to sustain rapid growth in the interim. It can also involve restructuring major stockholder positions through secondary transactions. This happens when there are early investors who want to reduce or liquidate their positions or if management has changed and the stockholdings of the former management, their relatives and associates are being bought out to relieve a potential oversupply after going public.

The Figure 5, developed by del-Palacio in 2009, help us to link each noticeable financial event —represented in the figure by vertical lines — with the evolution of a startup’s cash flow and the business development stages introduced above (3.3. The Entrepreneurial Venture: Periods of Development).

Figure 5 - New-venture funding stream: venture capital rounds, financing to milestones



Source: del-Palacio, 2009. (Adapted from Freeman and Engel (2008), based on Engel's lectures at UC Berkeley)

4. METHODOLOGY

4.1. Qualitative Approach

Qualitative methods included a combination of interviews, with startups and key informants; observations and document review. A total of sixteen interviews were made for the purpose of this study, mainly comprising in-person conversations and phone calls ranging from 40 to 90 minutes, some information was also gathered by email correspondence. The list of interviewees was based on recommendations and connections. The interviews were semi-structured, beginning with a set of open-ended questions and then allowing for free-form conversation.

We would like to know HOW and WHY the triple helix agents have evolved in the startup development process. When a research aims to answer "how" and "why" questions, when the investigators have little control over events, and the focus is posed on a contemporary phenomenon within some real-life context, case studies are the preferred research strategies (Yin, 1984).

In our specific research, the case study seeks to understand:

- *How have the University, Industry and Government's role changed during the startup creation process in Silicon Valley during the last 10 years?*

- *Why have they changed?*

We include the university, industry and the government in the research questions following the principles of the Triple Helix Model (described in 3.1.), which shows that the roles of the three agents overlap and that therefore each one takes the role of the other with hybrid organizations emerging at the interfaces (Etzkowitz and Leydesdorff, 2000). We aim to understand how and why this overlap has changed over a 10 years period.

Hypothesis

The Triple Helix Model shows us that the roles of the three agents overlap and that therefore each one takes the role of the other. As the population and environment changes; and entrepreneurs and investors gain experience; we expect the Triple Helix Agents to adjust its roles.

- **Hypothesis 1:** The role of the agents in an Innovative Ecosystem evolves. Once we acknowledge the evolution of the innovative system through the changes on the role of the Triple Helix Agents, we aim to understand the motivation of the changes. Our goal is to understand if one agent changed first, forcing the rest to readjust, or, on the contrary, each one has evolve by itself.

- **Hypothesis 2:** The evolution is caused by the change of at least one agent, forcing the rest to evolve.

Units of Analysis: Silicon Valley Start-ups

We interviewed the founders and managers of 6 startups in Silicon Valley. The goal was to obtain data to analyze and compare the roles played by the Triple Helix agents in the start-up process and its evolution in the last ten years. The interviews were collected between March and July 2017.

As established by Robert Yin (1984) in his book about Case Study Research — in order to collect more compelling data and develop more robust study — we've conducted 6 case studies arranged within a multiple-case design.

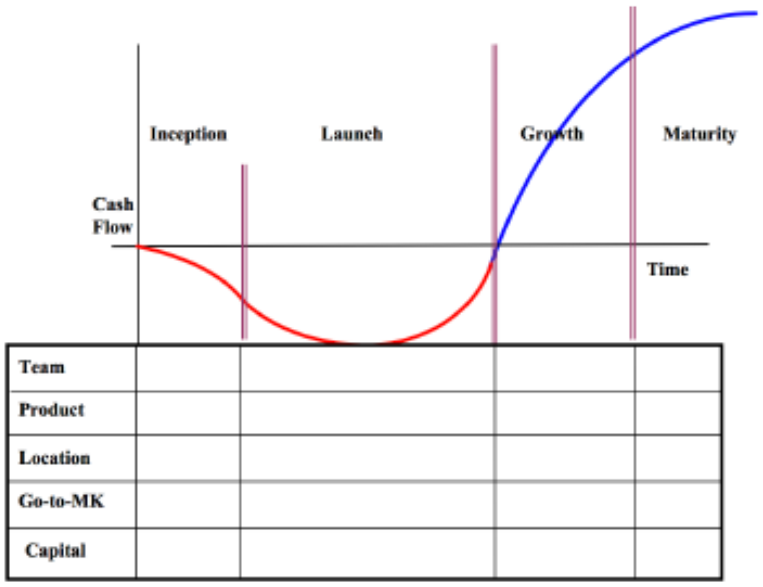
Tracks: Linking data to propositions

For a deeper analysis and in order to obtain comparable results with del-Palacio's research, we focused on five core tracks of the business development process. The five tracks linking data to propositions are developed on Table 1 and Figure 6.

Table 1 - Tracks on the Business Development Process

Talent/Team	Educational and Professional Background Global Diversity, Mentality and Networks Organization of Human Capital Alignment of Roles and Functions
Technology	Research and Development Intellectual Property Rights Product and Production Resources
Location	Local/Global Space Technology Platforms
Evolution/Go to Market	Value Proposition, Business Model, Business Plan Local and International Sales Local and Global Customers Value Chain
Finance/Capital	Sources of Financing Conditions Domestic or International

Figure 6 – Business development stages and the analysis of the five tracks



Source: del-Palacio, 2009

The criteria for interpreting the findings

The data collected from the interviews is analyzed on the basis of the Triple Helix Model, Clusters of Innovation and Coevolutionary theory. In this study we identify the role played by universities, industry and government during the different stages of the start-up process. We also aim to identify the changes in the role of each agent in each stage of business development since 2007.

The results of the analysis are presented in two forms. On the one hand, we build a table that identifies the changes and movements of the three agents of the Triple Helix compare with their roles in 2007. On the other hand, we build a table to represent the changes in the different tracks (talent, technology, location, go-to-market and capital) of the business development process. Finally, we create a graphic to represent the relative support of the three agents in each stage of business development compare with the representation from 2007.

4.2. Quantitative Approach

The goal of the quantitative study is to identify some hints on the changes while allowing us to corroborate or contradict the findings on the qualitative approach.

We analyzed the Triple Helix Agents: Public institutions, Universities and Industry. We also considered other facts such as population, employment, housing or commute in the study to better understand the changes.

Specifically, we identified and compared the incentives (for public administration), type and source of investments (for industry) and new programs (for universities) established after 2006.

5. QUALITATIVE RESEARCH: CASE STUDY

5.1. Interviews with Start Ups

In this research, we conducted in-depth personal interviews with 6 high-position founders or managers of startups to identify the support of and relationship established with universities, industries and government in each stage of business development. Interviews are very useful because they directly target the case-study topics and focus on causal inference (Yin, 1984).

Following del-Palacio's guidelines, the interviews were structured in three parts. First, we started the interview by introducing ourselves and by summarizing the goals of the study. Second, we asked the interviewees to introduce themselves and to give a short explanation of their company and technology. The third and most important part of the interview was the collection the data needed for answering the questions of this research. This last part was conducted through direct questions with the goal to fill out the data table while reporting additional information. The data table aims to collect information about the team, the technology, the location and the go-to-market strategy in each of the stages of the business development cycle (early stage, launch, growth and maturity).

Finally, we asked the interviewees about their views and observations about the evolution of the Silicon Valley during the last 10 years. This part allowed us to have a fluid conversation while collecting key information. The interviews took place between March and July 2017. All interviews were also recorded to ensure a more accurate attention to the interviewee and the conversation. The structured interviews became sometimes conversational in order to better understand 'how' the three agents of the innovation system provided support and 'why' it was beneficial. The role played by the university, the industry and the government has been identified for each company in the different stages of development.

5.2. Interviews with experts

As a part of the research, ten more interviews with key informants were conducted during the same period. These interviews were open-ended. The informants were ask about the facts of the matter allowing them to propose his or her own insight into certain occurrences. Key informants are often consider critical for the success of a case study.

Key informants provide insights into a matter and also can suggest sources of corroboratory or contrary evidence. In order to avoid dependency or interpersonal influence it is important to be cautious and search evidence to corroborate or contradict the shared insights.

6. QUANTITATIVE RESEARCH: SILICON VALLEY INNOVATIVE ECOSYSTEM

The goal of the quantitative study is to identify some hints on the changes of the Triple Helix Agents — Public institutions, Universities and Industry — in the last 10 years. We also considered other facts such as population, employment, housing or commute in the study to better understand the changes.

6.1. Public institutions

Public Administration in the US has three levels: federal, State and local, either county or city. Each administration plays a different role in the Triple Helix Model.

All U.S. Public R&D Funds are controlled by the Federal Government. U.S. Government releases every year the total spending of the different agencies. As a general perspective, R&D Federal Funds have declined since 2006. Some agencies such as Department of Homeland Security or Environmental Protection Agency have seen the most drastic cuts, while Department of Energy (DOE) and National Science Foundation (NSF) are the agencies with major gains in this period.

Nuclear, efficiency, and renewable energy have all seen the greatest growth since FY2006.

The two main Federal funding programs for startups, SBIR and STTR, have remained stable. From 2007 to 2016, roughly 400 companies each year have been funded through these programs. To date, the Program has resulted in 70,000 issued patents, close to 700 public companies, and approximately $41 billion in venture capital investments.

NSF launched in 2013 the i-corps initiative to increase the impact of NSF funded research. The goal of this program is to encourage commercialization of science and technology through partnerships between academia and industry. The Bay Area Node is focused on helping early-stage teams which have a fundamental technology, engineering or business model innovation, by learning how define a scalable business model through the Customer Discovery process: Lean LaunchPad.

The State of California — a high-cost tax state — employs tax exemptions as a way to keep companies within the State. During the last ten years manufacturing, specially related to biotechnology, physical, engineering, and life sciences have been prioritized. Through modifications of the Federal R&D Tax exclusion, California is also securing high-skilled jobs.

The State direct support to its entrepreneurial ecosystem is through the iHub program launched by Governor Brown in 2013. The program run out of money leaving consortiums without resources to achieve their original plan.

At a local level, we have seen two different strategies. San Francisco has been highly competitive at attracting new businesses into the city through incentive programs such as the Central Market Street & Tenderloin Payroll Tax Exclusion. Although the program attracted new ventures into the city, and allowed them to maintain their offices there, the economic effects remain to be seen when the actual incentives finish by the end of 2018. If a high percentage of the attracted companies choose to keep their offices in the city, the project will be seen as a success. On the contrary, if most of them or the famous ones decide to move out, only the negative effects (gentrification, rise of housing prices, and mobility problems) will remain and the project will be seen as a failure.

On the other hand, San Jose has chosen to become a facilitator of technology on the streets, allowing emerging and consolidated companies to showcase or test their new technologies in a real environment. This also has allowed the city to reduce the cost of some expenses like lighting and Wi-Fi services. On May 2017, San Jose identified five corridors[8] to be used by companies as a demonstration site for Autonomous Vehicles technology.

Although we have not studied changes of Federal Policies, according to a recent study from Silicon Valley Bank, 26% of startups are prompted by U.S laws or regulations to locate facilities or move non-sales operations outside the U.S.

6.2 Industry

The main changes seen in the industry are the emergence of accelerator programs and the role that big tech corporations are taking in Silicon Valley.

While in 2007 there were just 2 accelerator programs in the US, by 2014 the number reached 170.

The leading accelerator programs include funding, which combined with training and access to powerful networks suggest a positive impact on the startups but their overall impact remains to be assessed. A clear benefit of these programs is the big increase of seed deals sealed.

Traditional Tech Corporations have been involved with startups. However, big tech companies that were startups 10-15 years ago are changing the “rules” by engaging sooner with startups.

Corporate Venture Capital funds (CVCs), Corporate Accelerators and acquisitions are the most popular ways of engagement, but also becoming early costumers, organizing hackathons or engaging in partnerships.

Despite the long time existence of CVCs, the present amount of funds is extraordinary. This growth is in part caused by traditionally non-tech buyers entering the market seeking innovation and technology: Walmart, L’Oreal, Unilever, 7-Eleven, Campbell Soups or General Mills have now their CVC program.

The immaturity of some of these CVCs is causing a high level of skepticism from some entrepreneurs and investors. As they keep their presence in the market, speak up their intentions and start leading some rounds, their role will consolidate as a mature agent of the ecosystem.

Corporations are following the trend of accelerators by creating their own programs. While models continues to evolve — most organizations are still experimenting with different ways of setting up and managing their accelerator initiatives — we will have to wait to see the real benefits of these initiatives.

As more accelerator programs appear, and angel investors are more organized and reachable, sources of investment for seed and early stages have increased rapidly. Some corporates are also participating at these stages to keep track on early development technologies.

While the number of seed and early stage deals is increasing — which is encouraging for new startups — the investment funnel in later stages is shrinking. We see now less deals but bigger share of the investment at expansion and later stages, therefore fewer companies are being funded with larger amounts of money.

We are also seeing less IPOs in Silicon Valley. High valuations of some Silicon Valley Tech companies including Uber, Dropbox or Zenefits are challenging their odds of a successful IPO, while their investors cannot cash out or even increase their investments.

VC Firms are also getting bigger with offices all around the US. Interestingly, those that did not have their headquarters in SV back in 2006, now have it. The amount of deals made in 2016 by the most active firms have almost doubled those in 2006, and more surprisingly two accelerators and some angel groups are on the top 15 in number of deals.

In 2016 the hot thematic areas of investment in the US were Artificial Intelligence, Cybersecurity and Auto Tech, but all of them saw a recede in invested dollars during the last quarter of the 2016 so they might change in 2017.

6.3 Universities

As young companies have been responsible for a majority of net job growth over the last couple decades, entrepreneurship has increasingly become a fundamental force at universities nationwide.

To attract the best aspiring entrepreneurs, many universities are thinking outside the box and expanding their offerings to support students across various programs. Universities are fostering entrepreneur-friendly environments through a combination of:

I. **Going beyond business students:** Students with an interest in entrepreneurship grow out of diverse industries. Schools need to provide the adequate resources outside their main course.

Some schools are integrating entrepreneurship courses in concentrations including engineering, medicine and journalism.

II. **Industry engagement:** more schools are teaming up with organizations, to allow students to gain experience by working at startups or venture capitalist firms.

III. **Experiencing fundraising:** As fundraising is one of the more difficult jobs as an entrepreneur, some universities are helping their students to master it through real practice.

IV. **Mingling departments/ Cross-campus collaborations:** In order to succeed in a business, people from different backgrounds and skills are needed. Universities are creating multidisciplinary programs were students from engineering, medicine, law or business work together in a project.

This initiative helps entrepreneurs meet peers and gain insight into how to work with them.

Universities are offering more and more ways for students to pursue an entrepreneurial path and at the same time, strengthen ties between University and future entrepreneurs. To achieve this, different approaches are being deployed: (1) Business/Lean Plan competitions or awards; (2) crossfaculty programs; (3) providing infrastructure through incubators and accelerators; and (4) promoting commercialization of science (i-corps).

Offices of Technology License (OTL) are also becoming more ‘startup-friendly’. In 2006, OTLs did not consider creation of university related spin-off or technology transfer to a startup as a key indicator. Today, Silicon Valley universities include both as performance indicator in their annual reports. Even further, some Universities have developed specific programs to help their researchers or professors to pursue a business based on a OTL technology.

Through the prolific rise of University-backed VC Funds, Universities are also getting closer to investors and VC firms. Investing in their own students, researchers or professors ventures,

Universities are demanding their share in the seed/early round space. This also means, an increasing need to establish formal connections and relations with other investors to help their companies secure next rounds.

Universities and VC Firms are creating their own collaboration space. The Student Programs that some VCs run each year are just an example. Investors and VC firms also participate as a supervisors or advisors in affiliated VC Funds or Student Venture Funds.

Law firms are also partnering with university-related incubators or accelerators to provide free guidance to young companies, either directly or through the University's Law Faculty and students.

6.4 Other Facts

The addition of San Francisco to Silicon Valley, initially limited to Santa Clara County, has changed the demographics of the area.

The inclusion of San Francisco was not induced only by incentives given by the city from 2008.

Silicon Valley's younger generations, following the millennial demand of living in a "walkable city" (Florida, 2002) were forced to move to the closest: San Francisco — even if they had to do up to four hours commute per day.

San Francisco embraced this young population, and helped to create an environment to attract tech companies. The redevelopment of SOMA and Potrero Hills, and the widely criticized Payroll Tax Exclusions are some of the examples that have driven the city to lead job creation in Silicon Valley during the last 10 years. This has caused the known bad-effects of gentrification (Atkinson, 2004), and the creation of a New Economy in the inner city (Hutton, 2000, 2004).

The exponential growth of the main tech companies' workforce is a challenge for the area. While these companies are growing around Mountain View, Cupertino, Menlo Park and Santa Clara by building their own "private cities", the real cities and counties can not grow at same pace and provide the necessary infrastructure. Low housing availability and skyrocketing rent prices are coercing non tech employees to move further away or submit and pay unreasonable and highly unstable rents.

San Francisco and Silicon Valley have developed a synergy. Singles and couples with no children tend to live in the city. Once their family grow, they move out of the city to quieter and *family-friendly* areas like Palo Alto, Los Gatos or Mountain View.

A similar phenomena occurs to companies. Startups begin their journey in the city, where companies take advantage of social agglomeration factors such as critical masses of skills and relationships, access to information, and the availability of specific infrastructure (Utterback and Afuah, 1998; Hutton, 2004; Porter, 1995). Once their venture reaches a certain level (after early stage), they are forced to leave the city to grow on a cheaper and distraction-free environment.

The increase of movements between cities, neighborhoods and corporate-cities are collapsing the infrastructure, which is becoming a real problem in the area. It is important to notice that Bay Area was for decades a low densely populated area and its infrastructure is rather outdated. As O'Mara already pointed out in 2011, *"Silicon Valley may be a unique ecosystem for technology creation, but it falls short on many fronts in terms of functioning well as an urban place. It is haphazardly planned and economically polarized. It is crowded and car-dependent to a degree that lowers its quality of life and degrades the natural beauty that lured people there in the first place."*

Listening to their employees demands and usually against their corporate philosophy, some companies are recently opening small offices in San Francisco, or redesigning their campuses to look less like industrial parks and more like main streets of very hip and cosmopolitan small towns (O'Mara, 2016). As O'Mara pointed in the same article, being in a cool neighborhood helps with recruitment and retention. For example, different sources reported that Facebook is in talks for a space in SOMA district in San Francisco, considering this a "pilot" of a San Francisco office space.

All this job growth comes with an increase in base salary of high-skilled professionals. Increasing not only *per capita personal income* but also the disparity in Silicon Valley. But, the increase of personal income is also becoming the main problem for new ventures, which struggle to recruit their first employees.

Silicon Valley's population is growing less rapidly in recent years, primarily due to the large increase in net domestic out-migration. The region's birth rates remain relatively low, and the population has aged significantly over the past decade.

7. FINDINGS/RESULTS OF THE ANALYSIS

7.1. Evolution of the Triple Helix Agents

From the analysis of the data collected in the interviews, we can conclude that there are some general roles played by universities, industry and government in each stage.

From the analysis of data collected during interviews and validated by quantitative study, we can conclude that the role played by universities, industry and government have changed since 2006.

The summary of the findings are:

GOVERNMENT

As a general perspective, Federal R&D Funds have clearly declined and become more sophisticated since 2006. Now State Funds require consortium agreements, and Universities can access to specific programs to promote commercialization of science. Main changes:

1. Investor: The government role as an investor is steadily shrinking in Silicon Valley; both startups (SBIR/STTR Funds) and universities (R&D Programs) are relying on private funds to develop their new technologies.

2. From Customer to Facilitator: We are seeing a shift in cities role from customers to facilitators. Cities are becoming technology platforms, allowing emerging and consolidated companies to showcase their new technologies in a real environment.

3. Policy Maker: According to Silicon Valley Bank, U.S Laws and Regulations affect 1 in 4 startups in the US.

Main drivers:

- Immigration: the collapse of the H1B Visa Program - defined to attract international talent - has caused a shortage of engineers forcing startups to move their engineering teams totally or partially abroad.

- The Tax Exclusion Program launched by the City of San Francisco, along with Millennials demands to live in a walkable city, has extended Silicon Valley (historically related to Santa Clara County) to the city.

- Housing regulations around San Francisco and Silicon Valley are not allowing enough construction to keep up with demand. This has raised the price of housing beyond a reasonable level, creating more separation between high-tech workers and the rest of the population

UNIVERSITIES

Universities are still the main place were entrepreneurs meet and decide to start a business. For long time, universities were not taking full advantage of this, loosing an opportunity to increase their revenue. During this period, we have seen universities taking new roles and embracing their entrepreneurs:

1. Actively promoting entrepreneurship: Universities are actively supporting their entrepreneurs both while they are students and after graduation. Through Business Plan/Lean competitions, awards, cross-faculties programs or clubs, universities are providing soft-skills to future entrepreneurs. With incubator and accelerator programs they are also providing the necessary infrastructure to begin a venture.

2. Investor: A rise on University-backed VC Funds is clear in Silicon Valley and California in general, mainly as a result of a $250Million Fund from the University of California. Additionally, universities also invest in their startups through affiliated VC Funds, Student Venture Funds and Accelerator Programs.

3. Strengthening ties with VCs and Investors: at least 9 VC funds in SV are running a student program involving students as scouters of new ventures in their campuses.

4. Source of knowledge, not only in their classic meaning. Universities, an especially their professors, have become a source of knowledge for investors that want to keep track on what is disruptive and feasible technologically speaking.

5. Source of entrepreneurs: Financial and corporate investors are approaching university labs or technology transfer units to find high-tech startups. Technology Transfer Offices are also including creation of startups as a performance indicator.

6. Promoting commercialization of science: Programs such as i-corps are moving research closer to private companies, increasing relationships with private sector.

INDUSTRY

The main changes seen in the industry are the emergence of accelerator programs and the role that big tech corporations are taking in Silicon Valley. Other movements are identify below:

- Startups:

1. Startups have now easier access to technical and marketing (digital) resources, such as cloud or Adwords. Technological infrastructure is also cheaper. These two events lead to cheaper and easier beginning for startups compared with thus starting in 2006.

2. Talent has become the most precious resource in Silicon Valley. It’s always been precious but for startups is becoming more challenging to attract and retain engineers in their Silicon Valley teams.

3. Due to the shortage of engineers, startups are forced to move their engineering teams totally or partially abroad.

4. Growth has become the toughest stage. Companies have more competition (more companies are funded in seed&early stages), hiring is more expensive, and investment is concentrating in less companies in this stage.

5. Startups are more technical.

6. Raise of micro-multinationals: Silicon Valley IT startups establish subsidiaries abroad sooner than 10 years ago.

7. Lack of International Market strategy: Decisions to open overseas offices were based on merely economics (recruitment) or personal reasons, not responding to market assessment or strategy.

8. Entrepreneurs start their businesses everywhere but tend to move to Silicon Valley to grow.

9. Stronger ties with expert knowledge via the formalization of Advisory Boards.

10. Entrepreneurs are younger now than 10 years ago.

- Corporations:

11. New big tech companies are engaging sooner with startups: as an early costumer, investing through CVCs, accelerators, etc.

12. Some Silicon Valley investors question that early engagement of Corporates might have a negative effect on the ecosystem.

- Investment:

10. Venture Capital funds are more sophisticated, focusing in specific technologies and providing an array of other services to their companies.

11. Business Angels are more organized and syndicated.

12. Incubators have disappeared in favor of Accelerator Programs, which are considered an efficiency of the system.

13. Easier to get Seed&Early Funds: With more resources concentrated on Seed&Early stage (Business Angels, Corporations & accelerators) more startups are being funded.

14. Less risk in later stages: VCs are concentrating their investments in later stages, with larger investments in fewer companies, playing “Too Big to Fail” (Lazansky, 2017).

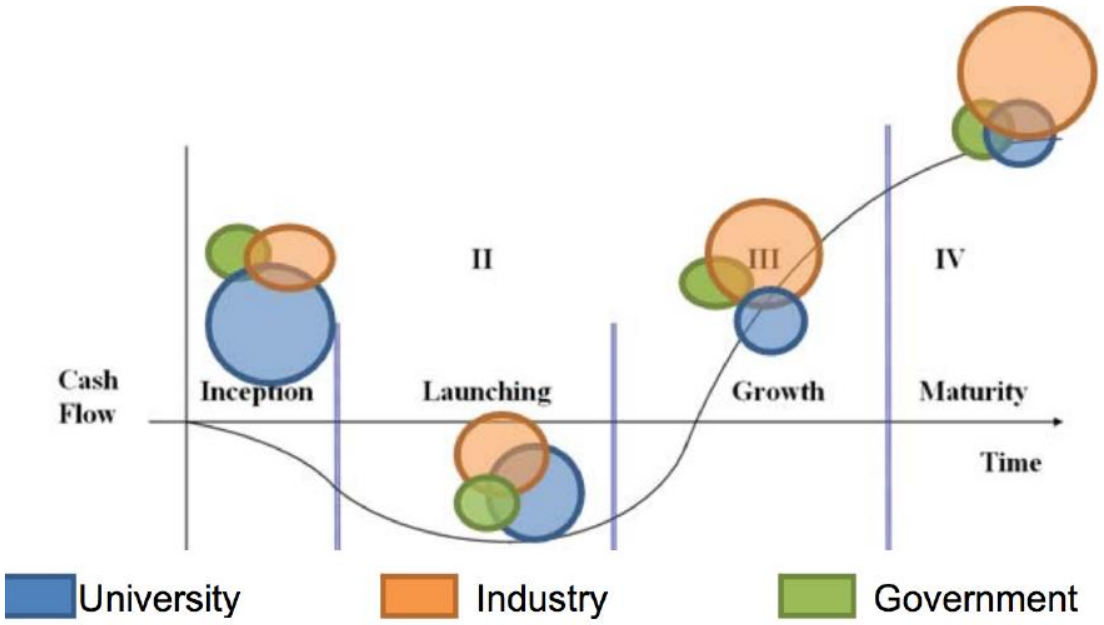
7.2. Evolution of the tracks with a Triple Helix perspective

In this part we will take a closer look at the changes identified above, identifying to which track and stage of development each one of them correspond. We will further analyze them by assigning to each one a level of change according to the following:

I. No-change: when the agent is keeping the same role. Some changes in the performance or development can apply, but the expected results by the agent are the same.
II. II. Incremental Change: the agent is developing the same role with a different approach or perspective. This may lead to bigger influence of the agent in one specific track and/or stage development
III. Disruptive Change: the appearance of a new agent, a new role or task developed by an agent not usually involved in that track and/or stage of development.

This will allow us to build a graph to represent the relative support of the three agents in each stage of business development in comparison with the graph from 2007.

Figure 7 - Relative importance of the three Agents at the Triple Helix Model for supporting the development of technology ventures in Silicon Valley in 2007



Source: del-Palacio, 2009

We expect the importance of these three agents as support providers to vary from one stage of the business development to another. The interviews showed that universities, industry and public administration play different roles at each stage of development of a new venture.

Inception: Universities keep their important role during the inception of companies. A new industry agent raised at this stage: Accelerators. Business Angels are also increasing the role of industry at inception stage. Government is trying to get closer to both universities and industry enlarging the collaboration area.

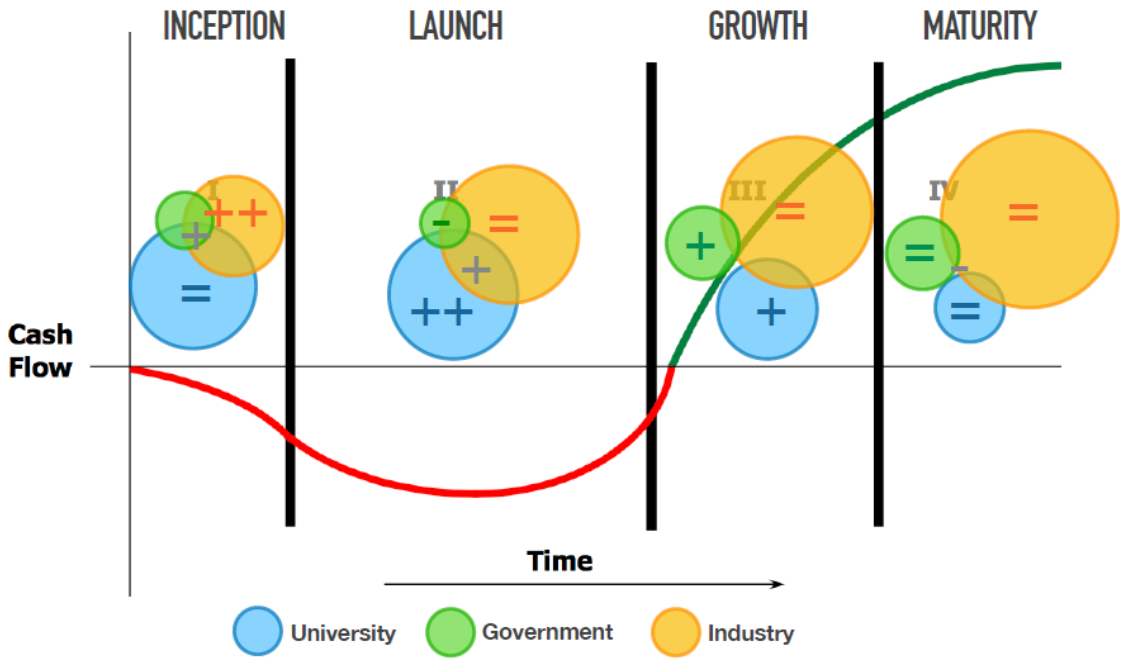
Launch: Few changes are observed in the relative importance of each agent in this stage. Universities and Industry are increasing their ties while government plays a relatively smaller role in this stage.

Growth: As companies grow, their necessities change and regulations start to affect them. Public administration has a slightly bigger influence in this stage: allowing companies to showcase their solutions in cities and through policy regulations. At this stage, Universities lose part of their influence but less than they did 10 years ago. Now, Universities keep ties with their startups longer through their VC Funds.

Maturity: Industry remains the most important agent at this stage. Administration keeps its role as a regulator while universities lose relevance. Less interaction between the three agents is identified compared with 10 years ago.

As a summary, when comparing both moments we find that relative importance of support provided by the three agents changed incrementally. This proves the evolution of the Triple Helix Agents; therefore, the evolution of the Innovation Ecosystem.

Figure 8 - Relative importance of the three Agents at the Triple Helix Model for supporting the development of technology ventures in Silicon Valley in 2017



8. CONCLUSIONS AND DISCUSSION

In this research, we have analyzed the support that Silicon Valley startups receive from Universities, Government and Industry throughout their Business Development Process and identified the incentives from public administrations; type and source of investments from the Industry; and new programs from universities, established after 2006. We have focused our research on Silicon Valley — a highly competitive Innovative Ecosystem — to determine how and why strong entrepreneurial ecosystems evolve with time. We also aim to identify if specific actions or events trigger evolution.

The study was developed in two parts. The first part use case-study methodology to compare the startup development process in Silicon Valley now and 10 years ago. A total of sixteen interviews — six of them with entrepreneurs and ten with key experts — compose this part. The second part analyzes the role of the Triple Helix Agents in Silicon Valley, compared with 10 years ago from a quantitative approach.

The Role of Triple Helix Agents Evolves Over Time

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 startups; (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.

The Rise of Acceleration Programs

While in 2007 there were just 2 accelerator programs in the US, by 2014 the number reached 170, more than 20 in Silicon Valley. The leading accelerator programs include funding, which combined with training and access to powerful networks suggest a positive impact on the startups. Their overall impact still remains to be assessed. By now, the clear benefit of accelerator programs is a big increase of seed deals sealed. In 2016, two accelerators were on the top 15 list of the most active US VC Firms by number of deals.

Big Companies Engage Sooner With Start Ups

Big tech companies that were startups 10-15 years ago are changing the “rules” by engaging sooner with startups. Corporate Venture Capital funds (CVCs), Corporate Accelerators and acquisitions are the most popular ways of engagement.

Despite the long-time existence of CVCs, the present amount of funds is extraordinary, including traditionally non-tech companies such as 7-Eleven or Walmart. Regardless the high performance of some of them: Intel or Google Ventures (GV); the immaturity of other CVCs is causing a high level of skepticism from some entrepreneurs and investors. Overall, we expect that CVCs will consolidate as a mature agent of the ecosystem in the near future.

Accelerator programs is another way corporates engage with startups. Since most organizations are still experimenting with different ways of setting up and managing their accelerator initiatives — either running the program in-house or outsourcing its administration to a partner such as Techstars, LMarks, or Nest — we will have to wait to see the real benefits of these initiatives.

Shifts within Investment Stages — Less chances to become a Unicorn

Investors have also advanced. Business Angels are becoming more organized and syndicated which is helping to spread their work and professionalize their role. On their side, VC Firms are focusing in specific technologies while providing an array of other services to their companies.

As more accelerator programs appear; angel investors are more organized and reachable; and corporates invest on early development technologies, sources of investment for seed and early stages have increased rapidly. But, while the number of seed and early stage deals is increasing, the investment funnel in later stages is shrinking, turning growth stage as the most difficult for startups.

Now, VC Firms as “Playing too big to fail” (Lazansky, 2017). Now, we see less deals but bigger share of the investment at expansion and later stages, therefore fewer companies are being funded with larger amounts of money.

San Francisco & Silicon Valley Synergy

All these changes concurred with Millennials reaching an adult live and demanding to live in a walkable city. The City of San Francisco embraced this young population, and helped to create an environment to attract tech companies. The redevelopment of SOMA and Potrero Hills, and the widely criticized Payroll Tax Exclusion Program are some of the examples that have extended Silicon Valley (historically related to Santa Clara County) to San Francisco. Although the Payroll Tax Exclusion Program attracted new ventures into the city, and allowed them to maintain their teams there, the economic effects remain to be seen when the actual incentives finish by the end of 2018.

By now, this has caused the known bad-effects of gentrification (Atkinson, 2004), and the creation of a New Economy in the inner city (Hutton, 2000, 2004).

Some corporations, listening to their employees demands and usually against their corporate philosophy, are recently opening small offices in San Francisco. Being in a cool neighborhood helps with recruitment and retention (O'Mara, 2015).

We are also seeing a shift in cities' role from customers to facilitators. Cities like San Jose are becoming technology platforms, allowing emerging and consolidated companies to showcase their new technologies in a real environment.

All being said, San Francisco and Silicon Valley seems to have developed a synergy: singles and couples with no children tend to live in the city, once their family grow, they move out of the city to quieter and family-friendly areas. A similar phenomenon occurs to companies: startups begin their journey in the city, where companies take advantage of social agglomeration factors, once their venture reaches a certain level (after early stage), they leave the city to grow on a cheaper and distraction-free environment.

Universities are getting closer to Industry

Universities are offering more and more ways for students to pursue an entrepreneurial path — Business/Lean Plan competitions and awards; cross-faculty programs; incubators and accelerators; commercialization of science — and at the same time getting closer to investors and VC Funds through the prolific rise of University-backed VC Funds. Investing in their own students, researchers or professors ventures, Universities are demanding their share in the seed and early round space.

This also means an increasing need to establish formal connections and relations with other investors to help their companies secure next rounds.

Through the i-corp Program — a Federal Program that promotes commercialization of science — Universities are increasing their relationship with companies and markets.

Offices of Technology License (OTL) are also becoming more 'startup-friendly' with the inclusion of spin-off companies or technology transfer to startups as key indicators. Other Universities have developed specific programs to help their researchers or professors to pursue businesses based on OTL technologies.

The Rise of Micro-Multinationals

Talent, main driver of Silicon Valley's growth and success is becoming a challenge, specially for new startups that struggle to recruit their first employees. The recent collapse of the H1B Visa Program — defined to attract international talent — and the exponential growth of the main tech companies' workforce has caused a shortage of engineers that have seen an increase of base salary over the average.

New startups are inclined to move their engineering teams partially abroad. Other entrepreneurs are following a different path, starting their companies elsewhere and moving to Silicon Valley to grow.

Both models seems to replicate the Israeli model, followed also by most of international companies when entering in Silicon Valley. These might lead to a change in the type of companies seen in Silicon Valley in the near future where less engineers will be needed, and only the core of the company — founders, business development and design team — will be in Silicon Valley.

Final Conclusions

Hypothesis 1: The role of the agents in an Innovative Ecosystem evolves.

Through the changes identified in this study, we can conclude that the role of triple helix agents have evolved over time in Silicon Valley. Since the Triple Helix Model is used to characterize an Innovative Ecosystem, we can extrapolate that the Innovative Ecosystem also evolves over time.

Hypothesis 2: The evolution is caused by the change of at least one agent, forcing the rest to evolve.

We cannot conclude if the changes are driven by the evolution of one of the agents or if each one of them evolved by its own. The information collected through interviews and qualitative report does not show an specific event that triggered changes on the rest.

A further analysis in this field could result interesting for future studies since it will allow us to identify the ties and connections between the Triple Helix agents. Further studies are also needed to determine the impact of accelerator programs and Corporate Venture Capital Funds. Even though this study helps to identify evolution in Innovative Ecosystems, additional analysis may be needed to further clarify their stages of development and their characteristics (Etzkowitz and Klofsten, 2005 and Etzkowitz and Dzisah, 2008). Similar comparisons in weak entrepreneurial ecosystems might be interesting since more changes are expected in less advanced innovative ecosystems.

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APPENDIX 5 – FIGURES AND TABLES

FIGURES

TABLES

Table 6. Template used to collect information about the start-ups.

Name	Plazah	MetaMoto	Zentri	Crysp	JeyLore	Parrable
Position (interviewee)	CEO & Co-founder	CEO & Co-founder	VP, Business Development and Product, Marketing	Co-founder	COO & Co-founder	CEO & Co-founder
Num. of founders	2	2	3	2	3	2
Board of advisors	Yes	Yes	Yes	No	Yes	Yes
Product	Platform that gives everyone instant access to sell top products and services from some of today's leading companies	Metamoto brings best practices for test and validation of autonomous system software to world-class enterprises and is a provider of superior simulation-centric products and services.	Helps companies build secure-connected products such as industrial HVAC systems to highly critical connected medical devices to high end commercial appliances. Zentri provides a secure IoT platform with integrated product OS, SaaS, and Mobile to deliver a connected product experience.	Crysp enables verification of users based on how they interact with their devices, leveraging their device-usage patterns, typing rhythm, gestures and touch-related sensor data.	AI-powered platform that maps consumer behavior into structured predictive attributes. This structured data allows companies to optimize content and communication, make better merchandising decisions, optimize search, and empower customer service.	Parrable unifies a user's profile across one device with its patented technology by providing the fundamental unit of data which is necessary for any advertiser, publisher or data company to target, retarget and/or measure their spend across any device.
Founding date	2016	2017	2013	2014	2012	2010
Headquarters	Los Gatos, CA	Los Altos, CA	Los Gatos, CA	Silicon Valley, CA	San Mateo, CA	San Francisco, CA
Sector	e-commerce	Autonomous Car	IoT	Software	Software, AI	Software for marketing
Team	6	6	23	4	NA	15
Accelerator	No	No	No	Yes	Yes	Yes

Table 7. Interviews with key informants.

Triple Helix agent	Role	Company
Industry	Business angel network	Keiretsu Forum
	Business angel	SandHill Angels, Silicon Catalyst
	Corporate investor	Samsung Catalyst Fund
	Corporate	IDEO, Dropbox, NIO
	Entrepreneur	Sensing Systems
	Entrepreneur	Promptu
University	University professor	University of California Berkeley
	University professor	Stanford University
Public administration	Local government	San Jose City Council
	State government	CITD

Table 8. Template used to collect information about the start-ups.

Name of the company:				
General information				
Name		Founding date		
Position		Headquarters		
Num. of founders		Sector		
Nationalities		Team		
Board of advisors		Accelerator (yes/no)		
Product/Service				
Stage of development and role of the TH agents				
	Early	Launch	Growth	Maturity
Government				
University				
Industry				

Table 9. Interview data template.

Name of the company:					
		Early	Launch	Growth	Maturity
Team	Number & source				
	Background (professional & education)				
	Nationality				
	Founders still at the company				
	Ownership (% shares)				
Technology	IP or knowledge source				
	Type of client				
Location	Headquarters				
	Subsidiaries				
	Infrastructure				
Go-to-market	Business model				
	# of clients/users				
	Markets				
	Partnerships				
Financing	Programs				
	Source				
	Round – Amount				
	Year (related to company)				
	Acquisitions				
Milestones					
Other information					

APPENDIX 6 – ACRONYMS

22@ - The New Code of Knowledge Based Land

22@Barcelona - The brand of the Innovation District of Barcelona

22a - Code of Industrial Land of Barcelona

AOI - Areas of Innovation

COI - Clusters of Innovation

CVC - Corporate Venture Capital

DEA - Advanced Studies Diploma

ENOLL - European Network of Living Labs

IASP - International Association of Science Parks and Areas of Innovation

ICT - Information and Communication Technologies

IFSC - Federal Institute of Santa Catarina

IPO - Initial Public Offering

IT - Information Technology

KBUD - Knowledge Based Urban Development

M&A - Merger and Acquisition

MPGM - Modification Metropolitan Master Plan of Barcelona

OAE - One Stop Shop

OUC - Consorted Urban Operation

PE – Private Equity

PUCRS - Pontifical Catholic University of Rio Grande do Sul

SBIR - Small Business Innovation Research Program

SME - Small and Medium Enterprises

STTR - Small Business Technology Transfer Program

TH – Triple Helix

TCI - Global Network of Clusters

UB - Barcelona University

UDESC - Santa Catarina State University

UFPE - Federal University of Pernambuco

UFRGS - Federal University of Rio Grande do Sul

UFSC - Federal University of Santa Catarina

UPC – Technical University of Catalonia

UPF – Pompeu Fabra University

VC – Venture Capital

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I would like to start with my wife, Roser, to give me the support and the necessary complicity for this long path that is a Doctoral Thesis. Also to my children, Camil and Palmira, to respect and understand my times and wish me good auguries.

Born sixth of six brothers and sisters gave me the opportunity to learn from a very small age something from each of them: the resolute capacity of my sister Núria, the skills of my brother Jaume, the commitment of my brother Ramon, the restlessness of my brother Sergi and the tenacity of my sister Raquel. All this in the framework of a father turned into farmer by religious coherence and a hardworking and generous mother. This will be the third thesis of the family.

La Salle Montcada gave me the academic and spiritual bases with the support of Brother Pablo and the community of Brothers, Professors and Companions. It was there that I met Brother Daniel in an EUETT La Salle information session. There, I decided to do Telecommunication Engineering, which would mark my professional and personal future.

From the Technical Engineering of Telecommunications of La Salle I learned that everything is possible and to be results-oriented. From the Higher Telecommunications Engineering of the Polytechnic University of Catalonia, I realized the importance of academic rigor and how to be tenacious. From the ESADE MBA, I understood the management of the complexity and the interaction between people and organizations.

The creation of the La Salle Innovation Park in 2001, thanks to the support of Brother Daniel, provided me with a test bench to learn how to create ecosystems of innovation in university environments. The incorporation in 2007 to the Innovation District, 22@Barcelona, thanks to the invitation of Mayor Hereu and Deputy Mayor Jordi William Carnes, allowed me the necessary leap to understand the complexity of the development of innovative ecosystems in urban environments. Replicating and exporting 22@Barcelona around the world, with the complicity of Mayor Trias and Deputy Mayor Sònia Recasens, stimulated me to model the Innovation Districts.

Being able to know all the Science and Technology Parks of Spain by Felipe Romera, and the Parks of the world thanks to Luis Sanz, I opened my eyes to understand that many cities and regions pretend to be the same: to create and develop Ecosystems of Innovation. The Presidency of the IASP has served me to visit Parks and Districts in the five continents and to observe a global movement in the development of Ecosystems of Innovation. The active participation in the International Conferences of the IASP gave me the opportunity to present articles annually with the collaboration of people like Dr. Montserrat Pareja, the Dra. Itxaso del Palacio, Dr. Joan Bellavista, Carmen Adán or the same Dr. Solé Parellada, with whom I had the opportunity to visit Silicon Valley and MIT. With Prof. Jerome Engel from UC Berkeley, I had the opportunity to write with Dr. Jasmina Berbegal articles and book chapters.

The Diploma of Advanced Studies, with professors like Dr. Jordi Aymerich, Dr. Àngel Ros and Dr. Joan Mundet introduced me to research activities, and with the direction of Brother Josep Martí, Dr. Mundet and Dr. Etzkowitz completed my studies in 2007.

It was in 2016, thanks to my return provided by Josep M. Santos, when I restarted my doctoral studies with the direction of Dr. Francesc Miralles and the co-direction of Dr. Jasmina Berbegal. With them, Dr. Clarissa Stefani Teixeira of the Federal University of Santa Catarina and her team, and Mònica Botey, worked on the set of publications that made possible this Thesis by Compendium.

The contributions over time of each of the individuals and institutions that I have mentioned have been crucial in finalizing this thesis, including the linguistic verification by Mª Jesus Orts and Michael O'Hara.

To all I owe this thesis, and to all I thank that at every moment of the path of this life in which I have coincided with them, they have supported me generously and disinterestedly.

Aquesta Tesi Doctoral ha estat defensada el dia ____ d_____ de 201__

al Centre_____

de la Universitat Ramon Llull, davant el Tribunal format pels Doctors i Doctores sotasignants, havent obtingut la qualificació:

President/a

_____

Vocal

_____

Vocal *

_____

Vocal *

_____

Secretari/ària

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Doctorand/a

(*): Només en el cas de tenir un tribunal de 5 membres