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Smart Cities in a globalized world, the importance of clusters and international collaboration

by

Patricia Amacifuen Vilchez

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Résumé

Nous examinons la relation des grappes dans les secteurs réguliers, dans les grappes à haute intensité de connaissances et dans la collaboration internationale avec les villes européennes. Pour évaluer cette relation, nous menons une étude empirique basée sur des méthodes quantitatives, sur un échantillonnage de 109 régions européennes sur une période de 3 ans (2013, 2015 et 2016). Les résultats sont à la fois significatifs quant à l'effet des grappes dans les secteurs réguliers, des grappes à haute intensité de connaissances et de la collaboration internationale sur les villes intelligentes. Les résultats de cette recherche présentent des implications managériales pour les entreprises en confirmant les *spillovers* dans les grappes. Ils contribuent également aux politiques publiques en montrant l'importance de promouvoir l'innovation pour favoriser la croissance. De plus, nos résultats contribuent de manière significative à la théorie sur les villes intelligentes illustrant l'importance du développement de grappes et de la collaboration internationale. Enfin, ces résultats sont pertinents pour les gouvernements locaux à l'échelle mondiale, leur permettant d'identifier les éléments compris pour devenir une ville intelligente pour une mise en œuvre future.

Mots clés : *Villes intelligentes, Diffusions de connaissances, Grappes, Réseaux, Collaboration internationale, Pôles de compétitivité.*

Abstract

We examine the influence of regular sector clusters, knowledge intensive clusters, and international collaboration on European cities. In order to test this, we conduct an empirical study based on quantitative methods on a sample of 109 European regions over 3 years (2013, 2015 and 2016). The results show great significance on the effect of regular sector clusters, knowledge intensive clusters, and international collaboration on Smart Cities. The results of this research present managerial implications to firms by confirming spillover effects in clusters. It also contributes to public policy by showing the importance of fostering innovation to contribute to growth. Furthermore, our findings add significantly to the theory on Smart Cities illustrating the importance of cluster development and international collaboration. Lastly, these results are relevant to local governments globally, allowing them to identify the elements comprised to become a Smart City for future implementation.

Keywords: *Smart Cities, Knowledge spillovers, Clusters, Networks, International Collaboration.*

Table of Contents

List of Figures

List of Tables

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Part 1

Introduction

There is evidence of how cities of the future should look like in magazines, movies, TV series and even cartoons. Recently, there have been different ways of classifying cities with characteristics that set them apart from others. For instance, in the late 1980s the concept of Ecocity emerged focusing mainly on energy efficiency, urban gardening and pollution reduction. The motivation behind this concept was about “resource depletion, pollution, over-population and extinction of the species” (Register, 1987, p. 3). Therefore, Richard Register (1987) proposed a sustainable kind of city where people could interact. Another denomination is the idea of Green Cities; where cities concentrate on efficient and renewable energy, waste management and sustainability.

Indeed, there is a clear intention from cities to become more efficient and sustainable. As a result, the concept of Smart Cities emerged by building upon the idea of renewable energies and sustainability and by combining other elements such as government and policy involvement. However, this convergence of different areas has resulted in many definitions being used to describe what Smart Cities are; no set definition exists. Yet, these definitions seem to have common characteristics. Therefore, the definition used for this

research is based upon a holistic view of Smart Cities as described by different researchers. We suggest that Smart Cities should balance efficient use of networks and implementation of digital and telecommunication technologies to benefit both citizens and business (Zanella, Bui, Castellani, Vangelista, & Zorzi, 2014) with a more human approach to make citizens part of the city elements (Hollands, 2008). With this in mind, the IESE Business School (2016a) has created the Cities in Motion Index. In their 2017 edition they analyzed 79 attributes related to 10 aspects of the urban life, they created an index that compares 181 cities of 80 countries around the world.

As a matter of fact, Smart Cities are not just about a trend they are also a necessity. According to the United Nations most people in the Americas and Europe live in cities, this is 50% of the population and accounts for 54% of the world population and by 2050 most of the 60% of the population will live in cities. Indeed, in the next few years all regions will increase their urbanization level (United Nations, 2014). Therefore, cities need to carefully plan for the future to be able to accommodate the increasing population in the most effective way for the benefit of their citizens. For this reason it is important for governments to understand the factors influencing the development of Smart Cities.

In addition to the environmental concern, Smart Cities need to balance other elements such as human capital, mobility and transportation, governance, social cohesion, economy public management, environment, technology (IESE Business School, 2014) and others. Clusters settle in cities and regions and influence cities according to their activities. In most cases, clusters collaborate with different stakeholders in their surrounding areas interacting with city elements and contributing to make cities smarter (Bakıcı, Almirall, & Wareham, 2013; Caragliu, Del Bo, & Nijkamp, 2011; Komninos, 2009).

Previous cluster and smart city research focused mostly on technological clusters (Bakıcı et al., 2013; Hollands, 2008). Authors considered technological

clusters as a Smart City component, but failed to measure their relationship to Smart Cities. In addition, at this time, to the best of our knowledge, there is no research on clusters in regular sectors and international collaboration associated to Smart Cities. This is an important factor, due to its proven growth effect at the regional level and at the city level (Marshall, 1920; Porter, 1990, 1995, 1998).

For this reason, this research aims to understand the relationship between regular sector clusters, knowledge intensive clusters and international collaboration; and their influence in the development of a Smart City. Specifically, addressing the following question: How do regular sector clusters, knowledge intensive clusters and international collaboration influence Smart Cities within Europe? For decades, Europe has promoted cluster integration among cities encouraging innovation and competitiveness (Porter, 1998) as well as knowledge intensive activities (Berry & Glaeser, 2005; Capello, 2009) increasing the opportunity for cities to become “smarter”. This study purposes to solve this question to help local governments to identify elements of Smart Cities for future implementation.

Researchers had focused on the importance of innovation in clusters, and their effects on cities. Clusters promote knowledge spillovers in multiple environments, facilitate social cohesion and have a positive impact on the economy (Bathelt, Malmberg, & Maskell, 2004; Komninos, 2009; Malecki, 2000). Berry and Glaeser (2005) also highlighted the importance of geographic clusters and how this helps shaping metropolitan areas. Additionally, knowledge intensive clusters are also important for technology innovation. Face-to-face communication facilitates tacit knowledge spillovers at the time individuals interact (Breschi & Lissoni, 2001). Knowledge intensive clusters are important as they provide skilled human capital and attract R&D oriented firms and their headquarters to urban areas. Universities are also a great source of information and knowledge sharing. In addition, clusters in general promote knowledge spillovers in the areas where they are located. Furthermore, regular sector

clusters also promote regional spillover effects that are beneficial to cities within the reach of the cluster (Marshall, 1920; Porter, 1995). Consequently, geographical clusters facilitate innovation among its members. The effect of clusters as knowledge spillovers spread beyond geographical political limits (Porter, 1998). Moreover, clusters reflect on growth within regions and this results in positive externalities to cities (Anselin, Varga, & Acs, 1997; Glaeser, Kallal, Scheinkman, & Shleifer, 1992; Malecki, 1984; Marshall, 1920; Porter, 1995; Starbuck, 1992).Therefore, we study the impact of geographic clusters on Smart Cities.

Moreover, the effect of clusters can be increased by developing international relationships. However, the effect of international collaboration has been overlooked in the Smart City literature. In order to foster innovation, clusters need to be in contact with global networks. International interactions are impacted by the level of trust between companies (Bathelt, 2007; Bathelt et al., 2004, p. 40). After a firm has accessed new knowledge, this new information is then incorporated into the local clusters promoting innovation. As a result, international collaboration intensifies local innovation between cluster participants (Bathelt et al., 2004, p. 41; Murdoch, 1995). Thus, due to the benefits of international collaboration on knowledge creation we analyze its influence on Smart Cities.

Europe has a recorded history of network agglomerations and industrialization areas that were formed by connected adaptable organizations that enjoyed labour market relations in an international setting. Firms within the network developed not only production activities; but also, contributed to the development of territories; due to, the collaboration of educational, government institutions and as a result, influenced the labour market (Scott, 1988). Therefore, this research uses statistical information from European regions. Developing hypotheses and testing them in the European context.

The importance of Smart Cities is not only relevant to policy makers, or the technological innovation industry, to name a few; but also, to all the stakeholders involved in these communities (Bakıcı et al., 2013; Hollands, 2008). Smart Cities combine many factors for the benefit of the city and for their inhabitants improving their lifestyle. Thus, the objective of this research is to understand how regular sector clusters, knowledge intensive clusters and international collaboration can contribute to cities to become smarter and to help local governments to achieve a Smart City status.

The data includes a sample of 109 regions in Europe over 3 years (2013, 2015 and 2016). The Smart City reference is retrieved from IESE Business School (2017) and approximated to a regional level. Data on knowledge intensive clusters, regular sector clusters, GDP per capita and land coverage comes from Eurostat. Data on international collaboration is manually constructed from the European Cluster Collaboration Platform. Data on patents, public expenditure in R&D and high tech exports is provided from the Regional Innovation Scoreboard. All these sources are sponsored by the European Commission.

This research is comprised of seven sections. Chapter two develops the literature review; we explore Smart Cities and the possible effect of regular sector clusters, knowledge intensive clusters and international collaboration; and develop hypotheses to explain their influence on Smart Cities emergence. Chapter three describes the data sources and our sample information. Chapter four discusses the methodological approach. Chapter five analyzes the data and describes the results. Chapter six examines the findings from the study, states the implications for theory and practice and addresses the limitations and further direction about this topic. Finally, chapter seven refers to the conclusion of the study.

Part 2

2. Literature Review

Even though, people have different opinions on how Smart Cities should like, it is still a relatively new concept that has evolved since the appearance of the Ecocity movement in the 1970s.

The review of the literature will cover the origins of a Smart City, the reason for institutions to adopt sustainable policies and the continuous search for a single definition. Nowadays, there is still not a set definition of Smart Cities (Caragliu et al., 2011; Chourabi et al., 2012; Hollands, 2008; Mori & Christodoulou, 2012). The definitions vary and are mostly grouped on two currents. First, the definition adopted by ICT companies that are based mostly on technological applications for Smart Cities (Mora, Bolici, & Deakin, 2017; Zanella et al., 2014). Second, a more holistic approach that has been supported by academia (Chourabi et al., 2012; Hollands, 2008; Mora et al., 2017). The later sees technologies as an element of cities and integrates a more human approach for the benefit of the citizens.

The elements of a Smart City are also an important aspect, in order to understand the foundation and importance of a Smart City. However, the lack of consensus on a definition for this topic contributes to different approaches

in describing the elements of a Smart City. For this reason, the set of elements that are used in this research are most relevant to the definition selected. As a result, and to continue with the same line of reasoning, the elements described are consistent with a more holistic approach.

2.1. Smart Cities

2.1.1. Background

The concept of Smart Cities is a concept that has evolved with the passage of time. As an illustration, during Theodore Roosevelt's administration, in the United States (1901-1909), there was already a concern about a better use of natural resources (McCormick, 1986, p. 178). As a matter of fact, the changes in the economic system around the world after WWII increased environmental pollution. As a result, people felt the need to make changes to ensure a better future (IUCN UNEP, 1980).

One of the first aspects of a more sustainable community is an Ecocity. Ecocity initiatives date as early as 1975 when Richard Register, a theorist and author (Ecocity Builders, 2016) founded a non-profit organization in the city of Berkeley in California (Urban Ecology, 2016). Ecocity builders proposed better alternatives to automobiles, such as pedestrian paths and bicycles, as well as planting fruit trees on the streets and the use of solar energy for a street in the city of Berkeley, California (Register, 1994; Roseland, 1997). This early approach was centered in better use of energy and waste management, pollution reduction and better alternatives to transportation, to discourage the use of cars and to promote sustainable ideas such as urban gardening. Likewise, these ideas were applied to existing cities in California and even new cities were built using these principals in Arizona and Oregon (Register, 1987). Based in the United States,

Richard Register became an activist promoting ideas of Ecocities by trying to make the community involved on ideas for an ecological city (Roseland, 1997).

At the same time, similar ideas were also supported in Europe. In 1980, the International Union for Conservation of Nature and Natural Resources (IUCN), an international organization with the cooperation and financial assistance of the United Nations (UN) and the World Wildlife Fund (WWF) published the World Conservation Strategy. This document proposed to apply sustainable development principals towards the conservation of resources such as species and ecosystems due to the growth of the world population and the inevitable increase in resource consumption (IUCN UNEP, 1980).

More importantly, this document was the first one to address issues related to the economic development and protection of living resources (IUCN UNEP; McCormick, 1986). However, these ideas were at an early stage and they needed more diffusion. For this reason, the United Nations (UN) World Commission on Environment and Development created a report in 1987 with the objective of creating “a global agenda for change” (p. 5) focusing on sustainable development for the next century. The report collected information from thousands of people from 21 countries around the world and encouraged communities, companies and governments worldwide to conserve energy, resources; reduce pollution, waste and consumption. Another contribution of this report was to recognize institutional gaps. Thus, the report recommended the use of ecological policies in economic, trade, energy agricultural and other fields (p. 17); and emphasised the importance of promoting a campaign of education (IUCN UNEP, 1980).

In fact, such initiatives remain relevant until today adding other components to sustainability such as diversity, democracy, social justice and a balance in life; environment and utilities (Hassan & Lee, 2015; Urban Ecology, 2016).

2.1.2. Importance of Smart Cities

Meanwhile, there is another factor that influences cities to use resources efficiently. Cities concentrate social and economic activities that leave an impact on the environment (Albino, Berardi, & Dangelico, 2015; Mori & Christodoulou, 2012). Currently, more than half of the world's population lives in cities. Furthermore, the number of people within the global population living in cities will reach 60 percent of the world population by 2050. Megacities around the world keep attracting numbers of individuals to them. As a result, by 2050 there will be approximate over 20 million inhabitants located in megacities in developing countries alone. This growth projection combined to the total world of the world's population represents an additional 2.5 billion people to urban areas (United Nations, 2014; United Nations University, 2016).

Therefore, it is imperative for governments and institutions to look for better alternatives to manage the increasing urbanization level at the most effective way. With this in mind, the development of new technologies allowed the incorporation of Information and Communication Technology (ICT) applications to urban planning strategies and existing cities promoting innovation and letting cities become intelligent or digital. (Batty et al., 2012; Chourabi et al., 2012; Hollands, 2008; Komninos, 2002, 2009).

All these elements enabled cities to evolve and improve urban planning and prepared the foundations of Smart Cities. Next, we will discuss what a Smart City is and its components.

2.1.3. Definitions and Existing Research

2.1.3.1. Smart City Definitions

Currently, cities face different challenges to provide better management of their services and resources. With the pass of time, the use of technology has become more accessible and easier to incorporate to our daily lives. Cities have also assimilated the use of new technologies to provide better services to their citizens. In addition, there are different applications of new technologies in culture or developing better public transportation, for instance, that have a positive influence improving peoples' lives and on the economy (Albino et al., 2015). Adding more components to the formation of the idea of Smart Cities.

At the time, the definition of a Smart City is fuzzy. Even though, there had been research on this topic since the 1990s, there is still a lack of agreement in providing a definition for a Smart City (Mora et al., 2017).

Institutions also contributed to the effort to define Smart Cities. For the purpose of creating a more consistent concept about Smart Cities and a way to measure them, the International Organization for Standardization (ISO) had created the ISO/TS 37151 (ISO, 2016). This recent initiative aims to help towards a more defined concept and at the same time to make Smart Cities easier to identify. Nonetheless, this initiative will contribute to a more constant parameter when speaking about Smart Cities; this project started in 2015 and it will take time before it becomes a widespread standard for cities, should it receive considerable acceptance.

Additionally, the United Nations defines a Smart City as a place that "ensures access to adequate and affordable housing; provides access to safe, affordable and sustainable transportation systems; enhances inclusive and sustainable

urbanization; safeguards the world's natural cultural heritage; reduces the number of deaths, displacements and losses caused by disasters; reduces their environmental impact; provides universal access to safe and accessible green and public spaces; supports positive economic, social and environmental links between urban and rural areas and integrates technologies and ITC within the different sectors" (Carreiro, 2015, p. 4).

The IESE Business School has studied different elements to elaborate a Cities in Motion Index. That being the case, a City in Motion is a city that improves human capital, stimulates social cohesion in the urban context, promotes economic development, has effective public management and governance, supports sustainable development, facilitates mobility and public transportation, has adequate urban planning, has international outreach and uses ICT to improve the quality of life of their citizens (IESE Business School, 2016a).

Due to the lack of a formal definition, as previously discussed, there are different concepts on the topic of Smart Cities. For instance, some researchers would interchange the terms smart, intelligent or digital cities (Chourabi et al., 2012; Komninos, 2009). In addition, some research has been focused on the emergence of Smart Cities as related to denominations based upon ICT ideas (Zanella et al., 2014) and others criticizing the lack of human capital development (Chourabi et al., 2012; Hollands, 2008).

Additionally, some authors use different attributes to describe and measure Smart Cities (Bakıcı et al., 2013; Batty et al., 2012; Caragliu et al., 2011). Contributing to the well-known lack of standard definition issue.

2.1.3.2. Existing Research on Smart Cities

Between 1992 and 2012, Smart Cities emerged as a field of study. During this period, European authors represented 51.4% of the current Smart City research. As a result, Europe has contributed vastly to the increase in Smart Cities research. In addition, North America is the second largest contributor with over 20% of citations on the topic, as shown in Figure 1 (Mora et al., 2017, p. 12).

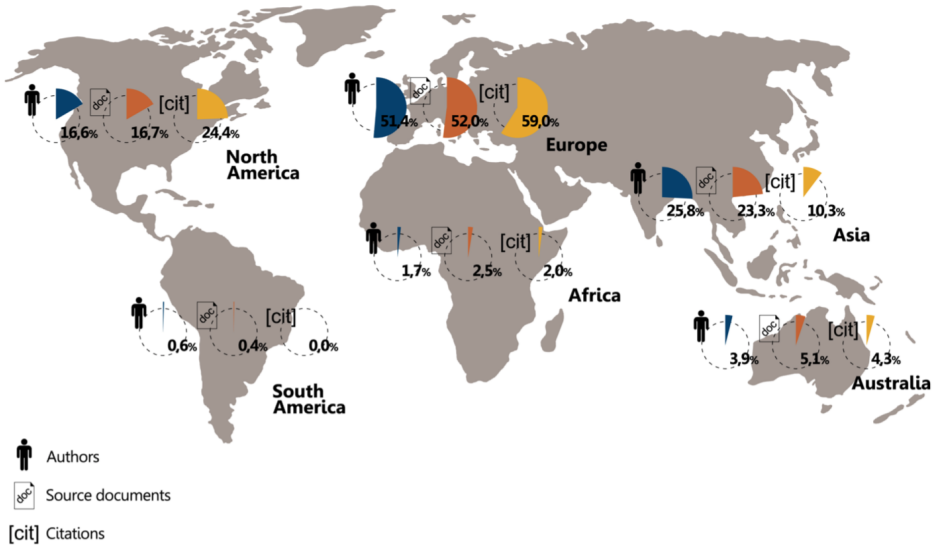

Figure 1 Smart Cities Research: Percentage of authors, source documents, and citations by continents (Mora et al., 2017)

Thus, Europe and North America serve as the largest contributors and knowledge sources for Smart City research. However, the research on these two regions are not similar. In Europe, most research on Smart Cities is performed by academia. These authors represent 68% of the European documents and 2% of the citations. On the other hand, in North America there is a combination of academic and ICT business authors. Whereas, half of the citations is attributed to the latter (Mora et al., 2017, p. 13). Consequently, these different research orientations impact the actual research field.

Overall, concepts can be classified into two main areas of focus, the technology-oriented approach and the holistic approach. The former, as the name

refers to is based upon the different applications of technology in making a city smart (Bakıcı et al., 2013; Batty et al., 2012; Caragliu et al., 2011; Mora et al., 2017; Schaffers et al., 2011). These contributions help the city's governance in areas such as health, transportation and others (Bakıcı et al., 2013; Batty et al., 2012; Mora et al., 2017; Schaffers et al., 2011). On the other hand, the holistic approach, incorporates the technology concept as another component of Smart Cities and adds elements such as environmental, social, cultural and human to offer a more balanced approach (Bakıcı et al., 2013; Caragliu et al., 2011; ISO, 2016; Mora et al., 2017).

The holistic approach is the one that is most used by academia. It was first published by Giffinger and Pichler-Milanović (2007). Stressing that Smart Cities are more than just ICT oriented cities. Cities incorporate ICTs to develop "a city well performing in a forward-looking way in [economy, people, governance, mobility, environment and living] characteristics, built on the 'smart' combination of endowments and activities of self-decisive, independent and aware citizens" (Giffinger & Pichler-Milanović, 2007, p. 11).

As a result, there are many common characteristics that define a Smart City in academia. Therefore, we collected the similarities among a number of authors and elaborated a concept. One that incorporates ecology and sustainability with ICT and infrastructure, governance, urban planning, economic networks and education. Thus, we suggest that a Smart City, as shown in Table 1, is a city improves the quality of life of their citizens by integrating infrastructure, applying ICT, has a better use of economy, provides sustainable development and promotes social development and social infrastructure.

Table 1 Smart City Characteristics

Characteristics	*Authors*
Improve citizens quality of life	Bakıcı et al. (2013)
	Batty et al. (2012)
	Caragliu et al. (2011)
	Chourabi et al. (2012)
	Hollands (2008)
	Schaffers et al. (2011)
Integrate infrastructure	Batty et al. (2012)
	Hollands (2008)
	ISO (2016)
	Schaffers et al. (2011)
Implement information and communications technology (ICT)	Bakıcı et al. (2013)
	Batty et al. (2012)
	Caragliu et al. (2011)
	Schaffers et al. (2011)
Has a better use of economy	Caragliu et al. (2011)
	Hollands (2008)
Provide sustainable development	Bakıcı et al. (2013)
	Caragliu et al. (2011)
	ISO (2016)
Promote social development and social infrastructure	Batty et al. (2012)
	Caragliu et al. (2011)
	Hollands (2008)

Note: Compilation of Smart City characteristics from various authors (Amacifuen-Vilchez, 2017)

As an illustration, one Smart City example is the case of Barcelona, Spain. The authors Bakıcı et al. (2013) conducted research on Barcelona and its transition towards becoming a Smart City. Indeed, they identified the application of ICT into public administration to make it “more accessible, efficient, effective and transparent”. Barcelona’s main motivation to become a Smart City was to remain competitive to attract investment and innovation. By doing so, the city infrastructure promoted the development of a knowledge economy based on the industrial network and clusters to stimulate interactions between social networks, companies, institutions, city hall and citizens (p. 139). The results indicated that Barcelona has succeeded in implementing Smart City strategies that support innovation development, urban growth and improving their resident’s quality of

life (p. 146). Consequently, Barcelona positioned itself as a Smart City model for other cities.

2.1.4. Elements

As well as different authors have different opinions on what a Smart City is, there had been different attempts to clarify the elements that encompass a Smart City. Even though, the elements are related to a definition of a Smart City, we will proceed to explain them to contribute to a better understanding of the concept. Table 2 shows the summary of two complementary approaches. Lombardi, Giordano, Farouh, and Yousef (2012) developed their model based on the triple helix framework. This was used to analyze knowledge-based innovation systems. The authors adapted this framework to apply it to Smart Cities and added one extra agent of knowledge to the components oriented to civil society. After that, they grouped them into five main elements: Smart Governance, Smart Human Capital, Smart Living, Smart Environment and Smart Economy. Overall the authors identified 60 indicators. Despite this contribution the authors missed considering the smart mobility dimension (Albino et al., 2015, p. 14). Another contribution to the elements for a Smart City comes from the IESE Business School (2014), on this work there are ten elements: Human Capital, Social Cohesion, Economy, Public Management, Governance, Environment, Mobility and Transportation, Urban Planning, International Outreach and Technology and Open Data (see Appendix A for a complete list of indicators). These elements cover the previous elements suggested by Lombardi et al. (2012) and also, add new elements for a more comprehensive analysis of cities making it a good indicator to understand Smart Cities.

Table 2 Smart City elements

Author(s)	*Elements*	No. Indicators
Lombardi et al. (2012)	*Smart Governance*	60
	Smart Human Capital	
	Smart Environment	
	Smart Living	
	Smart Economy	
IESE Business School (2014)	*Human Capital*	79
	Social Cohesion	
	Economy	
	Public Management	
	Governance	
	Environment	
	Mobility and Transportation	
	Urban Planning	
	International Outreach	
	Technology and Open Data	

Therefore, as presented on the table above, the second model proposes more detailed elements contributing to the formation of a Smart City and will be discussed in depth in the next section.

2.1.4.1. Human Capital

Komninos (2002) and Hollands (2008) critiqued the techno centric definitions of Smart Cities and requested, a more human related view of Smart Cities. At the time, Smart City and Intelligent City were almost merged concepts. Thus, Giffinger and Pichler-Milanović (2007) made a contribution towards this Smart City element. The authors added the human component, to balance the excessively technological view of Smart Cities, considering the elements of a Smart City and proposing to use these elements to create “aware and independent citizens” (Mora et al., 2017, p. 10). Caragliu et al. (2011) studied

European cities[1] and found a relationship between human capital and urban wealth. Supporting the theories about human capital their influence in economic performance (Lucas, 1988; Mankiw, Romer, & Weil, 1990).

Factors such as education are also relevant to Smart Cities. Since it is related to innovative industries that are always in the look for more educated labour (Berry & Glaeser, 2005; Malecki, 2000). Berry and Glaeser (2005) found the influence that entrepreneurs have in regional clusters attracting skilled labour to cities driven by higher wages.

2.1.4.2. Social Cohesion

Social cohesion has been an element present even since the concept of Ecocities (Roseland, 1997; Urban Ecology, 2016). Social cohesion has been promoted by the European Commission (2016) and it has been implemented in policy since 1992 with the objective of stimulating integration within the European Union members. As an illustration, the city of Barcelona has created a Smart City model integrating social housing, services, and offered new employment to stimulate creativity and cohesion (Bakıcı et al., 2013).

2.1.4.3. Economy

Smart Cities need to develop their economy to encourage the growth of the territory and to sustain innovation and offer better opportunities to generate employment (IESE Business School, 2016a; Schaffers et al., 2011). For instance, non-members of the European Union have more difficulties to attract human capital to impulse the economy in their cities. Because they had failed to provide this connection; as a consequence, it is harder for them to attract wealth (Caragliu et al., 2011, p. 76). Smart economies are also suggested when talking about Smart Cities (Chourabi et al., 2012). Certainly, economy is a vital component in

[1] Caragliu et al. (2011) studied European cities based on the Urban Audit survey data set, from the European Commission, from 2004.

every city. Economies need to be smart enough to be able to integrate all social aspects of society and emphasize the relation of capital and the attainment of new ICTs (Batty et al., 2012). Even more, economy is seen as a “pillar of sustainability” because it provides the funds to improve cities from the micro level to the global level (Hassan & Lee, 2015, p. 1281).

2.1.4.4. Public Management

Is the different process which aims to improve efficiency (IESE Business School, 2016a). This is usually connected to the use of ICTs that tends to improve efficiency and multitasking activities and is associated to urban wealth (Caragliu et al., 2011; Komninos, 2009). As in the case of Barcelona, where the “process of public administration both internally and externally [needs] to be more accessible, efficient, effective and transparent”. Allowing for better collaboration among stakeholders in the city (Bakıcı et al., 2013, p. 139).

2.1.4.5. Governance

Government presence is important to stimulate the need for innovation and to serve as a source of competitive advantage (Schaffers et al., 2011). The use of better ICTs to promote better city governance has been also associated with the concept of cyber cities, where all information is shared in the cyberspace. Urban development and governance facilitated by ICTs is also a new alternative for companies such as IBM, Cisco or Microsoft to contribute the Smart City agenda (Schaffers et al., 2011, p. 437). As an example of the application of eGovernance, the city of Barcelona is part of the Open Data project. “These data involve territory, population, management and procedure indicators, urban environment and documental data” (Bakıcı et al., 2013, p. 144).

2.1.4.6. Environment

The environment is another crucial component of a Smart City. It was due to the consequences of industrialization and pollution that citizens and governments started the Ecocity and sustainability movements (IUCN UNEP, 1980; Register, 1987, 1994; Roseland, 1997) which laid the foundation for today's Smart City ideas. However the importance goes beyond just protection of the environment, to initiatives that help to restore it and raise public awareness (Roseland, 1997). As a result, urban planners have started to incorporate environmental aspects into development. For instance, the Republic of Korea, by 2014, adopted environmental incentives in more than 12 cities (Hassan & Lee, 2015)[2].

2.1.4.7. Mobility and Transportation

There are new ways to implement new ICTs to transportation and mobility to benefit citizens' lives. Transportation networks can "digitally manage the mobility of people and vehicles as well as products in the city" (Schaffers et al., 2011, p. 439). Additionally, existing infrastructure could also be adapted to the new needs (Bakıcı et al., 2013).

Even more, public transportation is associated with wealth. An efficient network of public transportation reduces negative consequences of urban density and reduces costs associated with congestion (Caragliu et al., 2011, p. 74).

[2] "These projects have been implemented through coordination between the Ministry of Land, Transport and Maritime, and Ministry of Public Administration and Security and have been boosted by some Korean technology companies, including Korean Telecom, Samsung, and LG" (Hassan & Lee, 2015, p. 1274).

2.1.4.8. Urban Planning

Urban planning aims to improve the quality of life of their citizens increasing green public spaces leaving room for growth within the city (Hollands, 2008; IESE Business School, 2016a). Determinants for urban planning are also infrastructure “for education and innovation, the networks between businesses and governments, the existence of demanding citizens and businesses to push for innovation and the quality of services” (Schaffers et al., 2011, p. 444). For instance, the city of Barcelona had designed and invested in infrastructure to become a leading metropolitan city, thereby improving the quality of life of its residents in areas such as housing, environmental issues, energy and others to connect people and information for a better city (Bakıcı et al., 2013).

2.1.4.9. International Outreach

A Smart City must also be connected to the world by attracting tourists. Cities with a global exposure benefit from international recognition and attract foreign investment (IESE Business School, 2016a). The effect of economic growth and international tourism has been studied (Balaguer & Cantavella-Jorda, 2002; Bhagwati, 1988; Krueger, 1980). According to Balaguer and Cantavella-Jorda (2002), the earnings from tourism are also influenced by local firms and external competition, increasing the speed of economic growth over time. Also, another way of attracting tourism is with city branding. City branding, besides been a marketing tool (Cova, 1996), can be used as a powerful image-building strategy in order to attract more investment to a city and to promote social inclusion (Kavaratzis & Ashworth, 2005, p. 70; Kearns & Philo, 1993).

2.1.4.10. Technology Open Data

The internet of things (IoT) plays a significant role in the Smart City conception. “Urban IoTs, work seamlessly to support better services for the admiration of the city and their citizens”. The applications for IoT in cities allow

them to produce and store data that can be available in database systems. The IoT has multiple applications in the city life. For instance, sensors could be installed in buildings to detect any vibration or deformation avoiding the unnecessary use of any human intervention towards a better administration of maintenance. Energy consumption can also be improved in roads applying sensors to illuminate streets after a certain hour and other kinds of applications (Zanella et al., 2014, p. 22). Even though, it is important to develop all aspects of a Smart City, there is a special importance on developing ICTs to support the creation of this new initiative while balancing all the other aspects of a Smart City (Komninos, 2009, p. 1). All this technology is coordinated by computerized analytics known as big data, where data could be retrieved in real time. For this reason, data generated has to be properly analyzed, for instance, mobility behaviours could be studied and used for the benefit of the cities and their citizens (Batty et al., 2012).

2.2. Factors affecting the development of Smart Cities

Based on different trends of literature, we synthesized literature in economic geography and industrial clustering (Bathelt, 2007; Bathelt et al., 2004; Jacobs, 1969; Jaffe, Trajtenberg, & Henderson, 1993; Malecki, 1984; Marshall, 1920; Porter, 1995, 2000; Romer, 1990), innovation (Amin & Cohendet, 2005; Bottazzi & Peri, 2003; Coccia, 2011; Cohendet, Grandadam, Simon, & Capdevila, 2014; Ek & Söderholm, 2010; Feldman, 1999; Feldman & Florida, 1994; Guan & Ma, 2003; Sonn & Storper, 2008), and international business (Amin & Cohendet, 2005; Bathelt, 2007; Bathelt et al., 2004; Berry & Glaeser, 2005; Bottazzi & Peri, 2003; Cohendet et al., 2014) to define the factors that affect the development of Smart Cities.

Localised spillovers and research productivity of regions are often related to geographical innovation (Bottazzi & Peri, 2003; Jones, 1995). Geographical proximity promotes interaction between people and firms, as a result, companies are able to stay innovative (Sonn & Storper, 2008, p. 1020). Previous discoveries can be used to build on innovation (Bottazzi & Peri, 2003, p. 689; Jaffe et al., 1993). Particularly, the relationship between innovation and industry location has been measured by the number of patents. Even though, patents do not reflect all innovative activity, they are still a good representation of regional innovation (Porter, 2003, pp. 550-551). In addition, patents relative to the GDP per capita have been used as another method to test innovation. On their research Fagerberg and Verspagen (2002) found that increases on GDP per capita are positively associated with innovative activity (patenting) (p. 1298), thus having an impact on economic growth.

Creation and commercialization of new technology are important factors for the development of a region and the cities where the goods are produced (Hollanders & Es-Sadki, 2017b, p. 12). In addition, it has been studied that innovation capability is related to export growth (Guan & Ma, 2003). Also, exports in high-tech are used to measure technological competitiveness such as innovation in international markets or ability to commercialize the results of R&D and product specialization (Guan & Ma, 2003).

The innovation capacity of a region is considered to be an R&D externality (Bottazzi & Peri, 2003, p. 688) due to the effects of R&D spillovers onto regions in cases of spatial proximity (Jones, 1995; Romer, 1990). The impact of spillover effects has been studied in European countries, especially in projects generated by the government. For instance, R&D expenses are used to promote collaboration with other European countries, such as the European Wind Power Association (EWEA) (Ek & Söderholm, 2010). Public R&D activities relative to GDP have been used to measure productivity growth (Coccia, 2011; Ek & Söderholm, 2010).

Also, it is important to take into account the presence of different networks, such as social diversity and density of employment within a region (Lazzeretti, Domenech, & Capone, 2009, p. 14; Porter, 2000), a way to measure this by the land coverage of a region.

Smart Cities are in direct connection with urban-regional planning and innovation. Smart Cities are essential to foster knowledge-based economies for urban-regional planning. In regards to innovation, Smart Cities are critical to further knowledge. The combination of local assets and innovation activities help Smart Cities to progress and overcome the challenges in a global scale (Komninos, 2009, p. 338). Moreover, it is important to develop cluster-based strategies in regions and cities to promote innovation locally and globally. Fostering these settings are beneficial to enhance new knowledge and business models supported by collaboration and technology transfer worldwide (Komninos, 2009, p. 337). With this in mind, we propose two main factors that are relevant for this research: clusters (regular sector clusters, knowledge intensive clusters) and international collaboration.

Knowledge intensive clusters are mostly located in urban areas. Urban areas attract and congregate a large number of skilled labour and offer a large number of public services (Malecki, 1984). In addition, universities provide a large range of knowledge intense activities, promote research and prepare human capital for public and private sectors (Anselin et al., 1997). These knowledge intensive activities along with research provided by universities spread throughout urban areas influencing its economic activities (Amin & Cohendet, 2005; Anselin et al., 1997). Thus it is important to measure the influence of knowledge intensive clusters on Smart Cities.

Clusters are a great source of local knowledge. Urban and metropolitan areas are deeply influenced by knowledge sharing. Due to the constant

interaction of firms and agents within the value chain, clusters are rich in information and knowledge. This information could be shared in formal and informal settings stimulating collaboration and innovation (Cohendet et al., 2014). Clusters in regular sectors develop important relationships and collaboration that generate spillovers in the form of skills, new technologies and information. Moreover, the influence of clusters in regular sectors extends beyond geographical borders (Porter, 2000, p. 18). As a result, knowledge spillovers are also beneficial to the area where the clusters are located. For this reason, clusters play an important part developing regions and influencing cities to become smarter.

Clusters are a great source of knowledge, but they have limitations in terms of the amount of innovation that could be generated within the cluster. Therefore, it is important to develop relations outside the local cluster (Jacobs, 1969) in the form of international collaboration. For this reason, collaboration with global networks, or pipelines, is another great source of information. Once a company is part of a global network, it can access a great amount of knowledge. Thus, companies need to cultivate trust relations and to promote international collaboration with other companies in the global network, in order to decode and interpret the information available within the pipeline (Bathelt, 2007; Bathelt et al., 2004). Once this is achieved, the information is shared within the region where the firm is located and as a result, creating positive externalities in the area. For this reason, international collaboration has a regional effect that is related to the creation of Smart Cities.

It is important to establish the effect of regions on Smart City growth. Porter (1995) associated regional economic development to cities. On his research he highlighted the influence of nearby clusters, both local and global. First, regional cluster proximity to cities is a business opportunity for companies that are a part of the value chain. Companies that are close to different clusters in a region have the opportunity to increase market share. Then, companies also have a business

opportunity to offer their products in a global scale. Companies also require different degrees of skilled labour depending on the activity to perform in the value chain. As a result of the integration with regional clusters cities develop competitive advantage in the long term (Porter, 1995). For that reason, this research will focus on the effects of regions on the emergence of Smart Cities.

2.2.1. Importance of Clusters

A very well-known definition of clusters is the one explained by Porter (1998):

> *"[Clusters are] geographic concentrations of interconnected companies and institutions in a particular field" (Porter, 1998, p. 78).*

Geographic clusters are important for firms to compete, cooperate and to promote competitive advantage. Clusters create network connections that are essential for production activities stimulating innovation due to the knowledge exchanged by firms, suppliers, government and other institutions. Hence geographical areas benefit from these local interactions and promote positive externalities (Marshall, 1920; Porter, 2000). Smart Cities are often related to innovation. These innovations are not only technological but also related to all aspects of a city (Bakıcı et al., 2013). Developing cluster-based economies in cities and regions lead to increased innovation beneficial to Smart Cities helping cities to foster knowledge-based activities impacting local and regional economies due to their relation to innovation (Komninos, 2009, p. 338). Thus, it is important for Smart Cities to promote a cluster-based economy to increase knowledge locally and regionally.

On their research, Baptista and Swann (1998) and Feldman (1999) found that firms that have bigger market share also tend to innovate more, depending on the activity. Resulting in an increase of productivity (Capello, 2009) causing an effect in the economic activity (Feldman, 1999).

Besides the location and geography of a cluster, there are spillover effects that can spread throughout the clusters (Baptista & Swann, 1998) and even to the peripheral regions (Capello, 2009) reaching cities. On their studies Baptista and Swann (1998, p. 538) found strong statistical result to support the relation between cluster strength and innovation, as well as the influence of clusters in relation to growth. Clusters promote information exchanges in an informal setting due to the different face-to-face interactions between the diverse participants within the cluster (Breschi & Lissoni, 2001).

As a consequence, spillovers tend to increase cluster growth rapidly; thus, attracting more resources to the region from the surrounding areas in the form of higher-educated workers, financial investments and more efficient firms. Overall, accelerating the economic progress of regions compared to others. Cities, especially the ones that are the region's capitals, benefit from diversity and the productive structure (Lazzeretti et al., 2009, p. 21) that leads to innovation. More importantly, spillovers have a proven growth effect in Europe, where "mega" regions and capital cities such as London, Paris, Milan, Munich and Brussels experience a significant growth, compared to the rest of the region, thereby spreading this effect to the peripheral territories that benefit from the spillover effect (Capello, 2009, pp. 655, 656). Indeed, cluster locations and knowledge spillovers are not limited to the political geographical borders (Porter, 1998).

2.2.1.1. Knowledge Intensive Clusters

Hollanders and Es-Sadki (2017a) defined knowledge intensive activities as:

> *"Knowledge-intensive activities provide services directly to consumers, such as telecommunications, and provide inputs to the innovative activities of other firms in all sectors of the economy" (Hollanders & Es-Sadki, 2017a, p. 88).*

A city's true economic base is not exclusively its manufacturing activity. Cities need to promote innovating activities to generate new firms and adapt to changing technological conditions in their urban area (Thompson, 1965). Smart Cities congregate a variety of digital knowledge intensive activities in the form of digital networks and software applications helping cities perform social and economic tasks such as, health, security, education, transport, commerce and others (Komninos, 2006, p. 15). The influence of ICT infrastructure on economic development is important for Smart Cities. Availability of ICT systems contribute to economic performance increasing the smartness of regions as they provide tools to facilitate research in urban innovation. For this reason, the European Union is invested in ways to achieve smart urban growth in metropolitan areas (Caragliu et al., 2011, p. 67; Roller & Waverman, 2001). Knowledge intensive clusters stimulate competition beneficial to Smart Cities, cultural and geographical proximity motivate companies within a cluster to innovate contributing to the formation of new ideas for the Smart City (Hielkema & Hongisto, 2013, p. 195).

Knowledge intensive activities can be performed by all kinds of firms despite their size. All companies, from large corporations to local firms, that employ skilled professionals have an equal opportunity to influence the economy. In particular, firms' headquarters or R&D departments need to have availability of skilled employees Metropolitan areas offer a great variety of universities and cultural activities where skilled workers could locate and even switch jobs without having to relocate (Malecki, 1980, 1984). Knowledge intensive clusters contribute to open the innovation system involving different stakeholders and technology infrastructure (Hielkema & Hongisto, 2013, p. 196) to generate wealth to the regions.

Some examples of knowledge intensive clusters in the United States are: Northern New Jersey, Boston, San Francisco Bay and Los Angeles area. These urban areas offer not just the opportunity to employees to change jobs but also,

these are well established regions with good public services and large universities (Malecki, 1984).

In fact, localized R&D spills result from the amount of resources shared among nearby regions that affect the productivity of R&D (Bottazzi & Peri, 2003, p. 688). To illustrate this Bottazzi and Peri (2003) studied R&D patents in European regions to measure innovation spillovers and found that R&D spillovers diffuse within 300 kilometres from their source region. Moreover, their research found that spillover effects from R&D activities in clusters expanded from periphery regions to central regions equally.

Studies in innovation at the regional scale underline the importance of knowledge infrastructures and organizational networks of innovators (Audretsch & Feldman, 1996; Von Hippel, 2007). In regions with strong knowledge intensive clusters universities play an important role providing specialized workforce and research (Anselin et al., 1997, p. 423; Hielkema & Hongisto, 2013, p. 197). University research is important because it originates as a public good and then spills over the private sector stimulating innovation, and as a result creates positive externalities (Anselin et al., 1997). Cluster location becomes attractive to private sector R&D and high technology production because of knowledge spillovers effects and human capital attraction (Malecki, 1980). Universities work together with knowledge intensive industries to find solutions to industry problems. Consequently, this environment supports companies in the knowledge intensive cluster and also facilitates the emergence of startups in the sector supporting diversification of technological industries and contributing to the ecosystem of the Smart City (Hielkema & Hongisto, 2013, p. 197).

Concerning knowledge spillovers in technological clusters, the differences can be explained by Iammarino and McCann (2006) as they determined that knowledge spillovers vary according to the scope and the kind of cluster. For instance, large and small firms that are located in technological clusters can gain

from industries' spillover that appear from interactions within a "social network" system (Iammarino & McCann, 2006, p. 1031).

Clustering is an important phenomenon, especially in Europe. For example, in the technological industry policy makers encourage the industry to promote cluster collaboration. Because, being close to a geographical location not only has the advantages mentioned before for firms; but also, it offers the advantages of benefiting from spillovers to stimulate the innovation process (Amin & Cohendet, 2005; Baptista & Swann, 1998).

Some authors found that innovation is a geographical advantage on its own adding a locational advantage to the region where innovation is produced (Komninos, 2009; Marshall, 1920; Porter, 2000). Particularly, in technology a region that already reached a certain level of innovation, would facilitate new projects that can make use of the existing new technologies (Baptista & Swann, 1998; Feldman & Florida, 1994). Therefore, high technology innovation clusters "generate rapid technological advances" (Cowan & Jonard, 2003, p. 529). Indeed, previous research showed the relation of knowledge intensive clusters and Smart Cities (Bakıcı et al., 2013; Hielkema & Hongisto, 2013). Bakıcı et al. (2013) created a framework to assess Barcelona as a Smart City. The authors highlighted the importance of innovation clusters to promote interactions between firms, governments and cities to eventually create a knowledge society. Hielkema and Hongisto (2013) studied the Mobile Application Cluster from the Helsinki Region, where the municipality is making efforts to promote Open Data infrastructures to developers in the cluster to generate innovative ideas and compete locally and globally and as a result helping Helsinki to become a Smart City.

In addition, on the subject of innovation, it is also known that knowledge intensive clusters "generate rapid technological advance" (Cowan & Jonard, 2003, p. 529). Collective invention has occurred historically in different places and

times. As a result, innovation had also created technical advances (Cowan & Jonard, 2003, p. 529).

In particular, technological companies with departments participating in clusters benefit from a spillover effect, even if the innovation comes from a different location; which contradicts the general arguments about the geographical boundaries, but reaffirms the fact that, technology oriented industries tend to be grouped in clusters to gain from the spillover effect (Baptista & Swann, 1998).

Hypothesis 1a: The presence of knowledge intensive clusters within a region are positively associated with the formation of Smart Cities.

2.2.1.2. Regular Sector Clusters

Although knowledge intensive clusters are a significant factor for this research, we cannot overlook the importance of clusters in regular sectors. Clusters in regular sectors are essential to develop connections with companies, information, skills, marketing and customer feedback from firms across other clusters. These different interactions between companies and industries promote spillovers increasing innovation (Porter, 2000, p. 18). Therefore, it is relevant to explore the effects of clusters in regular sectors.

It has been shown that firms' innovation is directly related to geographical concentration due to the synergy between firms, industrial activity, and support centers that emerge with time (Baptista & Swann, 1998; Feldman & Florida, 1994, p. 226) the interconnection with these actors contribute to the origin of clusters (Porter, 2000). To illustrate, in the United States, the state of California has an important technology cluster in Silicon Valley that specializes in electronic innovations; or even Hollywood is another familiar example (Porter, 1990).

Moreover, cities attract high levels of human capital, gathering skilled people to metropolitan areas. As a result, companies increase innovation levels within these geographic areas across industries. Moreover, the number of these innovative areas increases with the development of better industries. Hence, metropolitan areas are also influenced by this force and eventually cities could grow in their innovation and skill structure (Berry & Glaeser, 2005; Malecki, 1984).

In addition, other institutions and human talent are also attracted by the economic activity that is generated in the region. Therefore, these regions or clusters develop a comparative advantage for innovation; and as a result, these regions create economic development due to the new-formed location advantage (Feldman & Florida, 1994, p. 226). In his research, Hollenstein (2003) investigated the effect of clusters and found that firms within a regular sector cluster benefit from the information that circulates within the cluster. An example of the reach of a cluster is the wine cluster in California, where wineries interact with other companies such as grape growers, wine makers, “including suppliers of grape stock, irrigation and harvesting equipment, barrels, and labels; specialized public relations and advertising firms; and numerous wine publications aimed at consumer and trade audiences” (p. 78). Additionally, other institutions are also part of this cluster, such as the University of California at Davis that offers an enology program, the Wine institute and lobbyists at the California senate and assembly (Porter, 1998, p. 78).

It has been studied that innovation occurs when companies of the same industry interact (Bottazzi & Peri, 2003; Feldman & Florida, 1994; Harrison, 2007). However, firms are not solely influenced by the information that circulates within regular sector clusters. Firms are still free to select the most effective economic strategy. However, firms are still restricted by their location and also by the hierarchy that other firms have over the innovation intensity within the cluster (Hollenstein, 2003, p. 860). Hence, competition between firms is another factor that influences regular sector clusters to innovate (Porter, 2000). Porter (2000)

suggests that regular sector clusters benefit firms due to the information that resides in the cluster. On a study, Baptista and Swann (1998) showed that firms that are part of a cluster in a strong industry are on average more innovative than firms that are not part of one. In addition, companies that are part of a highly competitive setting tend to innovate more. Supporting Porter (1990) conclusions that innovation is incentivized by rivalry.

Therefore, clusters in regular sectors benefit companies because of the enhanced knowledge; additionally, minimizing information costs compared to companies that are not part of the cluster (Cowan & Jonard, 2004). Given these points, the combination of local interactions (such as spontaneous reunions, information flows and others) with interactions across translocal connections promote knowledge creation (Bathelt, 2007, p. 1290). Moreover, innovations are more likely to occur in locations created to promote the highest opportunity where they will be concentrated in the form of clusters. Furthermore, Feldman (1999) found that companies enjoy spillover effects when these are located in a geographical region contributing to innovation that can be transferred to material products, patents and even people related to the activity. As a result, the reach of the spillover effect is also limited to the geographical extension of the cluster itself (Bathelt, 2007, pp. 20 - 21).

In brief, clusters in regular sectors have in important effect in cities because: They promote knowledge spillovers that foster innovation; and collaboration within the region they operate and generate positive externalities reaching cities. As a result, the location where regular sector clusters are established benefits and grows.

Hypothesis 1b: The presence of clusters in regular sectors within a region are positively associated with Smart City creation.

As previously discussed knowledge intensive clusters and regular sector clusters favour innovation due to the exchange of knowledge inside the clusters and the different collaborations with other stakeholders. However, companies in a knowledge intensive cluster often operate in an international market. For this reason, knowledge intensive companies have a bigger pressure to innovate to compete locally and globally. Hence, a great number of knowledge intensive companies are born globals and need to develop different strategies in management and marketing than regular sector companies therefore, companies in a knowledge intensive cluster are exposed to competition and collaboration outside the regional cluster. Thus, knowledge intensive companies benefit from external knowledge that can meet global market demands from an early stage (Hielkema & Hongisto, 2013, p. 198).

Knowledge intensive companies require continuous renewal of technologies. Knowledge intensive clusters provide networks to facilitate innovation, these networks often provide with digital spaces and shared IT applications to stimulate technology transfer among institutions, R&D centers, companies and others (Komninos, 2006, p. 15).

Knowledge intensive clusters promote exchanges among different participants such as, living labs, technology parks and technology districts. These collaborative platforms are well integrated via communication infrastructure, knowledge management tools and systems to facilitate innovation. In addition, this environment promotes an innovation environment beneficial for community and institutional interaction (Komninos, 2006, p. 19). As a result, knowledge intensive clusters provide digital tools and spaces to foster collective knowledge critical for Smart City sustainability.

Lastly, Caragliu et al. (2011, p. 77) found strong evidence of knowledge intensive activities and Smart Cities in Europe. They measured human capital related to knowledge intensive activities, urban transportation networks and

diffusion of ICTs. All these had a positive association to urban wealth, contributing to Smart City growth.

Hypothesis 1c: The presence of knowledge intensive clusters within a region are more likely to affect the formation of a Smart City when compared with regular sector clusters.

2.2.2. Global Networks - International Collaboration

Clusters in regular sectors are beneficial to firms participating in these clusters. Those firms are bounded by a similar language and develop common technological knowledge (Bathelt, 2007, p. 14). However, according to Cowan and Jonard (2004, p. 1572) too much clustering could be counterproductive to innovation. With regards to network theory, this is defined as cliquishness, which is explained as “the proportion of pairwise relationships over the possible total number of relationships” (p. 1560) reducing innovation due to the closeness of the group (Cowan & Jonard, 2003, 2004; Iammarino & McCann, 2006; Uzzi & Spiro, 2005). The cliquishness results in sharing similar information. That is why, the authors place emphasis on the importance of maintaining diverse strong ties outside the cluster (Cowan & Jonard, 2004, p. 1572), such as international collaboration, to promote innovation.

Networks of firms could have a worldwide extent; this represents significant knowledge sharing opportunities for firms. Companies could expand their knowledge outside the local cluster (Bathelt, 2007; Bathelt et al., 2004; Porter, 2000). This could have spillover effects on the local firms and more importantly an effect in the region (Porter, 2000). Thus, networks are a factor to analyze to allow for a better understanding of how Smart Cities are created.

In industrial systems, firms take part on multiple activities of the value chain. These systems are also known as networks of relationships among firms. Networks of firms interact and are free to choose counterparts (Johanson & Mattsson, 1987, pp. 34, 35). As a result, networks are important systems for transmitting information (Jackson, 2008). Because firms are established, most of the time, in urban areas and interact with diverse partners locally and globally; these are important for Smart Cities.

Social networks not only affect relationships between individuals; but also, at a larger scale they influence the economy within a specific location (Jackson, 2008, p. 17).

In addition, companies are also part of networks. Therefore, the structure and quality of the connections, or ties, also influence the creation of opportunities for a firm. Moreover, the type of network and the dynamics where a firm is embedded[3] will allow it to utilize opportunities and also position itself within the structure. Furthermore, the network itself also has physical limitations, as a result, the effects of a network are also constrained by its structural location (Uzzi, 1996, p. 675).

Collaborations within firms in the network help to develop trust; as a consequence, collaborations increase, and opportunism decrease within the network. Hence, firms benefit from cohesiveness among their partners (Ahuja, 2000; Casper, 2007; Gordon & McCann, 2000; Johannisson, Ramírez-Pasillas, & Karlsson, 2002; Uzzi, 1996). For Gordon and McCann (2000, p. 529) information is an embeddedness indicator, but when speaking about firms a stronger indicator of embeddedness could be given by “involvement in joint-ventures, lobbying activity, mutual-support networks or common patterns of socialization, along with means of controlling membership of the network”.

[3] Embeddedness refers to the strength of the relationship within the social network (Gordon & McCann, 2000, p. 520). On his research Uzzi (1996, p. 693) suggests that embeddedness is the exchange that can influence intentions and at the same time stimulates harmonized changes.

Therefore, relational embeddedness is important in the diffusion of innovation in networks (Grewal, Lilien, & Mallapragada, 2006; Simsek, Lubatkin, & Floyd, 2003, p. 434).

In addition, Kogut (2000) defined an economic network as the relation and interactions among firms and institutions (Kogut, 2000, p. 407). The ability of a firm to access the information within the network creates an advantage. For the author, sharing information is not product of casual interaction, but a bargain based upon contributions and compensation. Network structures influence sharing via communications. Therefore, as knowledge spreads through the network, it adds value (Cowan & Jonard, 2003, p. 529). Thus, in order to exploit information companies must be able to coordinate internal knowledge with the knowledge acquired from the network. Once this is achieved, then companies can have a competitive advantage on other firms (Kogut, 2000).

Networks generate multiple opportunities to firms. For instance, firms in new industrial clusters, such as in the aerospace industry, incorporate the regional supplier base of the cluster and take advantage of the global supply chain in early stages of their development (Turkina, Van Assche, & Kali, 2016, p. 11). For this reason, it is important that firms accomplish the right balance between local networks with exposure to external networks (Scott, 1988).

Relations outside the cluster are important in order to stimulate innovation (Cowan & Jonard, 2004) and to collect information (Bathelt, 2007). Yet, developing new relations and maintaining external connections involve considerable time and effort (Bathelt et al., 2004). There is a cost of maintaining sub-regional translocal relations in that it requires the development of trust and prosperous firm relations; which, makes knowledge transfer in an informal setting more difficult than in a casual translocal exchange of information (Bathelt, 2007). Thus, relations develop over regular communications and interaction throughout a period of time. In the case of external networks, companies can share with

others around the world. In addition, once firms have developed such relations "information and news about markets and technologies are *pumped* into internal networks" for the benefit of the local network (Bathelt et al., 2004, p. 41). This can represent a great advantage for companies seeking for better technologies and process. Once a pipeline[4] has been established in a network, a company could benefit from information well beyond their local cluster. Moreover, the benefits of global pipelines are the exposure to multiple environments and the opportunity to incorporate the knowledge in a local setting (Bathelt et al., 2004, p. 42). Thus, this knowledge brought to the region could spill over to the cities located near the cluster.

However, accessing information is not the most important task. Firms have to be able to interpret, or even translate, the information that flows in the pipeline (Bathelt et al., 2004; Cowan & Jonard, 2001). In order to establish a successful pipeline network, companies need to develop a "shared institutional context" (p. 43) to collaborate in problem-solving, learning and knowledge creation (Bathelt et al., 2004). Thus, it is important to cultivate relations and foster trust (Harrison, 2007; Owen-Smith & Powell, 2004). Consequently, a firm must select the number of pipelines they could manage at the same time to obtain the most benefits from the connection (Bathelt et al., 2004).

Figure 2 summarizes the importance of pipelines. A well-developed pipeline is one that connects the cluster to the rest of the world, thus providing a beneficial effect for the firms within the cluster. Clusters can obtain knowledge from outside the local cluster, anywhere in the world and gain competitive advantage. After this information is assimilated by the firm, that information will spill over to the rest of the firms within the cluster. However, as mentioned before, there are limits to the number of pipelines a company can maintain to benefit from a competitive edge. This is the main advantage of cluster participation, firms

[4] Owen-Smith, J., & Powell, W. W. (2004) use the tem "pipeline" to refer to channels designed to exchange information and interactions (p. 6).

within a cluster can manage information in a more efficient way than a company alone (Bathelt et al., 2004).

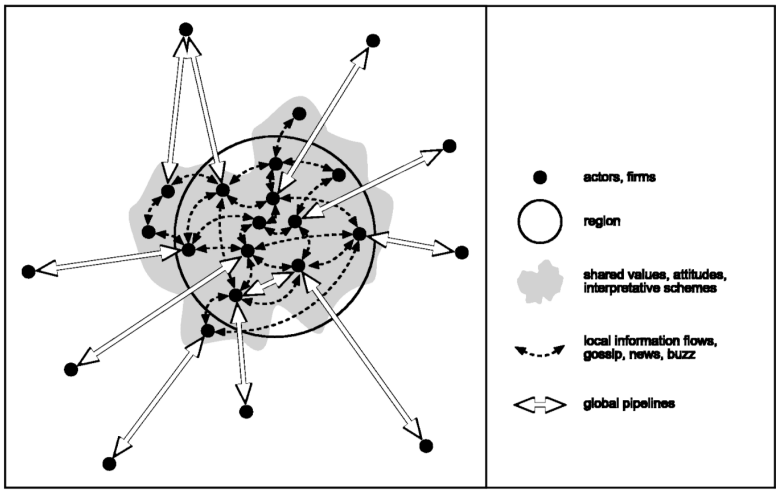

Figure 2 Structure and dynamics of clusters and global pipelines (Bathelt et al., 2004)

In sum, companies that interact in a pipeline develop trust which helps to share information and, as a result, promotes regional growth (Harrison, 2007, p. S115) that could then spillover to cities.

Hypothesis 2: External connectedness is positively related with the formation of Smart Cities.

Part 3

3. Data Description

3.1. Data Sources

This research includes data generated from two institutions sponsored by the European Commission and an academic source.

The first dataset was extracted from Eurostat, the statistical office of the European Union. Which role is to provide high quality statistics to the "Commission and other European Institutions with data so they can define, implement and analyse Community policies" (p. 1). Eurostat has been recognized by the European Foundation for Quality Management as *Committed to Excellence,* in 2016. Eurostat's databases are public, and as such, accessible to anyone looking for objective statistics in the region (Eurostat, 2018).

Unlike individual databases, Eurostat compiles data at European level and provides comprehensive information about general and regional statistics, population and social conditions, economy and finance, industry, trade and services, external trade, science and technology, among others. Even more, Eurostat receives data from Member States and collects it to make sure all data

is comparable. Making Eurostat the only provider of Statistics at European level that offers the most harmonized data (Eurostat, 2018). Therefore, this database is an abundant source of information to analyze the present topic.

The Regional Innovation Scoreboard (RIS), a regional extension of the European Innovation Scoreboard, was created to measure innovation in Europe on a limited number of indicators. It offers a detailed analysis to compare structural differences between regions (European Commission, 2018b). To develop this scoreboard, the RIS relayed on statistical information from Eurostat to determine the most innovative regions in Europe. This information is available through a public domain and is administered by the European Commission. This information is deeply concerned to regional innovation. Thus, it is a very meaningful data for this research.

The second dataset, also promoted by the European Commission, is the European Cluster Collaboration Platform (ECCP). The ECCP's role is to stimulate cluster cooperation within the European Union and to help clusters access international markets. By fostering international cooperation and partnerships to help European companies to become part of global value chains. At the time, the ECCP counts with information about over 950 registered cluster organizations from all over Europe that are part of the ECCP (European Commission, 2018a). For this reason, the ECCP is a great source of current information about European clusters that are relevant to this research. Data was generated from the ECCP's current clusters in industries related to innovation.

The third and last source comes from the academia. The IESE Business School has created a research platform "to create knowledge and innovative tools that generate smarter local governments. This initiative brings together [an] international network of experts, specialized companies and worldwide local governments." (p. 1). With this in mind, they created the *IESE Cities in Motion Strategies* to integrate the private sector and help local governments to develop

smart solutions to create sustainable ecosystems and generate more opportunities for citizens (IESE Business School, 2018).

Particularly, the IESE Business School has developed a tool in order to understand cities' performance regarding sustainability, innovation, connectivity and social cohesion. They designed the *Cities in Motion Index.* By doing so, they analyzed 77 attributes based on 10 aspects of the urban life, and had created an index that compares 181 cities of 80 countries around the world (IESE Business School, 2016b). According to this framework, Cities should be based on: human capital, social cohesion, economy, public management, governance, environment, mobility and transportation, urban planning, international outreach, and lastly, technology and open data (IESE Business School, 2016b). This framework aligns with a holistic approach to Smart Cities. Thus, due to the thorough analysis and the global sample the IESE is capable of producing a very useful tool for this research.

3.2. Sample

For this research, the data selection used was based on a regional level in Europe. We used a simple random sampling method, in order to provide equal chance of selection (Leavy, 2017). Thus, we selected European regions to analyze according to their population size. In order to have a meaningful and unbiased sample, we selected the top five most populated regions in European countries[5]. In the case of Cyprus, Estonia, Latvia, Lithuania, Luxembourg, and Malta information was included at country level[6]. The datasets imported from Eurostat provided regions according to the Nomenclature of Territorial Units for Statistics (NUTS). The NUTS classification (Nomenclature of territorial units for

[5] The sample included the 28 member countries of the EU, Norway, Serbia and Switzerland.
[6] The data available for these countries is identical at the regional and country level (NUTS 1 and NUTS 2).

statistics) is a "hierarchical system for dividing the economic territory of the EU[7], which distinguishes between three levels: NUTS 1 captures major socio-economic regions, NUTS 2 captures basic regions for the application of regional policies […]" (Hollanders & Es-Sadki, 2017b, p. 13). For the purpose of their research, Giffinger, Fertner, Kramar, and Meijers (2007) employed information from Eurostat corresponding to the NUTS 2 category in order to elaborate a European city index. With this in mind, we used the same nomenclature in all subsequent datasets imported from Eurostat and the rest of the sources.

Most of the data sample for the control variables was provided by the Regional Innovation Scoreboard (RIS)[8]. The RIS measures the innovation performance of European regions using detailed information (Hollanders & Es-Sadki, 2017b). The RIS' indicators selected for this research used data from Eurostat.

Subsequently, we generated data from the European Cluster Collaboration Platform[9]. The clusters selected corresponded to the largest R&D investment industries in the world, according to the *European Union Industrial R&D Investment Scoreboard* (IRI, 2017). We used data on R&D intensive clusters because of their capacity to drive innovation (Audretsch & Feldman, 1996; Hall & Bagchi-Sen, 2002; Kelm, Narayanan, & Pinches, 1995). Thus, for this sample we selected clusters in Aerospace, Automotive Biopharmaceuticals and IT & Analytical Instruments, corresponding to industries used in the *European Union Industrial R&D Investment Scoreboard* (IRI, 2017). In addition, we collected the number of international clusters in collaboration with the local cluster. Afterwards,

[7] The NUTS classification is available EU Member States, and also candidate countries, potential candidate countries and countries part of the European Free Trade Association (EFTA), including both Norway and Switzerland.

[8] For this research we used the last 3 years available from the Regional Innovation Scoreboard (2013, 2015 and 2016) http://ec.europa.eu/growth/industry/innovation/facts-figures/regional_en

[9] https://www.clustercollaboration.eu

we identified the region where each cluster is established was also classified according to the NUTS category.

Lastly, the dataset from the IESE Business School was selected from the *IESE Cities in Motion Index.* European cities were elected from the complete index respecting their position in the index. After that, they were matched to their corresponding region according to NUTS categories.

For all datasets, we collected yearly information from 2013, 2015 and 2016 inclusively; to have a more accurate information of the regional data. In addition, more variables are added from Eurostat to complement the sample. These variables will be further described in the next section.

The total sample consisted of 109 European regions and 327 total observations. Furthermore, data analysis, statistical tests and tables had been produced using STATA.

Part 4

4. Methodology

In the previous section we presented the data used on this research in order to determine the factors that influence the rise of a Smart City in Europe. In this section we will proceed to validate the hypotheses throughout robust statistical tests. Data will be described in more depth using descriptive statistics and Pearson correlations.

4.1. Research Design

4.1.1. Quantitative Research

For this research we examined the effect of networks and innovative activities on cities. In order to investigate further, we conducted quantitative research. Quantitative research determines statistically significant conclusions about a population by examining a sample of the population (Creswell & Creswell, 2017) by testing the effects of an independent variable on a dependent variable (Lowhorn, 2007). For the aforementioned reasons is the best fit to investigate this matter.

4.1.2. Dependent Variable

4.1.2.1 Smart Cities

To determine the number of Smart Cities from the total number of European Cities. We used the *IESE Cities in Motion Index.* We selected this index because of their consistency and reputation on assessing worldwide cities. Due to the number of indicators they use, the *IESE Cities in Motion Index* provide an objective view of cities' performance. In addition, this index evaluates cities in a holistic dimension which makes it a great tool for this research.

The importance of city rankings is explained by Giffinger et al. (2007):

> *"Amongst other instruments the comparison and ranking of cities is one of the most productive approaches to identify a city's comparative advantages, potentials and weaknesses in relation to other cities."*
> *(Giffinger et al., 2007, p. 5)*

We started by collecting yearly indexes. Once we collected the total cities from the index by year, we selected the cities located in Europe. After that, we respected their position in the index and then we matched them to their corresponding NUTS category. Finally, data was normalized.

4.1.3. Independent Variables

4.1.3.1 Clusters

4.1.3.1.1 Knowledge Intensive Clusters

First, we needed to collect information regarding knowledge intensive activities. We collected the dataset in employment information in knowledge intensive sectors from the science and technology section for population aged 15

to 64. Then, we gathered information about all regional employment for populations 15 to 64 years of age. Both provided by Eurostat, including their respective NUTS category.

After that, we used the location quotient (LQ) formula for each European region to measure the region's specialization in knowledge intensive industries as applied by the European Cluster Observatory (Ketels & Protsiv, 2016). According to this formula, values over 1 indicate the presence of a cluster. Therefore, we collected regions with values over 1. All values below 1 were not considered as cluster presence. Thus, values below 1 were represented as zero. Then, data was normalized.

$$LQ\iota = (e\iota/e)/(E\iota/E)$$

where,

$LQ\iota$ = Location quotient for sector in the regional economy

$e\iota$ = Regional employment in industry ι

e = Regional total employment

$E\iota$ = European employment in industry ι

E = European total employment

The fact that a region is more specialized in a specific cluster compared to the overall economy in all regions, indicated that "the regional cluster is strong enough to attract related economic activity from other regions to this location, and that spill-overs and linkages will be stronger" (Ketels & Protsiv, 2016, p. 7).

4.1.3.1.2 Regular Sector Clusters

To determine cluster presence in the regions, we used once again information provided by Eurostat. Thus, we collected information from Eurostat for regular employment activities for population aged 15 to 64. Then, we gathered

information about all regional employment for populations 15 to 64 years of age (Hollanders & Es-Sadki, 2017b). Both lists contained information according to their corresponding NUTS category.

Afterward, we applied the LQ formula (Ketels & Protsiv, 2016), used in the previous variable, to detect the presence of regular clusters in the region. Like in the previous step, values over 1 represent the presence of a cluster. In this case, we aimed to detect strong specialized clusters. LQ of 2 indicates the presence of strong clusters in regular sectors in the region, it corresponds to twice the number of employees in an industry (Ketels & Protsiv, 2016, p. 7). Hence, we collected regions with LQ values over 2. All values below 2 were not considered as cluster presence. Thus, values below 2 were represented as zero. After that information was normalized.

4.1.3.2 International Collaboration

In the case of international collaboration, we used information from the European Cluster Collaboration Platform. This dataset was manually elaborated.

First, we identified clusters in innovative sectors from the European Cluster Collaboration Platform's database, according to the *European Union Industrial R&D Investment Scoreboard* (IRI, 2017). On the European Cluster Collaboration Platform database each cluster provides information about their country and region of origin. Each cluster location was paired to their corresponding NUTS category. Since collaboration outside the cluster is important in order to promote innovation (Bathelt et al., 2004; Cohendet et al., 2014), we collected the number of international clusters collaborating with each local cluster as listed on the European Cluster Collaboration Platform. Lastly, data was normalized.

4.1.4. Control Variables

As mentioned in the theoretical part of this research, the following variables have been established to have an effect on Smart Cities. Thus, we controlled for them.

4.1.4.1 Patents

This dataset was provided by the *Regional Innovation Scoreboard* (Hollanders & Es-Sadki, 2017b). The number of European Patent Office (EPO) applications per billion regional GDP was determined by the number application of EPO by year of filling, according to the address of the inventor, then divided by the Gross Domestic Production in Purchasing Power Standard. The result, measures the capacity of firms to achieve competitive advantage by developing new products. This indicator measures the number of applications at the EPO. Data accessed from Eurostat (Hollanders & Es-Sadki, 2017b, p. 10).

4.1.4.2 Exports of medium-high / high tech intensive manufacturing

This dataset was provided from the *Regional Innovation Scoreboard;* it was calculated with the sum of exports in medium-high/high tech intensive manufacturing activities as a percentage of the total exports. The data source was obtained from a study from the European Commission[10] (Hollanders & Es-Sadki, 2017b).

4.1.4.3 R&D Expenditure in the Public Sector

This variable was provided by the RIS. It was calculated dividing all R&D expenditures in the government sector (GOVERD) and the higher education

[10] Study for European Commission, DG GROW: "Identifying Revealed Competitive Advantages in a EU Regional Context" by the Lower Saxony Institute of Economic Research (NIW), the Vienna Institute for International Economic Studies (wiiw) and the Center for European Economic Research (ZEW), 2015

sector (HERD) by the Regional GDP (Hollanders & Es-Sadki, 2017b). This dataset was obtained from Eurostat and matched with their corresponding NUTS region.

4.1.4.4 GDP per capita

This dataset was manually collected from Eurostat by their corresponding region and NUTS category. Then data was normalized.

4.1.4.5 Land Coverage

This dataset was manually collected with data from Eurostat by their corresponding region and NUTS category. Then, data was normalized.

4.1.5. Empirics

In order to test the hypotheses, we analyzed the relationship of clusters (in regular sectors and in knowledge intensive sectors) and international collaboration on Smart Cities, as appeared on the *Cities in Motion Index.* Simultaneously, we controlled for external influences that could have an effect on cities at the regional level. For this research, we used datasets where the behaviour of entities is observed over a cross-sectional time series. Thus, we used a panel data analysis to account for individual heterogeneity and also to account for the effect of time (Torres-Reyna, 2007, pp. 2, 3).

4.1.5.1 Data Normalization

Due to the fact that some data values are not limited to an upper threshold, some data could present a skewed distribution. As a result, most regions could present low performance levels and few regions show unusually high performance levels thus, data was normalized (Hollanders & Es-Sadki, 2017b). All datasets that did not proceed directly from the RIS[11] were normalized following

[11] All data imported from the RIS was already Normalized

the same procedure as indicated by the *Regional Innovation Scoreboard* methodology.

After the data was collected, it was tested for a degree of skewness. If the degree of skewness of the raw data exceeded 1, then this data was normalized to a value below 1. In order to achieve this, data was transformed using a squared root transformation (Hollanders & Es-Sadki, 2017b, p. 30). As an illustration, Table 3 shows the degree of skewness before and after the transformation for the 2016 dataset for the following variables: Cities in Motion IESE Index, knowledge intensive clusters, regular sector clusters, international collaboration, GDP per capita, patents, exports of medium/high high-tech intensive manufacturing, R&D expenditure in the public sector and land coverage.

Table 3 Degree of Skewness and Transformation for 2016 data

	Degree of skewness	
	Before Transformation	After Transformation
Cities in Motion Index	-0.007	---
Knowledge Intensive Clusters	0.328	---
Regular Sector Cluster	-0.034	---
International Collaboration	2.564	0.746
GDP per capita	0.874	---
Patents	1.767*	0.670*
Exports of Medium/High High-tech Intensive Manufacturing	-0.597*	---
R&D Expenditure in the Public Sector	1.239*	0.129*
Land Coverage	3.765	0.904

* Data retrieved in full from RIS
Note: Table adapted from RIS (Hollanders & Es-Sadki, 2017b)

After that, data was normalized using the min-max procedure, as indicated by the RIS methodology. Calculating the minimum value and then subtracting from the transformed score. Then, the result was divided by the difference between the maximum and minimum values. As a result, the maximum normalized value was 1 and the minimum normalized value is 0.

Part 5

5. Data Analysis & Results

Table 4 shows the descriptive statistics of the sample of 327 observations, (109 regions over 3 years: 2013, 2015 and 2016 inclusively). The EISE variable, shows a high standard deviation compared to the mean of the dependent variable. Therefore, it is important to explore the variation of this variable in relation to the independent variables.

Table 4

Descriptive Statistics

Variable	Obs	Mean	Std.Dev.	Min	Max
IESE	327	.21	.30	0	1
Int. Collaboration	327	.23	.23	0	1
Reg. Sector Clusters	327	.86	.31	0	1
Knowledge Intensive	327	.57	.22	0	1
GDP per capita	327	.26	.21	0	1
Land Coverage	327	.56	.24	0	1
Patents	327	.26	.21	0	.93
R&D Public Sector	327	.32	.23	0	1
Exports	327	.48	.24	0	.99

Table 5

Pearson Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
(1) IESE	1.00								
(2) Int. Collaboration	0.34***	1.00							
(3) Reg. Sector Clusters	0.05	0.06	1.00						
(4) Knowledge Intensive Clusters	0.32***	0.13**	-0.22***	1.00					
(5) GDP per capita	0.02	0.04	-0.24***	0.40***	1.00				
(6) Land Coverage	0.10*	0.29***	0.30***	-0.14**	-0.18***	1.00			
(7) Patents	-0.03	0.10*	-0.02	0.41***	0.42***	-0.07	1.00		
(8) R&D Public Sector	0.05	0.05	-0.08	0.25***	0.24***	-0.15***	0.53***	1.00	
(9) Exports	0.07	0.02	-0.27***	0.32***	0.15***	-0.14***	0.42***	0.34***	1.00

Sample size 327
Significant at: ***p < 0.05, *p < 0.10 and ***p < 0.01* (two-tailed)

Table 5 shows a Pearson correlation matrix. There are positive highly significant correlations at the 1 percent level between two independent variables (knowledge intensive clusters and international collaboration) and the dependent variable. However, this is not the case for the regular sector clusters. The latter is positively correlated with the dependent variable, but it is not significant.

Based on these results, we could suggest that international collaboration and knowledge intensive clusters have high probabilities to be associated with Smart Cities. However, the regressions will confirm whether the propositions are accurate.

Moreover, we can observe that none of the independent variables are highly correlated. Furthermore, we tested all our variables for multicollinearity. In order to test for potential multicollinearity, we applied the variance inflation factor (VIF). The independent variables showed a mean VIF of 2.06 and the entire model and mean VIF of 3.08 (see Appendix B). Therefore, the regression coefficients are not affected by multicollinearity effects (Neter, Kutner, Nachtsheim, & Wasserman, 1996).

Next, Table 6 represents regression models based on 327 observations. We performed a hierarchical approach, first we tested the control variables in the model, followed by the independent variables and finally tested the combined variables. These models tested our Hypotheses 1a to 2.

Table 6

Results of Regression Analysis with Location Fixed Effects

	Model 1 Coef./ (Std. Err.)	Model 2 Coef./ (Std. Err.)	Model 3 Coef./ (Std. Err.)
Independent Variables			
Int. Collaboration		0.383***	0.361***
		(0.07)	(0.08)
Reg. Sector Clusters		0.100**	0.149***
		(0.05)	(0.05)
Knowledge Intensive Clusters		0.423***	0.639***
		(0.07)	(0.09)
Control Variables			
GDP per capita	0.08		(0.08)
	(0.17)		(0.15)
Land Coverage	(0.391)**		(0.582)***
	(0.17)		(0.16)
Patents	0.01		(0.09)
	(0.12)		(0.11)
R&D Public Sector	0.13		0.06
	(0.09)		(0.08)
Exports	0.11		(0.02)
	(0.12)		(0.11)
Constant	0.297*	(0.210)***	(0.20)
	(0.16)	(0.07)	(0.16)
N	327	327	327
Prob>F	0.0000	0.0000	0.0000
R-sqr	0.29	0.20	0.45

** p<0.10, ** p<0.05, *** p<0.01*

Model 1 in Table 6 is a regression model where the *Cities in Motion Index* is the dependent variable. This model was run on the Control Variables with fixed effects according to the location of origin. The overall model explains 29 percent of the variance and is highly significant (Prob>F = 0.0000. $p < 0.01$). Model 2, similar to Model 1, shows a regression model with the *Cities in Motion Index* as the dependent variable. This model tested the Independent Variables. In this case, the overall model explains 20 percent of the variance and it is also highly significant (Prob>F = 0.0000. $p < 0.01$). Finally, Model 3 is a regression model including all previous variables with fixed effects in the location of origin. This model is also highly significant, and the overall model explained 45 percent of the variance (Prob>F = 0.0000. $p < 0.01$). Therefore, Model 3 gains 16 percent significance after adding the control variables as an indication of good fit.

Hypothesis 1a considered the relationship of the presence of knowledge intensive clusters, within a region, on Smart Cities. Model 2 showed the effect between knowledge intensive clusters and the dependent variable with a positive coefficient at 42 percent and highly significant ($p > 0.01$). Moreover, the full model remained highly significant ($p > 0.01$) and provided support for Hypothesis 1a.

Hypothesis 1b stated the importance of the presence of clusters in regular sectors within a region and their effect on Smart Cities. Model 2 showed the effect of this independent variable and the dependent variable with a positive coefficient at 10 percent and significant ($p > 0.05$). In addition, after the inclusion of the control variables, in Model 3, the independent variable shows a coefficient of 16 and becomes highly significant ($p > 0.01$). Thus, Hypothesis 1b was strongly supported.

Hypothesis 1c predicted a higher impact of knowledge intensive clusters against regular clusters. To analyze this, we performed a postestimation test. After running the regressions we used a Wald test on the coefficients of regular sector clusters and knowledge intensive clusters and we found a statically

significant difference ($p > 0.01$) between regular sector clusters and knowledge intensive clusters, both coefficients are highly significant but the coefficient of knowledge intensive clusters is higher than the one for regular sector clusters**.** Thus, supporting Hypothesis 1c.

Hypothesis 2 assessed the effect of external connections in the formation of Smart Cities. International collaboration between clusters shows a positive effect. In Model 2 we observed a positive coefficient of 38 percent and highly significance ($p > 0.01$). In fact, Model 3 also presented a positive coefficient of 36 percent and continued highly significant ($p > 0.01$). Thus, Hypothesis 2 was also supported.

Part 6

6. Discussion

The current study proposes to shed some light on the topic of Smart Cities. More specifically, we try to understand the association of regular sector clusters, knowledge intensive clusters and international collaboration with Smart Cities in Europe. The elements analyzed allow us to have a better understanding of the main elements that facilitate the development of Smart Cities.

6.1. Findings

Knowledge intensive clusters exhibited great significance in the models ($p > 0.01$). This highly significant results suggest their influence in Smart City emergence. Initially, the effect on the dependent variable showed a strong significance ($p > 0.01$). Then, those results were maintained after adding the control variables to the model. Suggesting the importance of fostering knowledge intensive clusters in a region and their positive effect to cities. In fact, these results are in line with Anselin et al. (1997) confirming the importance of promoting knowledge clusters to increase spillovers through the region and contributing to the possibility to make regions and cities smarter. In addition, these findings support the current literature that relates technological clusters and Smart Cities (Bakıcı et al., 2013; Hollands, 2008).

Clusters serving as a knowledge sharing structure that enables innovation have been studied extensively within the literature. Regional agglomerations result in knowledge externalities that promote development within the region (Cohendet et al., 2014, p. 932). There are different ways to stimulate knowledge spillovers within a cluster. For instance, this occurs through collaboration and interaction between firms that are part of a value chain or research bodies within regions (Breschi & Lissoni, 2001; Marshall, 1920) or R&D discoveries within the cluster (Bathelt et al., 2004; Maskell, 2001; Porter, 1990, 1998). In practice, the Berlin-Brandenburg region fosters five major clusters[12]. The Auto industry, part of the transport, mobility and logistics cluster, is in constant collaboration with 200 automotive companies within the region. The automotive Berlin-Brandenburg region has the largest number of research facilities in Germany. Innovation is achieved by working together on common projects with partners from both the industry and science sectors. Berlin is the only city in the country where three major German automakers have established locations. Moreover, the city of Berlin[13] congregates high quality manufacturing and R&D facilities promoting knowledge sharing and creation. As a result, Berlin attracts companies of all sizes.

This research explores the effect of clusters and how they could be related to the development of a Smart City. Indeed, our results confirm our hypotheses and their relevance to the Smart City literature. In other words, our results suggest that regular sector clusters in a region are associated with the emergence of Smart Cities. In addition, we observe that the regular sector cluster variable is significant in affecting Smart City emergence. Furthermore, the inclusion of the control variables increases this significance to one percent ($p > 0.01$). Therefore, our findings suggest that clusters need interaction inside the region where they

[12] https://www.berlin-partner.de/en/sectors-clusters/

[13] The city of Berlin reached the 9th position in the *Cities in Motion Index* 2017 and is the 3rd European city in this index after London and Paris respectively

are located in order to develop further. For instance, firms could benefit from regional demand in areas where clusters are larger than others. As a result, firms have the opportunity to innovate more in a particular region (Baptista & Swann, 1998, p. 533). Thus, the extension of the region is an important factor. Indeed, innovation is considered a geographical advantage to benefit a region with location advantage. As result this will bring economic benefits to the area where the cluster is located (Baptista & Swann, 1998). In fact, according to Lazzeretti et al. (2009) cities, in particular, benefit from the cluster activity within a region due to a spillover effect. Consequently, on this research this represents a positive correlation between land coverage and regular sector clusters. In the case of the Berlin-Brandenburg region, the automotive cluster is comprised of more than 250 companies. The city of Berlin alone, has more than 25 companies as part of the city cluster (see Appendix C). For this reason, the city of Berlin benefits from the activity generated within the region, attracting companies to the city, thus promoting a knowledge sharing environment. Hence, influencing the city to become smarter.

Even though the importance of clusters is highly significant on this study, it is necessary to emphasize the contribution of knowledge intensive clusters to Smart Cities. After showing a greater significance in the models we tested the coefficients of knowledge intensive clusters and regular sector clusters. We found that knowledge intensive clusters have a greater impact than regular sector clusters. This is in important result in line with Bakıcı et al. (2013); Caragliu et al. (2011); Komninos (2009) and others supporting the relation between knowledge intensive activities and Smart Cities.

Another finding is the significance of the global pipeline theory proposed by Bathelt (2007), which facilitates making regions and cities smarter. In parallel, Bathelt (2007); Cowan and Jonard (2004); and Jacobs (1969), among others, developed the idea that clusters need to cultivate relations outside the local cluster in order to stimulate innovation. By being exposed to the world, clusters

have the opportunity to incorporate this new knowledge into the local cluster benefiting local firms in the regions and in cities. Our results confirm the importance of international clusters and the positive spillovers to make regions and cities smarter.

Yet, the effect of an international cluster is so significant showing that having an internationally connected cluster in a region influences cities in becoming smarter. For our research this is represented by the high significance of the international collaboration variable ($p > 0.01$) even before the addition of control variables. The significance of the proposed construct is clearly shown by its outcome: international cluster collaboration, even without controls, was found to affect a city's likelihood of becoming smarter. Thus, we confirm the contribution of international clusters to regional and city levels. This is an important finding that confirms their capability to incorporate knowledge from external sources to a region. In addition, this outcome corroborates that collaboration has to be present between companies inside the international cluster and the ability of the cluster to decode this information to the local clusters. For this reason, this new information is later spread throughout the region reaching cities and bringing development and making cities smarter. In Germany, location of the automotive Berlin-Brandenburg network allows it to have access to other clusters within the region and automotive manufacturers in Saxony and internationally in Poland and the Czech Republic. All these adding new knowledge to the Berlin-Brandenburg region and contributing to the city of Berlin.

Overall, this study brings to the field of Smart Cities a theoretical and empirical perspective and objective considerations of an important component: clusters. Therefore, it offers evidence that the presence of clusters in a region, and in particular knowledge intensive clusters and international cluster collaboration, influence the emergence of Smart Cities.

6.2. Theoretical and Practical Implications

Our study contributes to the literature in the following ways.

Despite the extensive literature available on clusters (in regular sectors and in knowledge intensive sectors) and international collaboration in relation to their role in fostering innovation, there is almost no research investigating their relationship with Smart Cities.

Our research suggests the possibility of developing a richer conceptualization of the role clusters play influencing Smart Cities. More importantly, we predict and confirm the effect of regular sector clusters and their effect on a region has been shown to be empirically significant in explaining their influence on Smart Cities.

Another theoretical contribution relates to the effect on creativity literature. Knowledge infrastructures are important for regional networks of innovation (Audretsch & Feldman, 1996). On this research, our knowledge intensive cluster variable includes activities in different industries. Our findings are in line with Jacobs (1969) suggesting the contribution of diversity and variety of geographical industries promote innovation and growth. Therefore, our results contribute to theory by associating it with the Smart City field and the importance of this area.

This research contributes the existing literature on knowledge intensive clusters in Smart Cities. Our findings are in line with the studies of Bakıcı et al. (2013) associating knowledge intensive activities to Smart City presence. Moreover, this research extends previous research by measuring the relationship of knowledge intensive clusters on Smart Cities.

Furthermore regarding international collaboration, the sole presence of international collaboration has a significant effect in a region's opportunity to

develop smarter cities due to the knowledge sharing effect that encourages innovation and knowledge spillovers causing a trickle-down effect reaching cities and making them smarter. Thus, this study has extended Bathelt (2007) theoretical perspective in pipeline dynamics by empirically testing it in the context of smart city development.

Finally, there are some potentially important implications for public policy and management. For management, firms could foster innovation by participating within a local cluster. Moreover, companies could collaborate with international clusters to promote innovation and facilitate the spillover effect to the regions, which in consequence, will result in the creation of smarter cities. Even though, the latter might not be a firm's goal it is relevant due to the innovation effect that collaboration brings to companies and the positive externalities brought to regions. Governments are interested in the economic development of their regions, for this reason, these findings are also pertinent to them. The challenge is to implement measures to foster innovative environments in collaboration with different stakeholders and to provide adequate infrastructure in order to increase innovation. That is to say, public policy should stimulate private and public collaboration in order to attract new knowledge to regions and help cities become smarter. The fact that the impact of knowledge intensive clusters is higher than regular clusters in developing Smart Cities can help policy makers to allocate resources more efficiently when investing in Smart City funding.

Although this research was limited to a European sample, these findings are also applicable to governments around the world. In addition, it is also relevant for governments and firms to encourage regional collaboration among academia, firms and other institutions to promote innovation. In order to increase knowledge sharing in these networks and as a consequence, have a better qualified human capital. Thus, contributing to the emergence of Smart Cities.

6.3. Limitations and further directions

Our findings must be interpreted within the limitations of this study.

Smart Cities as an avenue of research is a difficult field to conduct studies upon as there is a lack of consensus related to definitions because different research uses different metrics to measure its development. In addition, there are two main contrasting views within the literature. Academia has recently begun incorporating the holistic approach that points towards a more balanced concept. On the other hand, non-academic literature, advanced by private ICT companies, supports a more technological approach in assessing Smart Cities. Subsequently, contributing to the lack of consensus on this topic. For this research, we collected information from academia and converged the concept towards a more holistic definition.

Another limitation was the data collection. First, the latest dataset from the Regional Innovation Scoreboard provided information about regions in Europe. However, some datasets were partially incomplete. Therefore, the missing data was calculated manually. Eurostat updates their databases continuously, providing information that was once missing. The missing data was treated following the methodology provided by the Regional Innovation Scoreboard to ensure it could be used to complete the existing dataset. However, there was not a Regional Innovation Scoreboard publication in 2015 (elaborated in 2014) therefore, we used data on 2013, 2015 and 2016 only. Second, data on international collaboration had to be manually collected. This data was provided by an agency of the European Commission[14], and then normalized using the same procedure used by the Regional Innovation Scoreboard.

[14] European Cluster Collaboration Platform: https://www.clustercollaboration.eu

Furthermore, our results investigate regions and their spillover effect to cities. It would be interesting to apply this research directly on a city level. At the time, there is very limited data available at the city level. Therefore, further investigation will be needed once enough data is produced to test our results.

Our investigation was limited only to European cities. Eurostat compiles information from all over Europe and they standardize the data to make it comparable throughout their members. However, this research could also be applied to a global scale by collecting data from other continents to measure their relationship with the emergence of Smart Cities.

Further investigation would be recommended to analyze the relationship of knowledge intensive clusters on regional innovation with respect to regular sector clusters. Our research showed a highly significant negative correlation for these variables. Thus, further research on how these interact could be an interesting research topic.

Part 7

Conclusion

The topic of Smart Cities is still a novelty. Therefore, there are many opportunities to explore in this field. This research tries to understand the relationship among regular sector clusters, knowledge intensive clusters and international collaboration with Smart Cities in Europe. Indeed, this research provides empirical evidence on the association of these three factors to Smart Cities.

To the best of our knowledge this is the first study that tried to measure regular sector clusters, knowledge intensive clusters and international collaboration and their relationship to Smart Cities. Thus, this research extends the empirical literature on Smart Cities as follows:

First, it contributes to the importance of geographical clusters, innovation literature and international business literature. Previous research had only focused on the presence of knowledge intensive clusters. Thus, this study builds on cluster literature by analyzing regular sector clusters, knowledge intensive clusters and Smart Cities. Moreover, this research also studies the influence of international collaboration on increasing innovation in Smart Cities.

Second, this study is also a contribution to local governments around the world. Our results show the importance to foster clusters, specially knowledge intensive clusters, and international collaboration. Therefore, it is important for local governments to promote international collaboration, in order to increase knowledge. In addition, local governments need to encourage collaboration between academia, firms, institutions and citizens to generate innovation.

Lastly, due to the novelty of the topic this research collects most of the data manually from European Commission sources and matches the information according to the Regional Innovation Scoreboard creating a unique dataset of regional level data.

Indeed, this research shows the importance to stimulate knowledge intensive clusters, regular sector clusters and international collaboration in regions in relation to Smart Cities. Our interpretation of the evidence is that is it important to promote collaboration to stimulate innovation. In addition, the interaction with other sectors contribute to our three independent variables. This is a significant discovery that reaffirms the importance of diversity to enhance knowledge spillovers in relation to Smart Cities.

Further studies are needed to extend the initial understanding of the relationship of clusters and international collaboration with Smart Cities using a sample beyond European regions. Moreover, additional studies at a city level are also important, to advance Smart City theory.

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Appendix A

IESE Cities in Motion Indicators

NO.	INDICATOR	DESCRIPTION / UNIT OF MEASUREMENT	DIMENSION / CLUSTER	SOURCE
1	Higher education	Proportion of population with secondary and higher education.	Human capital	Euromonitor
2	Business schools	Number of business schools (top 100).	Human capital	*The Financial Times*
3	Movement of students	International movement of higher-level students. Number of students.	Human capital	UNESCO
4	Number of universities	Number of universities.	Human capital	QS Top Universities
5	Museums	Number of museums per city.	Human capital	2thinknow
6	Art galleries	Number of art galleries per city.	Human capital	2thinknow
7	Expenditure on leisure and recreation	Expenditure on leisure and recreation. Expressed in millions of U.S. dollars at 2014 prices.	Human capital / country cluster	Euromonitor
8	Ratio of deaths	Ratio of death per 100,000 inhabitants.	Social cohesion	Euromonitor
9	Crime rate	Crime rate.	Social cohesion	Numbeo
10	Health index	Health index.	Social cohesion	Numbeo
11	Unemployment rate	Unemployment rate (number of unemployed / labor force).	Social cohesion	Euromonitor
12	Gini index	The Gini index varies from 0 to 100, with 0 being a situation of perfect equality and 100 that of perfect inequality.	Social cohesion	Euromonitor
13	Price of property	Price of property as percentage of income.	Social cohesion	Numbeo
14	Ratio of female workers	Ratio of female workers in the public administration.	Social cohesion	International Labour Organization
15	Peace index	The Global Peace Index is an indicator that measures the peacefulness and the absence of violence in a country or region. The bottom-ranking positions correspond to countries with a high level of violence.	Social cohesion	Centre for Peace and Conflict Studies at the University of Sydney
16	Productivity	Labor productivity calculated as GDP/working population (in thousands).	Economy	Euromonitor
17	Time required to start a business	Number of calendar days needed so a business can operate legally.	Economy	World Bank
18	Ease of starting a business	Ease of starting a business. Top positions in the ranking indicate a more favorable regulatory environment for creating and operating a local company.	Economy	World Bank
19	Number of headquarters	Number of headquarters of publicly traded companies.	Economy	Globalization and World Cities (GaWC)
20	Percentage of people at early business stage	Percentage of 18 to 64-year-old population who are new entrepreneurs or owners/managers of a new business (no more than 42 months).	Economy	Global Entrepreneurship Monitor

IESE Cities in Motion Indicators (continued)

NO.	INDICATOR	DESCRIPTION / UNIT OF MEASUREMENT	DIMENSION / CLUSTER	SOURCE
21	Entrepreneurs	Companies in an initial phase that represent a city's economic bases. They represent economic dynamism and include a high proportion of companies devoted to technology. Used per capita.	Economy	2thinknow
22	GDP	Gross domestic product in millions of U.S. dollars at 2014 prices.	Economy	Euromonitor
23	Total tax rate	This measures the total amount of taxes and compulsory contributions paid by businesses after accounting for deductions and exemptions allowed as part of commercial profits.	Public management	World Bank
24	Reserves	Total reserves in millions of current U.S. dollars.	Public management	World Bank
25	Reserves per capita	Reserves per capita in millions of current U.S. dollars.	Public management	World Bank
26	Embassies	Number of embassies per city.	Public management	2thinknow
27	Twitter	Twitter users in prominent user directories (e.g., Twellow). This includes users who define themselves as leaders (writers, activists, business leaders, journalists, etc.). In thousands of people.	Public management	2thinknow
28	Sales tax	Sales tax. This has a big impact on the economy. Lower rates of sales tax can be used to finance investment in services and intelligent infrastructure.	Public management	2thinknow
29	Strength of legal rights index	The strength of legal rights index measures the degree to which collateral and bankruptcy laws protect the rights of borrowers and lenders and thus facilitate access to loans. The values run from 0 to 12, where the highest ratings indicate that the laws are better designed to expand access to credit.	Governance	World Bank
30	Corruption perceptions index	Corruption perceptions index. The values go from 0 (very corrupt) to 100 (very transparent).	Governance	Transparency International
31	Functions of the innovation department	Number of functions of the city's innovation department (or ministry if there is one).	Governance	2thinknow
32	Range of government Web services	Range of online services for all city council users (residents or visitors). This is a measure of modern and technological municipal government. Scale from 0 to 5.	Governance	2thinknow
33	Open data platform	This describes whether the city has an open data system.	Governance	CTIC Foundation and Open World Map
34	CO_2 emissions	Carbon dioxide emissions from the burning of fossil fuels and the manufacture of cement. Measured in kilotons (kt).	Environment	World Bank
35	CO_2 emission index	CO_2 emission index.	Environment	Numbeo

IESE Cities in Motion Indicators (continued)

NO.	INDICATOR	DESCRIPTION / UNIT OF MEASUREMENT	DIMENSION / CLUSTER	SOURCE
36	Methane emissions	Methane emissions that arise from human activities such as agriculture and the industrial production of methane. Measured in kt of CO_2 equivalent.	Environment	World Bank
37	Percentage of the population with access to the water supply	Percentage of the population with reasonable access to an appropriate quantity of water resulting from an improvement in the water supply.	Environment	World Bank
38	PM2.5	PM2.5 measures the amount of particles in the air whose diameter is less than 2.5 µm. Annual mean.	Environment	World Health Organization
39	PM10	PM10 measures the amount of particles in the air whose diameter is less than 10 µm. Annual mean.	Environment	World Health Organization
40	Pollution index	Pollution index.	Environment	Numbeo
41	Environmental performance index	Environmental Performance Index (from 1 = poor to 100 = good).	Environment	Yale University
42	Traffic index	The traffic index is estimated by considering the time spent in traffic and the dissatisfaction this generates. It also includes estimates of CO_2 consumption and the other inefficiencies of the traffic system.	Mobility and transportation	Numbeo
43	Inefficiency index	The inefficiency index is an estimate of the inefficiencies in traffic. High values represent high rates of inefficiency in driving, such as long journey times.	Mobility and transportation	Numbeo
44	Number of road accidents	Number of road accidents per 100,000 inhabitants.	Mobility and transportation	Euromonitor
45	Metro	Number of metro stations per city.	Mobility and transportation	2thinknow
46	Flights	Number of arrival and departure flights (air routes) in a city.	Mobility and transportation	2thinknow
47	Means of transportation	The means of transportation represents the public transportation options for smart cities. The value of the variable increases if there are more transportation options. The lack of transportation options can reduce the attractiveness of a city as a smart destination.	Mobility and transportation	2thinknow
48	Index of traffic for commuting to work	Index of traffic considering the journey time to work.	Mobility and transportation	Numbeo
49	Bike sharing	The bicycle-sharing system shows the automated services for the public use of shared bicycles that provide transport from one location to another within a city. The indicator varies between 0 and 2 according to how developed the system is.	Mobility and transportation	Bike-Sharing World Map

IESE Cities in Motion Indicators (continued)

NO.	INDICATOR	DESCRIPTION / UNIT OF MEASUREMENT	DIMENSION / CLUSTER	SOURCE
50	Percentage of the population with access to sanitation facilities	Percentage of the population with at least sufficient access to facilities for the disposal of excreta that can efficiently avoid the contact of humans, animals and insects with excreta.	Urban planning	World Bank
51	Number of people per household	Number of people per household.	Urban planning	Euromonitor
52	Bicycle shops	Number of bicycle shops per capita.	Urban planning	2thinknow
53	Architects	Number of architecture firms per capita.	Urban planning	2thinknow
54	Cycling	Cycling enthusiasts per capita. Bicycle use represents both a sustainable measure of transportation and a metric for a city's exercise and cultural aptitude. Many cities that historically are smart cities have a certain correlation with the presence of a significant cycling culture (weather permitting).	Urban planning	2thinknow
55	Number of international tourists	Number of international tourists who visit the city. In thousands of people.	International outreach	Euromonitor
56	Number of passengers of an airline	Number of passengers who travel with airlines. In thousands of people.	International outreach	Euromonitor
57	Hotels	Number of hotels per capita.	International outreach	2thinknow
58	Sightsmap	Ranking of cities according to the number of photos taken in the city and uploaded to Panoramio (community for sharing photographs online). The top positions correspond to the cities with the most photographs.	International outreach	Sightsmap
59	Number of conferences and meetings	Number of international conferences and meetings in a city.	International outreach	International Congress and Convention Association
60	Number of broadband subscribers	Number of broadband subscribers per country with a digital subscriber line, cable modem or other high-speed technology, per 100 inhabitants.	Technology	World Bank
61	Broadband	Number of broadband users within a city, including wireless and fixed connections.	Technology	2thinknow
62	IP addresses	Number of IP addresses per capita.	Technology	2thinknow
63	Facebook	Number of Facebook users per capita.	Technology	2thinknow
64	Mobile phones	Number of mobile phones per capita.	Technology	2thinknow
65	Quality of Web services	The quality of the city council's website measures the commitment of its information technology policy, support for the development of local businesses and other technology initiatives. Scale from 0 to 5, the maximum corresponding to the website with the best-quality services.	Technology	2thinknow
66	Innovation index	Innovation index (Innovation Cities Index). Valuation of 0 (no innovation) to 60 (a lot of innovation).	Technology	Innovation Cities Program

IESE Cities in Motion Indicators (continued)

NO.	INDICATOR	DESCRIPTION / UNIT OF MEASUREMENT	DIMENSION / CLUSTER	SOURCE
67	Smartphones	Number of smartphones per capita. The use of smartphones and their penetration are a good indicator for the use of technologies.	Technology	2thinknow
68	Wi-Fi hot spot	Number of wireless access points globally. These represent the options to connect to the Internet of people on business trips.	Technology	2thinknow
69	Disposable income	Disposable income (annual average). Decile 1. Expressed in U.S. dollars.	City cluster	Euromonitor
70	Disposable income	Disposable income (annual average). Decile 2. Expressed in U.S. dollars.	City cluster	Euromonitor
71	Disposable income	Disposable income (annual average). Decile 5. Expressed in U.S. dollars.	City cluster	Euromonitor
72	Disposable income	Disposable income (annual average). Decile 7. Expressed in U.S. dollars.	City cluster	Euromonitor
73	Disposable income	Disposable income (annual average). Decile 9. Expressed in U.S. dollars.	City cluster	Euromonitor
74	Population	Number of inhabitants.	City/country cluster	Euromonitor
75	Percentage of population employed	Percentage of population employed.	Country cluster	Euromonitor
76	Expenditure on education per inhabitant	Expenditure on education per inhabitant. Expressed in millions of U.S. dollars at 2014 prices.	Country cluster	Euromonitor
77	Expenditure on medical and health services per inhabitant	Expenditure on medical and health services per inhabitant. Expressed in millions of U.S. dollars at 2014 prices.	Country cluster	Euromonitor
78	Expenditure on hospitality and catering services per inhabitant	Expenditure on hospitality and catering services per inhabitant. Expressed in millions of U.S. dollars at 2014 prices.	Country cluster	Euromonitor
79	Expenditure on housing per inhabitant	Expenditure on housing per inhabitant. Expressed in millions of U.S. dollars at 2014 prices.	Country cluster	Euromonitor

Note: Retrieved from IESE Business School, Cities in Motion Index 2017. © 2014-2107 IESE Business School

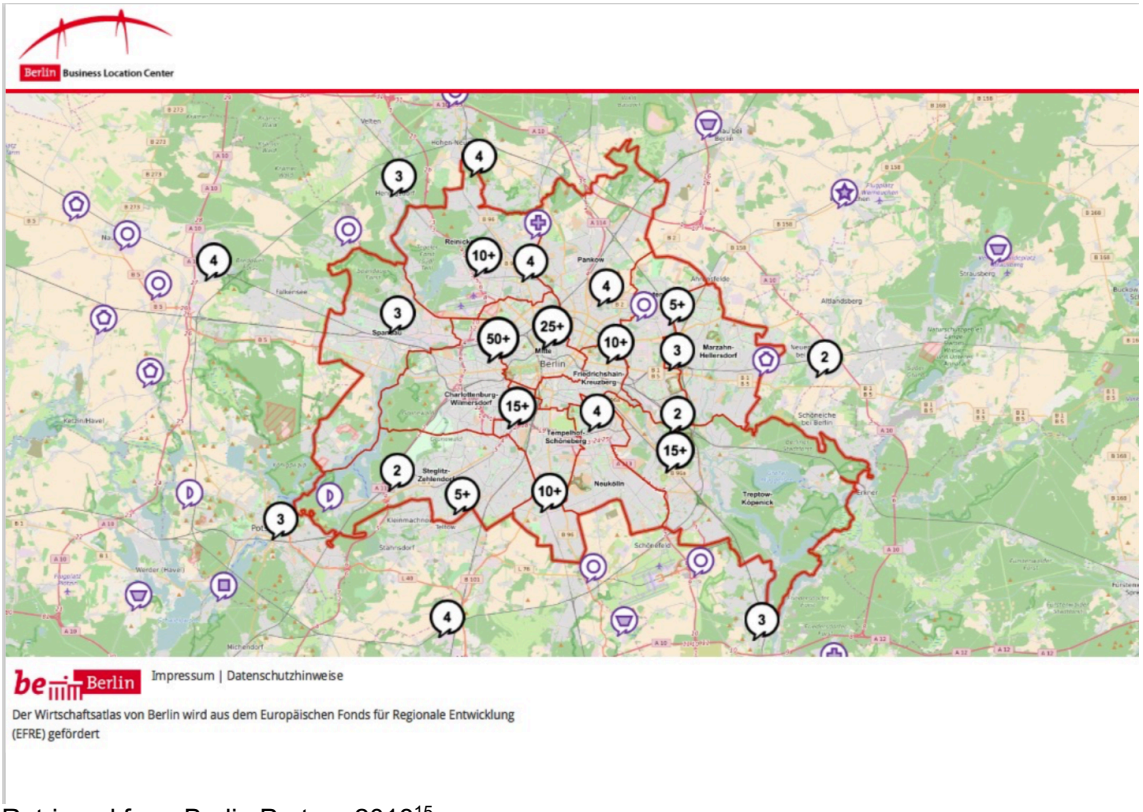
Appendix B

Variance Inflation Factors (VIF)

	VIF	1/VIF
Int. Collaboration	2.20	0.45
Reg. Sector Clusters	1.66	0.60
Knowledge Intensive Clusters	2.31	0.43
GDP per capita	6.27	0.16
Land Coverage	8.07	0.12
Patents	3.04	0.33
R&D Public Sector	1.77	0.57
Exports	4.15	0.24
Mean VIF	**3.68**	**0.36**

Appendix C

Berlin-Brandenburg automotive network map



Retrieved from Berlin Partner 2018[15]

[15] https://www.businesslocationcenter.de/wab/maps/automotive/