IRIS Utrecht presenteert:

Smart City start-ups – *Comparative analysis between Utrecht and Nice*

Auteur:
Martina Picari

Achtergrond/context van het rapport of product:
Because of urbanization and the pressure on the quality of life in cities that comes with it, it is relevant to know how smart city initiatives can be encouraged. This thesis looks smart city startups and how business incubation contributes to the performance of these startups.

Samenvatting:
This thesis aims at evaluating the performance of smart city start-ups within three business incubators, Utrecht Inc., Climate-KIC and PACA-EST. Its purpose is to make a contribution to the existing literature both by providing an example of the application of the Smart City Index and by reflecting on the factors that contribute to an improvement in the performance of individual business incubators. The results show that technology, ICT, sustainability and economy are the prevailing characteristics for a project to be qualified as a smart city. Moreover, through the empirical analysis carried out, in the Utrecht Inc. and Climate-KIC incubators, the market type (b2b), the product type (software-based product) and the incubation programs are the main aspects which influence the growth of projects. Whereas, in the PACA-EST incubator, the entrepreneurial experience and a high percentage of males in the founder’s team are the main aspects which influence the growth of projects. Even though the smart city startups variable are not statistically significant for what concerns performance, this thesis provides a solid basis on which to build further empirical analyses in the future.

Tags:
Smart City; Business Incubation; Performance

Contact:
m.picari@students.uu.nl

Utrecht University

Master Thesis U.S.E.

Smart City start-ups

Comparative analysis between Utrecht and Nice

by

Martina Picari

Student number: 06897878

E-Mail: m.picari@students.uu.nl

Supervisor: Mark Sanders

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Abstract

This thesis aims at evaluating the performance of smart city start-ups within three business incubators, Utrecht Inc., Climate-KIC and PACA-EST. Its purpose is to make a contribution to the existing literature both by providing an example of the application of the Smart City Index and by reflecting on the factors that contribute to an improvement in the performance of individual business incubators. The results show that technology, ICT, sustainability and economy are the prevailing characteristics for a project to be qualified as a smart city. Moreover, through the empirical analysis carried out, in the Utrecht Inc. and Climate-KIC incubators, the market type (b2b), the product type (software-based product) and the incubation programs are the main aspects which influence the growth of projects. Whereas, in the PACA-EST incubator, the entrepreneurial experience and a high percentage of males in the founder's team are the main aspects which influence the growth of projects. Even though the smart city start-ups variable are not statistically significant for what concerns performance, this thesis provides a solid basis on which to build further empirical analyses in the future.

1. Introduction

The World Bank has claimed that urban poverty will become the most explosive issue of the 21st century (Urban Development, 2019). Most developing economies are confronted with the problem of urban population growth, and in these countries, especially in cities with more than 10 million people, their populations are increasing exponentially. Therefore, there is an important need for innovation, as many of these cities lack the facilities necessary to support such a large number of people: it is vital therefore, that essential services, affordable housing, well-connected and reliable transportation systems, as well as employment, be provided without delay. Smart cities, therefore, might be a long-term solution to some of these problems.

The aim of this paper is to evaluate the performance of smart city start-ups and to present and test a smart city index to ascertain whether it codes the data of certain chosen incubators effectively. Furthermore, the paper will establish whether projects qualifying as smart cities have a greater probability of survival and growth in the light of this qualification. Its purpose is to make a contribution to the existing literature by providing a practical example of the application of the Smart City Index (Hermse et al., 2020) as well as an analysis of the factors which contribute to an improvement in the performance of individual business incubators.

The existing literature highlights the importance of the support of a business incubator for the growth and success of new projects (Totterman et al., 2005). Smart cities are defined as a viable solution to the problem of urbanization, as well as for the interaction between technology, sustainability and the economy. The assessment and evaluation of the performance of smart city start-ups is based on their survival, or whether at the time the data is collected the start-up is still in operation, as well as its growth, which is measured as the difference in the number of employees between the time when the data is collected and the moment when the application to the incubator was submitted. Performance evaluations of these start-ups makes it possible to further investigate business incubators, which should be generating value by combining the start-ups' entrepreneurial drive with resources which are generally unavailable to small companies.

At this time, however, there is no one common definition of a smart city, and it has yet to be established whether being classified as a smart city contributes to performance. In a global context which relies heavily on technology, it is important to fill this gap, so as to understand whether further development of smart cities could be beneficial.

To accomplish this, this research tests the performance of smart city start-ups belonging to three incubators, Utrecht Inc., Climate-KIC and PACA-EST, all of which are included in the collaboration with IRIS Smart-Cities. In the three incubators there are, respectively, 125, 144 and 308 smart city start-ups. The main difference among them is that two are located in Utrecht, while the third is located in Nice. This can affect the final performance of the incubators, since in different countries there is a different economic environment, which influences start-ups in different and distinctive ways.

This paper analyzes the plethora of existing definitions of smart city, examining in particular, the elements that characterize them. After that, it focuses on business incubators and incubation programs offered by these incubators to assist and develop new projects. In addition, in order to conduct the quantitative analysis, possible performance proxies are analyzed so as to link the potential benefit a smart city project can bring to incubators. The analysis then uses two different datasets, belonging to the Utrecht Inc and Climate-KIC, and PACA-EST incubators respectively, to test the research question. Finally, by means of empirical analysis, the results obtained are then discussed and compared to test the hypotheses and highlight the possible limitations encountered.

2. Literature review and Theoretical Framework

This thesis focuses on the performance of smart city projects in three different incubators. Hence, the theoretical framework, that I present, narrows down key elements for my analysis. I have structured this topic starting with the definition of smart city projects, why they are relevant to society and what the benefits related to them are. Following this, I explain the definition, characterization, and the advantages and the disadvantages of business incubators. In addition, I present various incubation programs within business incubators, examining various benefits as well as drawbacks. Then, I give the definition of performance that I will use as a parameter for comparison in the analytical section that follows. Different topics, for which there is a considerable amount of closely related research, are examined to be closely related and then presented.

2.1 Smart city

The urban demographic environment requires new approaches to public services. Cities are stretched beyond their current available services and assets capabilities. The development of cities is leaning towards a more technological, innovative and sustainable path (Cocchia, 2014), and as a result, more innovative and intelligent solutions are being sought to be exploited. These types of solutions are identified as “smart city”, hence the quest for initiatives able to drive technology adoption into the public sector at an increasing rate (Kumar et al., 2020). Smart city is an articulated concept without an agreed upon definition, that can either be designed as a solution to numerous existing problems and/or to entirely new ones (Samarakkody et al., 2019). Thus, many scholars have published articles with the intention of elaborating one single and precise explanation of what a smart city is. The definitions applied are based on different themes, elements, or dimensions, which makes the concept still more ambiguous (Giffinger et al., 2007; Winkowska, Szpilko, & Pejić, 2019; Silva, Khan & Han, 2018). One example defines it as “an urban environment which able to improve the quality of citizens’ life by using ICT systems” (T. Heo et al., 2014). This description highlights the importance of the citizen. In fact, the prime objective should be the improvement of their quality of life, which is possible through the integration of technology. According to Ortiz-

Fournier et al., it is the “effective integration of human, digital, and physical systems in the built place to deliver a sustainable prosperous and inclusive future for the people.” (L. V. Ortiz-Fournier et al., 2010). Once again, the importance of the citizen is emphasized here, as well as the interaction he or she has with technology and the system surrounding him/her. A definition embodying another distinctive element is “smart cities are envisioned as creating a better, more sustainable city, in which people's quality of life is higher, their environment more livable and their economic prospects stronger” (Lee et al., 2014). In this description, environmental and economic components are added. Therefore, for a more stable future it is essential to invest in human and social capital as fuel for a sustainable economic growth (Caragliu et al., 2011).

Indeed, there is a long list of city-based initiatives that have been proposed to improve the urban planning of cities. These include open data initiatives, hence the access to publicly-available data; government strategic processes of internal realignment and modernisation; resident / citizen engagement activities, hence the importance of transparency around data collection; management, sharing and use, non-tech related transit projects, and civic/urban improvement initiatives (Collier, 2020). However, without connectivity, data collection and government involvement, these are traditional projects cannot be classified as a smart city.

In Hermse, Nijland & Picari (2020), we developed the Smart City Index (SCI), using a specific classification scheme, as a means of determining whether projects and start-ups can be defined as ‘smart city’ and to measure their intensity. Therefore, by necessity, a project definable as smart city necessarily has to address an urban challenge and necessarily has to use or implement a technology. Moreover, other non-necessary conditions consist of the use of Information and Communication Technology, the inclusion of citizens, the aim of being environmentally sustainabile, and the goal of improving the quality of life and the economy.

In this thesis I will define the smart city concept as a solution for the citizen and the urban context, as well as the interaction between technology, sustainability, efficiency and the economy.

2.2 Business incubation

Business incubation can be defined as an innovative, emerging organizational process for generating value by combining a start-up's entrepreneurial drive with resources commonly available to large or medium-sized companies (Aernoudt, 2004). According to the definition given by the European Commission (EC, 2002), "a business incubator is an organization that accelerates and systematises the process of creating successful enterprises by providing them with a comprehensive and integrated range of support, including: Incubator space, business support services, and clustering and networking opportunities".

The first European incubator was established in the United Kingdom in 1975, through the British Steel Industry, with the aim of increasing employment in areas in economic decline (Aernoudt, 2004) as was the idea behind the first incubator conceived in the Netherlands in the 1970s. In both cases, small businesses were given the opportunity to operate in unused buildings and to use some services to support their development, with the final objective of stimulating the economy at the local level (OECD, 1997). The first French incubator was created in 1979 as a response to infrastructure needs by young entrepreneurs (Mutin-Quinsin, 2004) and it and others were sponsored mainly by local governments in order to stimulate job creation (OECD, 1997). Subsequently, France and the Netherlands promoted incubators at university level (Aernoudt, 2004). Nowadays, there are around 3,000 business incubators of various types worldwide and in Western Europe, there are currently thought to be around 900 business incubators (EC, 2002).

Business incubators support the development of new potential companies not only by giving them relevancy but also by helping them build successful support and business networks (Totterman et al., 2005). The combination of different resources, services and skills creates synergies for incubated businesses; this means that the incubator is more than just an infrastructure with a specific geographical location, where start-ups can minimise costs through access to space, shared services and business support. In fact, according to Dee there are two relevant business incubation's sights (Dee et al., 2012). Firstly, business incubation is a way to tackle market failures, which limit the ability of high-tech start-ups to overcome uncertainty and obstacles associated with the early stages of firm development (OECD, 1997; Phan et al., 2005). For example, a typical cause of failure is the high costs incurred by high-tech start-up companies. In the Eurobarometer survey on obstacles to setting up a new business, 69% of respondents identified as the main obstacle the complexity of administrative procedures and 76% the absence of available capital (Pezzini et al., 2003) as the main ones. Secondly, business incubation accelerates the entrepreneurial process thus supporting and encouraging guidance for high-growth enterprises (Hansen et al., 2000).

Business incubators have been forced to evolve in order to shape new companies capable of reaching the market quickly, to be part of the network, to innovate, cultivate talent and to operate globally (Mac Chinsomboon et al., 2000). Incubation is now seen as a core component of regional and national policies for economic development, promoting and stimulating progress in all sectors (Harman et al., 2003). The incubator also acts as a bridge between the incubated companies and the external environment, leveraging entrepreneurial talent and/or resources (Bollingtoft, 2012).

According to the National Business incubator association (NBIA, 2000), the are five main categories of business incubators. These are: the mixed–use type, connecting customers from a wide range of businesses and supporting governments in leading economic development and job creation; the technology incubators type, focusing on community-based research and development of high-tech incubators, which will have a long-term impact on economic development and job creation; the manufacturing incubators type, sharing the physical space and technical support for manufacturing industries; the targeted incubator type, focusing on the software, food, multimedia, arts production; and the empowerment incubators type, focusing on advisors from different communities to assist and grow business enterprises (Al-Mubaraki et al., 2010).

In addition, the business incubators that reside within the universities are extremely important because it provides the opportunity to linking talent, technology, capital, and know-how to leverage entrepreneurial talent, accelerate the development of new technology-based firms, and speed up the commercialization of technology (Smilor & Gill, 1986). The cooperative exchanges undertaken by entrepreneurs and universities is important for the formation of a concentration of technology-oriented projects. In accordance with this, the term "science park" is generally used to describe a property-based project which has structured and functional relations with a university. A science park is a market support and technology transfer program that sustains and facilitates the start-up, the incubation and creation of innovation driven, high growth, knowledge-based enterprises, and one that offers an atmosphere where large and foreign enterprises can create unique and similar relationships with a particular knowledge-building centre for their mutual benefit (Salvador, 2011).

The study carried out in this thesis concerns the type of technological incubators within universities. Therefore, the primary focus is on logistic and financial support for start-ups interested in developing high-tech and innovative projects.

2.3 Incubation programs

As stated previously, a business incubator is a constantly evolving tool and innovative system, with its own diverse features used to identify heterogeneous realities. It is a multifaceted concept, that is translated into reality in very different forms and on that depends on the context in which it is inserted. For instance, each incubator offers specific programs in line with its main interests so it is relevant to define the goals and objectives of every programs. Each program follows one or more objectives: national, regional or local economic development; property/real estate; rural/urban industrial regeneration; small firm and/or venture creation; technology transfer; innovation and its commercialization; increases in new firm formation/spin-outs; creation of new and sustainable jobs; acceleration of business growth/development of fast-track companies; reduction in the failure rate of new enterprises; creating value for stakeholders; empowerment/opportunities for specific groups of entrepreneurs; development of an entrepreneurial culture/role models (NBIA, 2006). There are as many aims as there are incubation programs and for this reason it is important that the chosen program complies with the goal of the project and maximizes the result.

Furthermore, business incubation programs provide the start-up company's asset of services, as business support, networking, guidelines to the market, financial management, access to funds and letter of guarantee, presentation skills, higher education resources, advisor for best partners, link to venture capital, training programs, aid for the regulatory compliance services (NBIA, 2006).

In accordance with the choice undertaken by the OECD (1997), it is possible to interpret the technology incubator as a knowledge-based incubator linked to a university, a science and technology park or an innovation centre. For example, science parks are characterized by a complex set of activities within a limited geographical area, where value-added research, industry and capital activities are combined with entrepreneurship. The aim is to promote the birth and development of knowledge-based enterprises (OECD, 1997), thus providing, in addition to the typical services of traditional incubation, specific services (Chan, 2005), facilitating knowledge transfer (Felsenstein, 1994). The presence of academic knowledge and expertise at the local business level is the key factor of the Science Parks (Lofsten et al., 2002).

A start-up incubator is a program meant to help new ideas succeed (Willson, 2019). The business incubation program concerns the cooperative activity of several players who will, in turn, benefit from the same. Currently two environments are affecting the conduct of programs, the internal and the external environments (Ryzhonkov, 2014). In the internal, the main players are the holder of the innovative idea and the entity chosen by them to develop the idea. The entity chosen can be both private and public. In recent years many universities and brands have developed, within them, a track that focuses on the exploitation of start-ups. This is certainly an important advantage both for the start-upper, who on his own, would not have been able to pursue his idea, and for the incubator, who will benefit not only from popularity but also financially.

In this thesis I analyse three different incubators, all of which focus on incubation programs on climate, health and education. Moreover, they provide start-ups with the tools and support to build a great team, create customer value, provide traction, create revenue, and validate the business model through experiential learning. These incubators chosen, have worked with start-ups for a considerably long time, ensuring and refining a better program each year. The common thread is the qualification of most of these projects as a smart city solution.

2.4 Performance

Thus far, it has been understood how encouraging the development of new businesses and supporting entrepreneurship is considered fundamental for sustaining economic growth and for providing new opportunities in a country. In order to analyse the reality of business incubators, it is necessary to identify the variables that constitute the element of comparison to evaluate the success between different incubation programs. There is no uniformly acceptable performance assessment method that can be applied under all circumstances to all forms of organisations (Wadongo et al., 2014). This is due to the lack of a consistent definition framework on which to base studies and findings. In fact, the methodology used will depend both on the type of incubator to which we are referring and on other elements, such as, for example, the objectives dictated by internal management, which may coincide with a number of incubated business exits per year. Moreover, many studies focus on large corporations rather than start-up companies. It is relevant for start-up organizations to find a performance measure to better understand and improve their operations (Rompho, 2018). In general, therefore, the performance of a business incubator should be measured according to its objectives and the achievement of these objectives by the business incubator, taking into account the differences between incubation models.

It is possible to measure a start-up's performance in different ways, taking into consideration determinate aspects related to a type of start-up. For example, in regard to a mobile app, it can be measured considering the number of downloads, the percentage of people paying for the service, the virality, and many other factors, can be measured (Rompho, 2018). According to Eveleens', 2019, a start-up's performance can be quantified in four ways: the *survival*, hence if the start-up is still in operation at the time the data is collected; the *size* of employment; the *growth*, "measured as the difference between the employment at the time of applying to the incubator and the employment at the time of collecting the data"; *investments*, therefore, the capability of the start-up to attract external investments in the form of equity. Also, Morin (2019), in his analysis has also used the same parameters to measure the performance.

For this analysis I used the same parameters to measure performance as Eveleens and Morin (2019) did. The following will list the key elements: "survival, success, market or business performance, achievement of entrepreneurial goals, team size growth” (Eveleens, 2019).

3. Empirical Strategy

In the following part, I will present the statistical methods, which are used to test the hypothesis. This section includes a short introduction of the methods and an outlook of their use for the collected data. I will narrow down the statistical outcome related to the first part of my analysis – by adopting the Smart City Index (Hermse et al., 2020) - and the possible outcome predictions statistics related to the second part of my analysis – by adopting the performance proxies chosen.

3.1 Data collection

In this paper, I use the datasets already collected and analyzed in the Ph.D. thesis of Chris Eveleens (2019), the Bachelor thesis of Eckinger (2019), and the Master thesis of Morin (2019). These datasets are elaborations of the information provided by three incubators, Utrecht Inc., Climate-KIC and PACA-EST. The three incubators are part of a collaboration with IRIS Smart-Cities, a European funded project in the HORIZON 2020 program since October 2017. IRIS aims to track, organize and implement local solutions with the help of collaborators and stakeholders in different cities (as Utrecht, Nice, Gothenburg, Vaasa, Alexandropoulis, Santa Cruz de Tenerife and Focsani) in order to boost their smartness and sustainability in five transformation paths (respectively renewable and energy-positive districts, energy management and flexibility, mobility solutions, digital services, and monitoring and finally citizen engagement) (IRIS Smart cities). Considering the aim of IRIS's programs, the two incubators have to select smart and sustainable city-oriented start-ups which will take advantage of the incubation.

Utrecht Inc., located on the Utrecht Science Park, was founded in 2009 in Utrecht, The Netherlands, and it is the number 10th in the world. Since now, the start-ups supported were 217, with a 64% still active. The incubator found investment equal to more than €1.6 billion, with revenue registered of €733 million. The incubator PACA-EST was founded in 2001 in Sophia-Antipolis, Nice, France. The total number of projects followed by the incubator is equal to 308, with 161 projects incubated and 132 start-ups created.

Chris Eveleens' thesis focuses on "How business incubation impacts the performance of start-ups", relying on data collected in Utrecht Inc. The dataset has been shared by the Climate-KIC and Utrecht. Inc partner incubators. This paper gives an accurate description and analysis of Utrecht Inc. and the related 259 start-ups that applied to two incubation programmes in the Netherlands, Utrecht Inc and Climate-KIC between 2014 and 2017. This dataset includes all the start-ups that applied for the programs, rejected or not. The paper concludes that the knowledge base had no major effect on the survival or success of the start-ups under research. The Utrecht Inc. dataset includes projects specialized in sustainability-related start-ups. Such singularities support further studies over different incubators. The dataset is very solid, it has been accurately verified several times with different approaches to increase its reliability.

Morin Romain's thesis focuses on the "Incubation performances and impact of start-up's resources", a study-case of a research-based incubator in Nice, relying on data collected in a French incubator (PACA-Est, Sophia-Antipolis, Nice) over eighteen years. The thesis gives an accurate description and analysis of the Nice incubators and the related 308 incubated and non-incubated projects developed from 2001 to 2019. The data furnished is very uneven over the years, with many missing cases for most variables, especially before 2010 and after 2017 (Morin, 2019). Moreover, it has been created through the collaboration of the start-up incubator PACA-EST and the IRIS Smart-Cities project of Nice. Morin's work has been developed to be as comparable as possible with the cross-sectional analysis already carried out at Utrecht by Eveleens (Eveleens, 2019). However, there are some significant differences such as the lack of data for non-incubated firms, compromising the analysis in assessing the effect of incubation on the performance of start-ups (Morin, 2019). In fact, even if the Nice dataset collected more start-ups there are more missing cases. Moreover, Eveleens' thesis is a work conducted over many years, which could not be replicable in Morin's case. For instance, the incubators are different and, therefore, also the chosen mechanism behind the acceptance in the program. For what regards Utrecht Inc., most of the start-ups are already firms, hence, more mature projects, and this is not the case for the PACA-EST incubator that required applicants to not to be founded yet, with exceptions (Morin, 2019).

I have adapted the two datasets described above in order to use the Smart City Index. In this sense, I created two new excel sheets containing the descriptions of the collected start-ups. To avoid temporal bias, each description dates back to the year in which they requested to be admitted to the incubation program. Regarding the Utrecht start-ups, Eveleens provided three different descriptions, a full text, a cleaned text and a short text. For the purpose of my research, I selected the descriptions in the cleaned text section, that in a few sentences describe the type of start-up, to whom it is addressed and the purpose of it. The PACA-EST incubator dataset also provides detailed descriptions of the start-ups. The length of the descriptions is considerably longer, they contain the project file, business plan and executive summary. Out of a total of 309 start-ups contained in the dataset, I found 7 descriptions in English, 302 descriptions in French and, for the remaining 7, I found no descriptions. I proceeded by translating the 302 French descriptions into English and checking them using the online translator DeepL to make sure they were correct (DeepL).

3.2 Smart city and non-Smart city start-ups

To differentiate smart city and non-smart city start-ups in each incubator, I used the Smart City Index (SCI), developed by Hermse, Nijland and Picari (2020).
In the Appendix C of this thesis there is the working paper "Classification of Smart City Startups: Smart City Index".

We created the classification scheme on which the index is based, by collecting 165 articles, found in the literature, from 2000 to 2020. From these 165 articles 73 have been selected that contain a wide variety of definitions of the smart city concept. Subsequently, keywords, representing essential elements common to all definitions, were selected. This selection follows the methodology developed for the definition of "user innovations" in Eckinger and Sanders (2019). This way, the division of the keywords provides two different categories of conditions, two 'necessary conditions' - technology and city - and five intensity conditions - ICT, citizen, environmental sustainability, quality of life and economic.
Formula of the smart city index (1):

*SCI = (technology*city)*(1+ICT +citizen+environmental sustainability+quality of life+economic)*

NC(x) = 0 if not; NC(x) = 1 if yes IC(x) = 0 if not; IC(x) = 1 if yes

Based on formula (1), start-ups are granted a score between 0 and 6, with the following meaning per score:

0 = At least one of the NCs is = 0

1 = All the NCs, none of the ICs

2 = NCs + (ICT or citizens or environmental sustainability or quality of life or economic)

3 = NCs + MAX 2 (ICT and/or citizens and/or environmental sustainability and/or quality of life and/or economic)

4 = NCs + MAX 3 (ICT and/or citizens and/or environmental sustainability and/or quality of life and/or economic)

5 = NCs + MAX 4 (ICT and/or citizens and/or environmental sustainability and/or quality of life and/or economic)

6 = NCs + MAX 5 (ICT and/or citizens and/or environmental sustainability and/or quality of life and/or economic)

I used the Smart City Index to distinguish smart city start-ups from non-smart city start-ups. Therefore, I coded the descriptions with the necessary and the intensity conditions provided by the algorithm. I assigned 1, in case the condition analyzed was contained within the description, and 0, in case it was not.
Once I finished the process, I used the formula (1) to select whether the start-up is a smart city start-up and what the intensity is. I ran the same procedure for both the Utrecht dataset and the Nice dataset.

The results obtained are the following. Before calculating the overall value of the dataset, I wanted to break the process down into two steps. First, I coded the start-ups affiliated to the Climate-KIC incubator and then to Utrecht Inc. In this way I was able to compare the two results and understand the differences.

Table (1) shows the results for the Climate-KIC incubator. Out of a total of 144 start-ups, of which 136 with description and 8 without description, 42 start-ups can be defined as “smart city” projects, corresponding to around 31%. Moreover, these 42 smart city start-ups have an average score of nearly 4 out of 6 (maximum achievable result if the project meets all seven required characteristics).

Table (2) shows the results for the Utrecht Inc. Out of a total of 125 start-ups, of which 113 with description and 12 without description (enclosed), 21 start-ups can be defined as “smart city” projects, corresponding to 18.5%. Furthermore, these 21 smart city start-ups have an average score of around 3.2 out of 6. Compared to the previous result the score here is lower. In fact, the two incubators have very different projects. For example, in the Climate-KIC incubator the start-ups present are more focused on sustainability, while in Utrecht Inc. on information and communication technologies.

Table (3) shows the overall results both for the Climate-KIC incubator and Utrecht Inc. Out of a total of 269 start-ups, of which 249 with description and 20 without description, 63 start-ups can be defined as “smart city” projects, corresponding to around 25.30%. These 63 smart city start-ups have an average score of around 3.7 out of 6.

CK	City	Technology	Quality of Life	Citizen	Economic	Sustainability	ICT	SCORE	Smart city
total	42	135	35	24	98	127	49	164	42
percentage	30.88%	99.26%	25.74%	17.65%	72.06%	93.38%	36.03%	3.904761905	30.88%

Table 1 - SCI results - Climate-KIC

UI	City	Technology	Quality of Life	Citizen	Economic	Sustainability	ICT	SCORE	Smart city
total	20	107	23	13	40	20	90	68	21
percentage	17.70%	94.69%	20.35%	11.50%	35.40%	17.70%	79.65%	3.238095238	18.58%

Table 2 - SCI results - Utrecht Inc.

CK-UI	City	Technology	Quality of Life	Citizen	Economic	Sustainability	ICT	SCORE	Smart city
total	62	242	58	37	138	147	139	232	63
percentage	24.90%	97.19%	23.29%	14.86%	55.42%	59.04%	55.82%	3.682539683	25.30%

Table 3 - SCI results - Utrecht Inc and Climate-KIC

Table (4) shows the results for the Nice dataset. Out of a total of 302 start-ups, of which 295 with description and 7 without description (enclosed), 28 start-ups can be defined as “smart city” projects, corresponding to almost 10%. It must be taken into account that these projects were created from 2010 to 2017. Moreover, these 28 start-ups have an average score of 3.214 out of 6.

PACA-EST	City	Technology	Quality of Life	Citizen	Economic	Sustainability	ICT	SCORE	Smart city
total	29	294	68	10	74	86	103	90	28
percentage	9.83%	99.66%	23.05%	3.39%	25.08%	29.15%	34.92%	3.214285714	9.49%

Table 4 - SCI results - Nice

3.3 Variables

In the following paragraphs I display the variables which will be used in the empirical analysis. Therefore, I present the parameters chosen to measure the performance of the Nice and Utrecht smart city start-ups, the independent and control variables.

3.3.1 Start-ups performance

In order to find a proxy to measure the performance of a start-up, I apply the same procedure used by Eveleens (2019) and Morin (2019) in their works, where they used a similar approach. In fact, they used three main dependent variables, survival, growth and a third which corresponds to investment for the Utrecht Inc. analysis and turnover for the Nice incubator analysis. Hence, the dependent variables chosen to measure the performance in the Utrecht and the PACA-EST datasets are survival and growth.

Variable	Obs	Mean	Std. Dev.	Min	Max
Survival	269	0.6431227	0.4799711	0	1
Growth	269	1.226022	2.670125	0	24.5

Table 5 - Descriptive statistic dependent variables - Utrecht

Variable	Obs	Mean	Std. Dev.	Min	Max
Survival	271	0.6273063	0.4844162	0	1
Growth	297	0.5411591	1.524109	0	19.16667

Table 6 - Descriptive statistic dependent variables - Nice

The first variable is survival. It refers to the existence of the start-up until the year 2018, hence it shows whether the start-up is still operating or not. This variable is a dummy; hence it is equal to 1, in case the project survived after the incubation year, and 0, in case it did not. With regards to the PACA-EST dataset, the final date is spring of 2019, when the data was collected. The Nice dataset had around 62% of start-ups still alive in 2019 - Table (6). Whereas the Utrecht dataset finishes in December 2018, when the data was collected. The Utrecht dataset had around 64% of start-ups still alive in 2018 - Table (5).

The second variable is the growth of employment size. It measures the average number of employment change over the years since application until 2019. It is a major proxy for start-up performance, as it translates the company's economic vitality as well as its commercial expansion. The definition of this variable is different from the definition in the Utrecht database used in Eveleens et al. (2019). In the Utrecht dataset, the employment size uses the number of people employed full-time. Unfortunately, the same information is not available in the Nice dataset. It is also important to mention that the death of the start-up is taken into account. Hence the employment growth of the start-up reflects its status back in 2019. To calculate this variable, I used two different procedures for the datasets. For the PACA-EST dataset, the size of the teams was provided both for the year in which the individual projects were incubated and in 2019. On average, the growth of employment size in the PACA-EST incubator is equal to 86%. As far as the Utrecht dataset is concerned, I searched on LinkedIn for the number of current employees present. Obviously, as the data was calculated in May 2020, the values do not date back to December 2018. This could lead to a bias. The average growth of employment size in the Utrecht dataset is equal to 160.73%.

3.3.2 Independent Variables – Utrecht Dataset

The descriptive statistics of the chosen control variables for Utrecht Inc. and Climate-KIC are shown in Table (7). The variables chosen are: smart city index, percentage of male in the founder's team, the percentage of male squared, the entrepreneur experience of the founder's team, a dummy to identify whether the project has been incubated or not, the product type (hw), the age of the start-ups, size of the teams (founders team), market type (market b2b).

Variable	Obs	Mean	Std. Dev.	Min	Max
Age start-up	173	3.17341	0.9486762	1	5
Male percentage	229	0.8510917	0.3014261	0	1
Male percentage^2	229	0.814818	0.3477343	0	1
Experience	250	1.836	0.8555888	1	3
Incubated	269	0.4832714	0.5006515	0	1
hw	268	0.4141791	0.4935013	0	1
Investment	268	0.0970149	0.2965318	0	1
Founders team	267	2.685393	1.553039	0	9
Smart City	249	0.2409639	0.4285298	0	1
Market b2b	256	0.7734375	0.4194271	0	1

Table 7 - Descriptive statistics - Utrecht

The smart city index is a binary variable that corresponds to the interaction between the characteristics of a start-up to be defined as "smart city". I assigned 1, in case the condition analysed was contained within the description, and 0, in case it was not. This variable was generated after the use of the Smart City Index, and the procedure is explained in detail in section 2 in Table (3) of this thesis.

The second independent variable is the percentage of males within the group that requested incubation back in time. To calculate it I counted the number of males present in each single founding group and divided by its total. Considering the 269 start-ups present in the dataset, the average percentage of males within the groups is around 85%. Hence, the percentage of women in the sample is equal to 15%. This result is very low and shows the gender dominance in the sample. Moreover, more than 78% of the teams record no woman, and only 7.5% of them have just females. I also generated the variable male percentage 2 which would be the square of male percentage. Thus, I will test the quadratic relationship between the percentage of males in the founder's team and performance. This models more accurately the effect of male percentage, which may have a non-linear relationship with the independent variable.

The third independent variable is the number of people working in a start-up at the time of the application. This variable is used to check if the size of the founding team has an impact on dependent variables. Hence, whether a limited or a large team is suitable in start-up projects. The start-ups teams analysed were quite small in the beginning, in fact they varied from one to nine members. The average number of members was around 2.6. A large team can have both positive and negative aspects. It can have benefits in terms of resources, but it can be more complex to organize and manage.

The fourth independent variable is market type. In the dataset there are two variables that determine the type of market in which the start-up works, business to costumer (b2c) and business to business (b2b). In total the business to business projects are 198 on 269, corresponding to 77% of the projects, and the business to customer projects are 100 on 269.

The fifth independent variable is product type. The start-ups contained in the dataset produce different types of products that lead to diverse processes and investments. For this reason, I differentiate the start-ups that develop products based on software or services from those that develop products that are partly or entirely physical. I use the variable dummy hw (hardware) which is equal to 0 in case it is a product based on software and equal to 1 in case it is based on hardware. 41% of the start-ups in this dataset offer products based on hardware and 59% products based on software.

The sixth independent is entrepreneurial experience, hence the ability of founders to already navigate the knowledge space. The variable measures entrepreneurs' experience with three values: 1 if it is “low”, up until 2 years; 2 if it is “medium”, up until 10 years; and 3 if it is “high”, more than 10 years of aggregated entrepreneurial experience Eveleens (2019). As Table (7) shows, on average the experience of entrepreneurs is "medium".

The seventh independent variable is the incubated. This is a dummy variable which identifies whether the project has been incubated or not. Therefore, it assumes the value 1 if the start-up that applied at the incubator was incubated, and 0 if it was not incubated.

The last independent variable is the age of the start-ups. To calculate this variable I subtracted 2018, the year in which the data was collected, with the year in which the single start-ups were inserted in the incubation program. In addition, I took into account whether the project under consideration remained active in 2018. As there is no data on the year in which some start-ups left the program, there is some missing data. On average, the sample presents start-ups with around three years of affiliation to the program. In conclusion, Table (8) and (9) report the correlations between the variables. All variables have a p-value of less than 0.13, so the variables are not highly correlated with each other. The only two correlated variables with a value of 0.97 are Male Percentage and Male Percentage2. This is because Male Percentage2 is created by the square of the Male Percentage.

Variables	Survival	Smart City	Male Percentage	Male Percentage2	Founders team	hw	Entrepreneurial Experience	Incubated	Market type
Survival	1.0000								
Smart City	-0.0603	1.0000							
Male Percentage	0.1183	0.0311	1.0000						
Male Percentage2	0.1116	-0.0065	0.9770	1.0000					
Founders team	0.0675	0.0846	-0.0663	-0.0818	1.0000				
hw	-0.1376	0.1182	-0.0789	-0.0669	0.0985	1.0000			
Entrepreneurial Experience	0.0131	0.0102	0.1420	0.1024	0.0295	-0.2717	1.0000		
Incubated	0.2150	-0.0447	0.1309	0.1126	0.1282	0.0603	0.0185	1.0000	
Market type	0.1262	-0.1433	0.0733	0.0662	0.0293	-0.0728	0.1153	0.0444	1.0000

Table 8 - Correlations among variables - Utrecht

Variables	Growth	Smart City	Male Percentage	Male Percentage2	Age start-up	hw	Entrepreneurial Experience	Market type	Incubated
Growth	1.0000								
Smart City	0.0043	1.0000							
Male Percentage	0.0359	-0.0223	1.0000						
Male Percentage2	0.0240	-0.0556	0.9761	1.0000					
Age start-up	-0.0660	-0.1168	0.0854	0.1017	1.0000				
hw	-0.1157	0.0427	0.0375	0.0647	0.3395	1.0000			
Entrepreneurial Experience	0.0499	-0.0245	0.0129	-0.0349	-0.0864	-0.3261	1.0000		
Market type	0.0208	-0.1140	0.0774	0.0497	0.0743	-0.0347	0.1190	1.0000	
Incubated	0.2070	-0.0662	0.1295	0.1067	0.2772	0.0844	0.0234	0.0563	1.0000

Table 9 - Correlations among variables - Utrecht

3.3.3 Independent Variables – Nice Dataset

The descriptive statistics of the chosen control variables for the PACA-EST incubator are shown in Table (10). I chose smart city index, percentage of male, male2, entrepreneur experience, incubated, hw, age of the start-ups, size of the teams, market type (b2b).

Variable	Obs	Mean	Std. Dev.	Min	Max
Age start-up	160	7.95625	4.653188	1	18
Male percentage	269	0.8608028	0.2518105	0	1
Male percentage^2	269	0 .8041543	0.3194621	0	1
Experience	212	1.613208	0.7977546	0	3
Exited	297	0.5858586	0.4934045	0	1
Incubated	297	0.0707071	0.2567675	0	1
hw	297	0.4309764	0.4960486	0	1
Turnover	243	0.7201646	0.4498448	0	1
Founders team	291	2.766323	1.571415	1	10
Smart City	297	0.0942761	0.2927056	0	1

Table 10 - Descriptive statistics - Nice

The smart city index is a binary variable that corresponds to the interaction between the characteristics of a start-up to be defined as "smart city". I assigned 1, in case the condition analysed was contained within the description, and 0, in case it was not. This variable was generated after the use of the Smart City Index, and the procedure is explained in detail in section 2 in Table (4) of this thesis.

The second control variable is male percentage. This variable corresponds to the percentage of males within the group that requested incubation back in time. To calculate it I counted the number of males present in each single founding group and divided by its total. Considering the 297 start-ups present in the dataset, the average percentage of males within the groups is equal to 86%. Hence, the percentage of women in the sample is equal to 14%. This result is very low and shows the gender dominance in the sample. Moreover, more than half of the teams record no woman, and only 25% of them have a share of females higher than 30%. Again, I generated the variable male percentage 2 which would be the square of male percentage, as I have done for the Utrecht dataset.

The third control variable is number of people working in a start-up at the time of the application. This variable is used to check if the size of the founding team has an impact on dependent variables. Hence, whether a limited or a large team is suitable in start-ups project. The start-ups teams analysed are quite small at the start, in fact they vary from one to ten members. The average number of members scores around 3 as standard team size, and half of the sample has a team between 2 and 3 members.

The fourth control variable is product type. The start-ups contained in the dataset produce different types of products that lead to diverse processes and investments. For this reason, I differentiate the start-ups that develop products based on software or services from those that develop products that are partly or entirely physical. I use the variable dummy hw (hardware) which is equal to 0 in case it is a product based on software and equal to 1 in case it is based on hardware. 43% of the start-ups in this dataset offer products based on hardware and 57% products based on software.

The sixth variable is entrepreneurial experience, hence the ability of founders to already navigate the knowledge space. I calculated the values following the same ordinal scale, based on the aggregate number of years of entrepreneurial experience, carried out by Eveleens (2019) for the Utrecht dataset. As Table (10) shows, on average the experience of entrepreneurs is "medium".

The seventh variable is incubated. This is a dummy variable which identifies whether the project has been incubated or not. Therefore, it assumes the value 1 if the start-up that applied at the incubator was incubated, and 0 if it was not incubated.

The last control variable is the age of the start-ups. To calculate this variable I subtracted 2019, the year in which the data was collected, with the year in which the single start-up was inserted in the incubation program. In addition, I took into account whether the project under consideration remained active in 2019. As there is no data on the year in which some start-ups left the program, there is some missing data. On average, the sample presents start-ups with around eight years of affiliation to the program. In conclusion, Table (11) and (12) report the correlations between the variables. All variables have a p-value of less than 0.10, so the variables are not highly correlated with each other. The only two correlated variables with a value of 0.97 are Male Percentage and Male Percentage2.

Variables	Survival	Smart City	Male Percentage	Male Percentage2	Founders team	hw	Entrepreneurial Experience	Incubated
Survival	1.0000							
Smart City	-0.0810	1.0000						
Male Percentage	-0.0480	-0.0050	1.0000					
Male Percentage2	-0.0526	0.0032	0.9711	1.0000				
Founders team	0.0646	-0.0972	-0.0586	-0.1073	1.0000			
hw	-0.0282	-0.0544	0.0370	0.0069	-0.0213	1.0000		
Entrepreneurial Experience	-0.0538	0.0132	-0.0222	-0.0343	-0.0641	0.0498	1.0000	
Incubated	0.0310	0.1063	0.0850	0.0793	0.0065	0.0458	-0.0267	1.0000

Table 11 - Correlations among variables - Nice

Variables	Growth	Smart City	Male Percentage	Male Percentage2	Age start-up	hw	Entrepreneurial Experience	Incubated
Growth	1.0000							
Smart City	0.0266	1.0000						
Male Percentage	0.0653	0.0941	1.0000					
Male Percentage2	0.0452	0.0916	0.9730	1.0000				
Age start-up	0.0333	-0.0984	-0.0456	-0.0377	1.0000			
hw	-0.0540	-0.0423	0.0340	0.0108	-0.0830	1.0000		
Entrepreneurial Experience	-0.1021	0.0131	0.0029	-0.0256	0.0595	0.0396	1.0000	
Incubated	-0.0042	0.0348	0.0622	0.0518	-0.4681	0.0478	-0.0174	1.0000

Table 12 - Correlations among variables - Nice

3.4 Methodology

To compare the performance of the two incubators I chose to use two different regression models: the logistic and the negative binomial models.

The first, which uses survival as a dependent variable, is the logistic model. I use the logistic model in order to regress a nonlinear model with a binary dependent variable, survival. Logistic regression analysis investigates the relationship between binary or ordinal response probability and explanatory variables (Statistical consulting). An important advantage of using a logistic model is that the predicted probabilities are always between 0 and 1.

The second, which uses growth as a dependent variable, is the negative binomial model. The employee variable growth takes values from 0 to 24.5 for Utrecht and from 0 to 19.16 for Nice. In both cases, when the variable takes the value 0 it can be for two different circumstances. The first is due to the fact that there is no change in the number of employees within the start-ups, which therefore result in zero growth. The second because the start-ups may not be survived, thus the growth is zero. For this reason, an OLS regression is not the right choice for the case. In addition, Tables (13) and (14) show how there is a high frequency of zeros and the descriptive Tables (15) and (16) show that the variance of our outcome (the deviation) is larger than the mean.

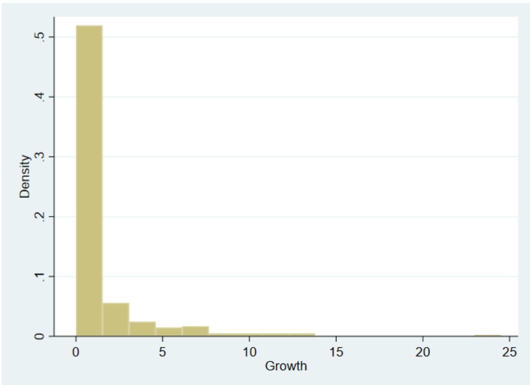

Table 13 - Density of 'Growth' – Utrecht

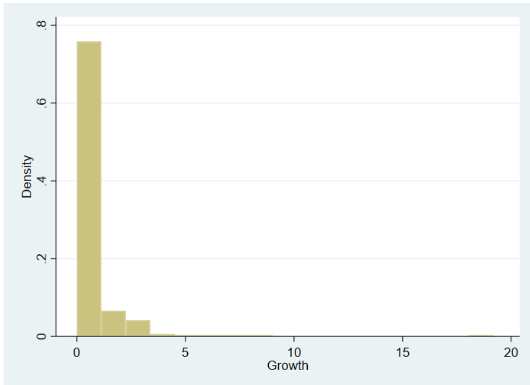

Table 14 - Density of 'Growth' - Nice

Growth				
	Percentiles	Smallest		
1%	0			
5%	0			
10%	0		Obs	269
25%	0		Sum of Wat.	269
50%	0		Mean	1.226022
		Largest	Std. Dev.	2.670125
75%	1	11.4		
90%	3.75	13	Variance	7.129569
95%	6.5	13	Skewness	4.203645
99%	13	24.5	Kurtosis	27.82577

Table 15 - Descriptive statistics of Growth – Utrecht

Growth				
	Percentiles	Smallest		
1%	0			
5%	0			
10%	0		Obs	297
25%	0		Sum of Wat.	297
50%	0		Mean	0.5411491
		Largest	Std. Dev.	1.524109
75%	0.5	5.866667		
90%	1.666667	7	Variance	2.322908
95%	2.571429	8.727273	Skewness	7.433036
99%	7	19.16667	Kurtosis	80.74796

Table 16 - Descriptive statistics of Growth - Nice

Accordingly, I proceeded to check whether the Poisson model was appropriate for the case (see Appendix A). With the dispersion test - Table (17) and (18) - it is clear that this type of model is also not suitable for the case.

Deviance goodness-of-fit	=	4.438.304
Prob > chi2 (133)	=	0.0000
Pearson goodness-of-fit	=	603.356
Prob > chi2 (133)	=	0.0000

Table 17 - Dispersion test – Utrecht

Deviance goodness-of-fit	=	2.584.732
Prob > chi2 (133)	=	0.0000
Pearson goodness-of-fit	=	4.439.851
Prob > chi2 (133)	=	0.0000

Table 18 - Dispersion test - Nice

Due to the over-dispersion of the dependent variable, that is when the conditional variance exceeds the conditional mean, I chose the negative binomial model (Statistical Consulting).

4 Results

	Survival				Growth							
	Logit				Negative Binomial							
	(1)	(2)	(3)	(4)	(5)	(6-irr)	(7)	(8-irr)	(9)	(10-irr)	(11)	(12-irr)
Smart City	-0.593		-0.147		0.113	1.120			0.149	1.161		
	(0.536)		(0.374)		(0.362)	(0.406)			(0.282)	(0.327)		
Founders team	0.078	0.093	0.107	0.114								
	(0.128)	(0.128)	(0.113)	(0.111)								
Male Percentage	0.182	0.269	0.626	0.046	6.728**	835.499**	6.719**	828.422**	-0.208	0.811	0.494	1.638
	(3.618)	(3.589)	(2.420)	(2.345)	(3.375)	(2820.621)	(3.373)	(2794.4)	(2.169)	(0.118)	(1.996)	(3.271)
Male Percentage2	-0.583	-0.623	-0.001	0.457	-4.418**	0.012**	-4.395**	0.012**	0.353	1.424	-0.181	0.834
	(2.751)	(2.729)	(2.094)	(2.045)	(2.285)	(0.027)	(2.283)	(0.028)	(1.796)	(2.559)	(1.662)	(1.138)
Age start-up					0.016	1.016	0.015	1.015	-0.130	0.878	-0.188*	0.828*
					(0.028)	(0.029)	(0.028)	(0.028)	(0.134)	(0.118)	(0.123)	(0.102)
Market Type (b2b)			0.519*	0.515*					0.116	1.123	0.125	1.133
			(0.365)	(0.357)					(0.302)	(0.339)	(0.288)	(0.326)
Entrepreneurial Experience	-0.154	-0.158	-0.164	-0.120	-0.379**	0.684**	-0.378**	0.685**	0.063	1.065	0.033	1.033
	(0.231)	(0.230)	(0.200)	(0.196)	0.171	(0.117)	(0.171)	(0.117)	(0.141)	(0.151)	(0.134)	(0.139)
Hardware	-0.161	-0.133	-0.708**	-0.679**	-0.241	0.785	-0.250	0.778	-0.362*	0.695*	-0.273	0.760
	(0.374)	(0.371)	(0.336)	(0.329)	(0.233)	(0.183)	(0.231)	(0.180)	(0.277)	(0.192)	(0.258)	(0.196)
Incubated	0.406	0.308	0.920***	1.034***	0.132	1.141	0.127	1.135	0.893***	2.443***	0.924***	2.519***
	(0.675)	(0.662)	(0.325)	(0.318)	(0.420)	(0.480)	(0.420)	(0.477)	(0.249)	(0.610)	(0.237)	(0.597)
Constant	1.874*	1.715*	-0.152	-0.216	-1.768*	0.170*	-1.75*	0.172*	0.275	1.317	0.332	1.394
	(1.202)	(1.179)	(0.727)	(0.720)	(1.220)	(0.208)	(1.219)	(0.210)	(0.690)	(0.909)	(0.660)	(0.920)
Obs.	190	190	206	206	147	147	147	147	142	142	150	150
Log Likelihood	-92.047	-92.623	-177.926	-122.533	-201.904	-201.904	-201.95	-201.95	-262.40	-262.40	-279.95	-279.95
Chi2	3.25	2.10	19.44	20.83	10.88	10.88	10.78	10.78	15.97	15.97	18.51	18.51
Prob > chi2	0.860	0.910	0.012	0.004	0.144	0.144	0.09	0.09	0.042	0.042	0.009	0.009
t statistics in parentheses												
* p<0.1, **p<0.05, ***p<0.001												

Table 19 - Regression results

Table (19) shows the results extracted by applying the aforementioned statistical test to the data and adopting the Logistic and the Negative Binomial procedures. It also includes an analysis and interpretation of those findings. The t-test has been used to check if each independent variable is individually significant, hence if their p-value is lower or above the threshold. The hashes display whether the coefficients are significant at 10% (*), 5% (**) or 1% (***). Regressions 1, 2, 5, 6, 7 and 8 refer to the Nice dataset, while regressions 3, 4, 9, 10, 11 and 12 to the Utrecht dataset. The dependent variables I used to measure the performance of incubators are two: survival and growth. For the first model, I developed two regressions for each dataset in order to analyse the difference between smart city and non-smart city start-ups. The same procedure has been done for the second model with the addition of incidence rate ratios regressions.

Firstly, I analyse the results of regressions with the dependent variable survival using a logistic model. The regression (1) of the table has 190 observations, with Chi2 of 3.25 and a p-value of 0.86. Hence, the model shown is not statistically significant (exceeds the level of significance of 10%). Besides, the control variables present are not even 10% significant, making the results unreliable. The same conclusion applies to regression (2). It has 190 number of observations, with a Chi2 of 2.10 and a p-value of 0.91, hence it is not statistically significant.

Subsequently, the regression (3) of the table has 206 observations, with Chi2 of 19.44 and a p-value of 0.012. The regression (4) of the table has 206 observations, with Chi2 of 20.83 and a p-value of 0.004. Hence, both models shown are statistically significant. The smart city variable is not significant, which shows that there is no variation in performance when start-ups are characterised as smart city projects. Instead, the components that have an impact on performance are market type, hardware and incubated. Choosing a business-to-business market type increases the log odds of survival (versus non-survival) by 0.51. Also, the model demonstrates how the incubation programs offered by Utrecht Inc and Climate-KIC increase the chance of survival by 90%. This result is a significant finding that confirms the positive impact that business incubators have on project growth. On the other hand, as far as the type of product is concerned, in this case, the choice to offer a hardware type product penalises the start-up compared to how beneficial a software-based product could be.

Secondly, I analyse the regression results with the dependent variable growth, using the negative binomial procedure. This model estimates negative binomial regression coefficients for a one-unit increase of a variable, given the other variables are held constant in the model (5, 7, 9, 11) (Negative Binomial Regression). Alongside this model are reported the results obtained using the negative binomial model in terms of incidence rate ratios (6-irr, 8-irr, 10-irr and 12-irr). The regression (5) of the table has 147 observations, with Chi2 of 10.88 and a p-value of 0.14. Likewise, the regression (6-irr) has the same number of observations as the statistical model summary. Hence, the models shown are not statistically significant (exceeds the level of significance of 10%). The regressions (7) and (8-irr) of the table have 147 observations, with Chi2 of 10.78 and a p-value of 0.09. Hence, the models shown are statistically significant. In these models, the smart city variable is omitted after verifying that it has no impact on performance. The results show that the percentage of males within the founding groups is relevant. The gender disparity that allows Nice start-ups to grow over time is underlined. Furthermore, the regression (7) shows that the entrepreneurs' experience has not been an additional component of success for start-ups, but this leads to a potential decrease in the number of employees involved in projects. Nevertheless, considering the model (8-irr) and thus, the rate at which this event occurs, if a start-up were to increase its entrepreneurial experience by one point, its rate for size growth would be expected to increase by a factor of 0.68.

The regressions (9) and (10-irr) of the table have 142 number of observations, with Chi2 of 15.97 and a p-value of 0.042. Hence, the models shown are statistically significant. Neither does the smart city variable have any impact on the performance growth of start-ups, even if it is taken as a dependent variable employee growth. However, in this case, as well, the type of product offered by start-ups and the incubation process has a significant impact on performance. The incubation process at Utrecht Inc. and Climate-KIC is beneficial for the performance of projects over the years. More specifically, the difference in the logs of expected growth is expected to be 0.89 units higher for incubated start-ups compared to not incubated. Incubated start-ups compared to non-incubated ones, are expected to have a rate 2.44 times greater for team size growth. The same applies to the type of product offered. Here too, software-based products are preferred for potential growth in size. The regressions (11) and (12-irr) of the table, where the variable smart city is omitted, have 150 observations, with Chi2 of 15.97 and a p-value of 0.009. Hence, the models shown are statistically significant. These last two regressions once again emphasise the role of the incubation process in the performance of start-ups. Values change with an increased positive impact. Indeed, the difference in the logs of expected growth is expected to be 0.92 units higher for incubated start-ups compared to not incubated. Incubated start-ups compared to non-incubated ones, are expected to have a rate 2.52 times greater for team size growth.

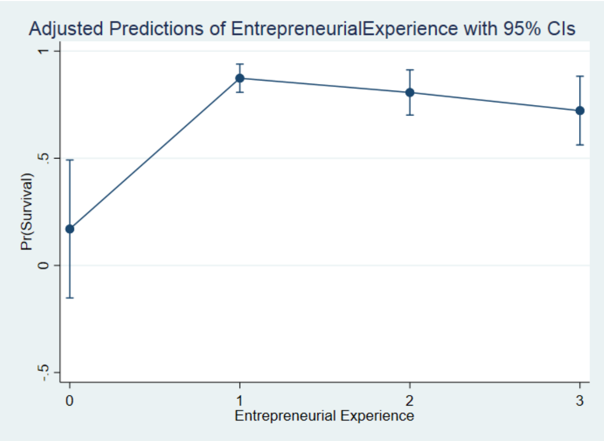

Figure 1 - Relationship Entrepreneurial Experience and Survival – Nice

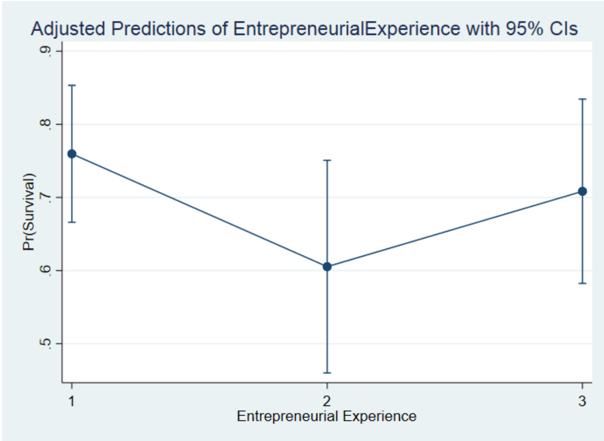

Figure 2 - Relationship Entrepreneurial Experience and Survival - Utrecht

Concluding my analysis, I wanted to examine specifically the impact that the entrepreneur's experience has on the survival variable, distinguishing the different levels of experience. Table (21), present in the Appendix B, shows the results obtained using the same regression model as table (19) regressions (1) and (3). The only variation that occurred was the difference by degree of experience. As can be seen from Figure (1), which concerns the Nice dataset, the probability of survival is higher if the experience of the entrepreneurs of the founder teams is "low". The same is valid for Figure (2), concerning the Utrecht dataset. The above results confirm that start-ups of young entrepreneurs are more likely to have a positive performance over the years thanks to incubation programmes.

5 Discussion

This thesis aimed at evaluating the performance of smart city start-ups within three incubators, Utrecht Inc., Climate-KIC and PACA-EST, which are included in collaboration with IRIS Smart-Cities. Its purpose is to make a contribution to the existing literature both by providing an example of the application of the Smart City Index (Hermse et al., 2020) and a reflection on the factors that contribute to an improvement in performance in individual business incubators.

Through the several existing definitions of smart city and the SCI, I have demonstrated the existence and the number of projects that could be considered as smart cities. The total number of start-ups of the two data sets examined - 269 for Utrecht and 295 for Nice – are similar. In adapting the datasets provided by Eveleens (2019) and Morin (2019), I tried to pay attention to the length of the descriptions and the information contained in them to render them similar for the purposes of comparison. Applying the SCI, I concluded that there are more smart cities in Utrecht than in Nice, and of the start-ups in the incubators of Utrecht Inc and Climate-KIC 25.30% fit the definition of a smart city. This means that these projects are being developed to meet the needs and demands of the city using innovative technological systems. Furthermore, the average smart city score obtained by these 63 projects is 3.6 out of 6. These projects mainly focus on the areas of sustainability (59.04%), the economy (55.42%) and ICT (55.82%) while the values obtained in the areas of quality of life and citizen are relatively low. As far as the Nice dataset is concerned, the percentage of smart cities is significantly lower at 9.49% although the average smart city score is similar at 3.2 out of 6. It should be noted that although their percentages are lower, these 28 projects favour the areas of sustainability (29.15%), the economy (25.08%) and ICT (34.92%). Even though analysis is based on relatively old projects, the new start-ups in the incubators may be considered "smarter". Furthermore, the descriptions relate to the year in which the individual start-ups applied for incubation, so changes may have been made or perhaps even the purpose of the project itself may also have been modified. Moreover, the data appears to be more or less time-sensitive, depending on the dependent variables (Morin, 2019). Despite this, the results obtained match the main objectives of Smart City projects, and hence solve urban problems efficiently to improve the sustainability of the city and the quality of life of its inhabitants (Monzon, 2015).

On the other hand, concerning the empirical analysis carried out, the impact that smart city projects have on the performance of incubators is not relevant. Specifically, for both performance proxies chosen - survival and growth - the smart city variable is not significant. The analysis demonstrates that there are other factors that have a positive impact on performance over time. The existing literature highlights how important the support of a business incubator is for the growth and success of new projects (Totterman et al., 2005). Indeed, the empirical results show that incubated start-ups have a higher probability of success in the long term, both from the point of survival and an increase in size. Notably, the incubators analysed are located in universities, thereby providing the opportunity to link talent, technology, capital, and know-how to leverage entrepreneurial talent, accelerate the development of new technology-based firms, and speed up the commercialisation of technology (Smilor & Gill, 1986). Nevertheless, it is crucial that the chosen incubation program complies with the goals of the project and maximises the result. In addition, each incubator offers specific programs in line with its main interests, so it is relevant to define the goals and objectives of every program (NBIA, 2006). For instance, the findings differ between the incubators evaluated, in that while start-ups related to Utrecht Inc and Climate-KIC business incubators are more likely to grow and develop if incubated, the same result does not apply to the PACA-EST incubator.

Furthermore, as far as Nice is concerned, the results show that the composition of the internal team of each project has an impact on its growth. The negative impact of the entrepreneurs' experience on performance leads to the conclusion that teams of young minds are more likely to grow, indicating that start-ups of young students and/or professionals are more attractive to market demands. Less encouraging, unfortunately, is the positive impact that the higher percentage of males, involved in a project, has on growth. Recently, the gender gap has been a highly debated issue given that to "Achieve gender equality and empower all women and girls" is one of the goals on which the United Nations are currently working (United Nations, 2019). This goal needs to be addressed and worked towards to result in a peaceful, prosperous and sustainable world.

However, as far as Utrecht is concerned, the type of market and product offered by start-ups have an impact on performance. From the results, we can conclude that the start-ups that are most likely to grow are those that are relevant to a business-to-business market and that are based on software technology. Indeed, software products are more flexible than hardware, their production cost is lower, and any changes and/or additions required are easier to process (Thompson).

This study has a number of limitations. For instance, the samples analysed have a low number of smart cities and a consistent impact on performance is difficult to assess. If the datasets had contained a higher number of smart city projects the results would presumably have been different. In future research, it would be interesting to see whether there will be a greater number of smart city start-ups within those incubators, and whether they are actually more likely to grow than the others. This is mainly because the demand for smart solutions to implement citizen quality of life is growing. Obviously, the content of the datasets could be improved, adding new information and making the one available more consistent and detailed. But this was beyond the scope of my thesis. Surely it would be interesting to add longitudinal data to track the sample at different points of time. Nevertheless, this thesis contributes to improve empirical research on the impact of smart city start-ups on incubation. In particular, it is useful because it presents a unified dataset which can be used for further researches.

All in all, the index developed clarifies what the prevailing characteristics for a project to qualify as a smart city are (Hermse et al., 2020). This allowed me to develop a practical example of how to differentiate between smart city and non-smart city start-ups in incubators, contributing to screening efficiency for future studies, while also highlights the elements start-ups should focus on in order to be defined as smart cities. The empirical analysis carried out differentiates which aspects influence the growth of projects in the business incubator examined.

Bibliography

Aernoudt, R. (September 2004). *Incubators: tool for entrepreneurship?* Belgium: Small Business Economics volume.

A.L. Samarakkody, U. Kulatunga and H.M.N. Dilum Bandara. (2019). *What differentiates a smart city? A comparison with a basic city.*

Al-Mubaraki, H, Al-Karaghouli, W and Busler, M. (2010). *The Creation of Business Incubators in Supporting Economic Developments.* Abu Dhabi: European, Mediterranean & Middle Eastern Conference on Information Systems 2010.

Bifulco, F., Tregua , M., Amitrano, C. C. and D'Auria, A.;. (2016). *ICT and sustainability in smart cities management.* International Journal of Public Sector Management.

Billy Wadongo and Magdy Abdel-Kader. (2014). Contingency theory, performance management and organisational effectiveness in the third sector: A theoretical framework. *International Journal of Productivity and Performance Management*, 680-703.

Bollingtoft, A. (2012). The bottom-up business incubator: Leverage to networking and cooperation practices in a self-generated, entrepreneurial-enabled environment. *32*, 304-315.

Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). *Smart cities in Europe* (Vol. 18). Journal of urban technology.

Chang, A. (2013, March 19). *How a Garage-Based Incubator is Fueling the Hardware Revolution.* Retrieved from Wired: http://www.wired.com/gadgetlab/2013/03/lemnos-labs-hardware-incubator/

Chan, K. L. (2005). *Assessing technology incubator programs in the science park: the good, the bad, the ugly.* Technovation.

Chourabi, H., Nam, T., Walker, S., Gil-Garcia, J.R., Mellouli, S., Nahon, K., Pardo, T.A. Scholl, H.J. . (2012). *Understanding smart cities: An integrative framework.* . 45th Hawaii international conference on system sciences .

Cocchia, A. (2014). *Smart and Digital City: A Systematic Literature Review* . Springer.

Collier, C. (2020, January 27). *What a Smart City Is… and Is Not.* Retrieved from Smart City connect: https://smartcitiesconnect.org/what-a-smart-city-is-and-is-not/

Commission, E. (2010). *A strategy for smart, sustainable and inclusive growth.* Brussels : COMMUNICATION FROM THE COMMISSION EUROPE 2020 .

EC. (2002). *Benchmarking of Business Incubators.* Brussels: European Commission.

Eckinger, C., & Sanders, M. W. J. L. (2019). *User Innovation and Business Incubation.* Utrecht University School of Economics ~ Sustainable Finance Lab Utrecht University.

Eveleens, C. (2019). *How business incubation impacts the performance of start-ups.* Utrecht.

Felsenstein, D. (1994). *University-related science parks – 'seedbeds' or 'enclaves' of innovation?* Technovation.

Hamdani, D. (July 2006). *Conceptualizing and measuring business incubation.* Ottawa: Science, Innovation and Electronic Information Division (SIEID).

Hansen, M. T., Chesbrough, H. W., Nohria, N. and Sull, D. N. (2000). *Networked Incubators Hothouses of the New Economy.* Harvard Business Review.

Harman, P. and Read, L. (2003). *Supporting incubation in the UK through the development of benchmarks.* 48th World Conference. Northern Ireland: UKBI: International Council for Small Business.

Henrik Totterman, Jan Sten. (2005). *Start-ups Business Incubation and Social Capital.* Finland: Swedish School of Economics and Business Administration.

Hermse, M., Nijland, I., Picari, M. (2020). *Classification of Smart City Startups: Smart City Index. Working paper.* Working Paper.

J. Piet Hausberg, Sabrina Korreck. (January 2018). *Business incubators and accelerators: a co-citation analysis-based, systematic literature review.* The Journal of Technology Transfer.

Kumar, H., Singh, M. K., Gupta, M. P., & Madaan, J. (2020). *Moving towards smart cities: Solutions that lead to the Smart City Transformation Framework.* New Delhi: Technological forecasting and social change.

L. V. Ortiz-Fournier, E. Márquez, F. R. Flores, J. C. Rivera-Vázquez, and P. A. Colon. (2010). *Integrating educational institutions to produce intellectual capital for sustainability in Caguas, Puerto Rico* (Vol. 8). Knowledge Management Research & Practice.

Lee, J. H., Hancock, M. G., & Hu, M. C. (2014). *Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco.* Technological Forecasting and Social Change.

Lofsten, H., Lindelof, P. (2002). *Science Parks and the growth of new technology-based firms – academic-industry links, innovation and markets.* Research Policy.

Mac Chinsomboon, O. . (2000). *Incubators in the New Economy.* Massachusetts: Master of Business Administration at the Massachusetts Institute of Technology.

Morin, R. (2019). *Incubation performances and impact of start-up's resources.* Utrecht.

Monzon, A. (2015). *Smart cities concept and challenges: Bases for the assessment of smart city projects International.* SMARTGREENS. Lisbon: 2015 Conference on Smart Cities and Green ICT Systems.

Mutin-Quinsin, I. (2004). *Pépinières d'entreprises: origines et modes opératoires.* Retrieved from http://doc.sciencespo-lyon.fr/Ressources/Documents/Etudiants/Memoires/Cyberdocs/MSPCP/mutinquinson_i/pdf/mutinquinson_i.pdf

NBIA. (2000). *National Business Incubation Association*. Retrieved from NBIA publications: www.nbia.org

NBIA. (2006). *State of the business incubation industry.* Athens,: NBIA Publications.

Nations, U. (2019). *TRANSFORMING OUR WORLD: THE 2030 AGENDA FOR SUSTAINABLE DEVELOPMENT.* Retrieved from sustainabledevelopment.un.org

Nicola Dee, David Gill, Robert Lacher, Finbarr Livesey and Tim Minshall. (2012). *A review of research on the role and effectiveness of business incubation for high-growth start-ups.* University of Cambridge Engineering Department.

OECD. (1997). *Technology Incubators: Nurturing Small Firms Organisation for Economic Co-Operation and Development.* Paris.

Pezzini, A., Di Cesare, M. (2003). *Le piccole e medie imprese in Europa. Innovazione, ricerca e sviluppo tecnologico, responsabilità sociale e finanza d'impresa.* Soveria Mannelli: Rubbettino editore.

Phan, P.H., Siegel, D.S., Wreight, M. (2005). Science park and incubators: observations, synthesis and future research. *Journal of Business Venturing, 20*, 165-182.

Ryzhonkov, V. (2014, April 30). *Generic Business Incubation Model – Part 3.* Retrieved from ENTREPRENEURSHIP, BUSINESS INCUBATION, BUSINESS MODELS & STRATEGY BLOG: https://worldbusinessincubation.wordpress.com/2014/04/30/generic-business-incubation-model-part-3/

Rompho, N. (2018). *Operational performance measures for startups.* Bangkok, Thailand: Measuring business excellence .

Salvador, E. (2011). Are science parks and incubators good "brand names" for spin-offs? The case-study of Turin. *Journal of Technology Transfer, 36*(2), 203-232.

Smilor, R., & Gill, M. (1986). *The new business incubator: Linking talent, technology and knowhow.* Massachusetts: Lexington Books.

Statistical consulting. (n.d.). *Logistic regression*. Retrieved from Institute for digital research & education: https://stats.idre.ucla.edu/stata/dae/logistic-regression/

Statistical Consulting. (n.d.). *Negative Binomial Regression*. Retrieved from Institute for digital research & education: https://stats.idre.ucla.edu/stata/output/negative-binomial-regression/

T. Heo et al. (2014). *Escaping from ancient Rome! Applications and challenges for designing smart cities* (Vol. 25). Transactions on Emerging Telecommunications Technologies.

Thompson, K. (n.d.). *Hardware vs. Software Development: Similarities and Differences*. Retrieved from cprime: https://www.cprime.com/2015/11/hardware-vs-software-development-similarities-and-differences/

Umberto Rosati, Sergio Conti . (2016). *What is a smart city project? An urban model or a corporate business plan?* . Turin, Italy: Elsevier Ltd.

United Nations. (2020). Retrieved from Sustainable Development Goals: https://www.un.org/sustainabledevelopment/sustainable-development-goals/

Urban Development. (2019). Retrieved from The World Bank: https://www.worldbank.org/en/topic/urbandevelopment/overview

Washburn, D., Sindhu, U., Balaouras, S., Dines, R. A., Hayes, N. M., & Nelson, L. E. . (2010). *Helping CIOs Understand "Smart City" Initiatives: Defining the Smart City, Its Drivers, and the Role of the CIO.*

Willson, N. (2019, October 21). *What is a Startup Incubator?* Retrieved from TOPMBA: https://www.topmba.com/blog/what-startup-incubator

(n.d.). Retrieved from IRIS Smart cities: https://irissmartcities.eu

(n.d.). Retrieved from DeepL: https://www.deepl.com/translator

Appendix

Appendix A

	Poisson	
	(1)	(2)
Smart City	0.148	0.076
	(0.255)	(0.148)
Male Percentage	10.861**	0.319
	(4.501)	(1.197)
Male Percentage2	-7.049**	-0.087
	(2.905)	(0.963)
Age start-up	0.018	-0.146**
	(0.019)	(0.066)
Market Type (b2b)		0.084
		(0.155)
i.Entrepreneurial Experience	-0.326***	0.006
	(0.121)	(0.072)
Hardware	-0.251	-0.366***
	(0.166)	(0.140)
Incubated	0.057	0.854***
	(0.308)	(0.140)
Constant	-3.358	0.411
	(1.641)	(0.380)
Obs.	147	142
Log Likelihood	-230.224	-348.465
Chi2	21.80	54.01
Prob > chi2	0.002	0.000
t statistics in parentheses		
* p<0.1, **p<0.05, ***p<0.001		

Appendix B

	Survival - Logistic			
	(1)	(2)	(3)	(4)
Smart City	-0.466		-0.452	
	(0.558)		(2.428)	
Founders team	0.178	0.187	0.122	0.127
	(0.145)	(0.143)	(0.113)	(0.111)
Male Percentage	0.073	0.210	0.452	0.057
	(3.784)	(3.727)	(2.428)	(2.346)
Male Percentage2	-0.373	-0.436	0.252	0.546
	(2.878)	(2.840)	(2.108)	(2.050)
Age start-up				
Market Type (b2b)			0.538*	0.497*
			(0.368)	(0.359)
i.Entrepreneurial Experience				
1	3.517***	3.267***		
	(1.210)	(1.231)		
2	3.015**	3.100**	-0.722*	-0.649*
	(1.217)	(1.239)	(0.409)	(0.388)
3	2.540**	2.646**	-0.262	-0.155
	(1.239)	(1.257)	(0.415)	(0.671)
Hardware	-0.166	-0.156	-0.655**	-0.609*
	(0.390)	(0.388)	(0.339)	(0.333)
Incubated	0.212	0.133	0.904***	1.019***
	(0.691)	(0.679)	(0.327)	(0.320)
Constant	-1.771	-2.023	-0.352	-0.353
	(1.731)	(1.721)	(0.682)	(0.671)
Obs.	190	190	206	216
Log Likelihood	-85.541	-85.875	-116.689	-121.287
Chi2	16.27	15.60	21.91	23.32
Prob > chi2	0.061	0.048	0.009	0.003
t statistics in parentheses				
* p<0.1, **p<0.05, ***p<0.001				

Table 20 - Regressions Results

Appendix C

Universiteit Utrecht

Classification of Smart City Startups: Smart City Index

Working paper

By: Maaike Hermse (5672945), Imke Nijland (6868126) & Martina Picari (6897878)
Supervisor: Dr. Mark Sanders
Data: 26-06-2020

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Table of Contents

1. Introduction

This article develops a classification scheme for smart city startups based on 73 definitions found in the literature. Smart city development is high on the policy agenda of urban planners around the world (de Lima et al., 2020). Research has shown that smart cities are part of a new and fast reality that will change the ways of improving the efficiency, equity, sustainability, and quality of life in cities (Batty et al., 2012). However, the literature is developing without a clear and unambiguous definition of the concept. It is essential to have a reliable meaning to ensure consistency and comparability across studies. A clear and specific definition of the concept would be helpful in a range of different applications.

In the literature, we found 20 literature review articles looking for a common thread in the numerous existing definitions. In this paper, we develop a workable definition of the concept "smart city" based on 73 definitions found in 93 academic articles. The resulting algorithm allows us to classify, e.g. projects and startups as being "smart city". We develop this classification scheme based on the methodology developed for the definition of "user innovations" in Eckinger and Sanders (2019). These authors classify the concept in two steps. After collecting a wide variety of definitions from the literature, we first identify the essential elements common to all interpretations. These make up the necessary conditions for being defined as a smart city project (0/1). We then code and count additional elements and take the eight most common ones. Scoring projects and startups on each of these (1/0) and adding these, give us an intensity score.

The contribution of this paper is, therefore, twofold. First, we collected definitions of smart cities used in the emerging literature, providing an overview of the emerging concept. Second, we adapt the classification method in Eckinger and Sanders (2019) to classify projects and startups as a "smart city." In this way, we will facilitate data collection and future empirical research on smart city development greatly.

The remainder of the paper is structured as follows. Firstly, we present an examination of the ground of prior research and summarizing the current state of literature in reference to the smart city concept. Secondly, we present the method used for data collection and coding processing. Thirdly, we reported the results obtained by applying the coding developed to three different databases of three incubators in Utrecht, Gutemberg and Nice. Lastly, we extended the presentation of the final results by a conclusion and a discussion of the limitations of this paper.

2. Literature review

Although there is a growing interest in smart cities, there is no common definition of this concept. In some research smart cities are termed as for example intelligent city, digital city, innovative city or knowledge city (Tan, 1999; Krisna Adiyarta, 2020; Sun & Poole, 2010; Ismagilova et al., 2019; Fietkiewicx et al., 2017; Sproull & Patterson, 2004; Stolfi & Sussman, 2001). These terms are all tangential to the concept of a "smart city" but are not identical. As smart cities represent something more than those concepts (Yigitcanlara et al., 2018; Samarakkody et al., 2019). The variety of terms used to refer to the concept of smart cities makes the definition of the concept ambiguous. Definitions used are based on different themes, elements, or dimensions (Giffinger et al., 2007: Winkowska, Szpilko, & Pejić, 2019; Silva, Khan & Han, 2018). A highly cited definition of smart city that incorporates many of these elements is "a city is smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and high quality of life, with a wise management of natural resources, through participatory governance" (Caragliu, Del Bo & Nijkamp, 2011, p.70) However, other definitions emphasize other dimensions. For example, according to Zhuhadar et al. (2017, p. 274) "smart cities are those cities that have the greatest quality of life and economic wellbeing for their citizens". This definition emphasizes the citizens in a city and their quality of life. Whereas, e.g. Neirotti et al. (2014, p.25) focus on the Information and Communication Technologies (ICT) aspect of smart cities, stating: "smart cities are characterized by the pervasive use of ICT, which, in various urban domains, help cities make better use of their resources". Governance and institutional components are also often emphasized in definitions. According to for example Nam & Pardo (2011, p.284) "smart cities are an organic connection among technological, human and institutional components. The usage of 'smart' captures innovative and transformative changes driven by new technologies". Most scholars emphasize the quality of life, citizen wellbeing, technology, or governance. But other topics are also frequently incorporated, such as innovation, collaboration, and infrastructures. None of the definitions incorporates all the themes identified in the definitions of smart city. To be able to progress with the smart city movement, entrepreneurs form an essential part (Lombardi et al., 2012). However, as mentioned, there is no readily available definition of smart city, so it is even harder to define a smart city start-up. Creating such a definition and the additional coding scheme for smart city start-ups improves the research possibilities for smart cities.

3. Methodology

The aim of this paper is to develop a clear classification scheme to identify "smart city" projects and startups. To do so, we follow the method of Eckinger and Sanders (2019), using a variety of definitions found in the existing literature. Based on these definitions, we develop an index using necessary conditions for "smart city" on the one hand, and on the other hand, use non-necessary variables to measure the intensity. We call this our Smart City Index (SCI). In this section, we explain how we get to this index.

First, we looked for papers regarding smart cities and their definitions in the literature via Google Scholar. The search terms used were "smart city", "smart-city", "smart city" AND "literature review", "smart city" AND "definition", and "definition smart city". In total, we came up with 165 articles, including multiples of the same reference and twenty literature review articles from which we took articles and definitions to supplement our reference list. After deleting the recurring papers, we were left with a list of 92 peer-reviewed papers, excluding 20 literature reviews (see Appendix A). These 92 references were collected in an Excel file with a column for the author, publication date, title, and journal. Next, these remaining articles were ranked by the number of citations per paper, since there was a difference in relevance among them. These citations were taken from Google Scholar on the 1st of April 2020 and added to the spreadsheet in a separate column. To be more accurate, two extra columns were added; one with citations per year, thus taking the total citations per article and dividing it by the years the article had been in circulation, and another for the rounded up number of these citations per year. We deleted articles below 3 citations per year, however keeping the articles of 2019 and 2020 regardless, plus the definitions of the European Parliament (2014). Finally, we ended up with 78 different references.

Next, we divided the 78 articles amongst ourselves (excluding the literature reviews) and looked in each one for a definition using "smart city", "define" and/or "definition", later adding this to the Excel file in a new column. Some definitions were quoted multiple times by different authors. These were deleted, after which we ended up with a total of 73 unique definitions of a smart city in an Excel sheet (See Appendix B). Afterwards, we listed the main keywords per definition. To come to an idea on what keywords appeared most, we did an initial search of the recurrence per word. Based on this, we were able to code the most recurring keywords and chose the following themes, coded 0 if the definition did not include the theme, coded 1 if it did. The themes were “technology”, “ICT”, “quality of life”, “city”, “sustainability”, “innovation”, “collaboration”, “citizen”, “integration”, “economic”, “human capital”, “social capital”, “business”, “resource management”, “infrastructure”, “efficiency”, “safety/security”, “transportation”, “network”, “energy”, “growth”, and “creativity”. Next, we calculated the percentage of appearances in the 73 definitions by making a sum of all the codes and ordered them in descending order (see Appendix C1). Additionally, we also calculated the percentage of appearances based on the total amount of citations per year (see Appendix C2).

3.1 First results

Based on the percentages, the following themes and keywords are identified (see Table 3). In this table, the themes are presented as well as the keywords that are included in the particular theme. For the first results, we defined two necessary conditions - technology and city - and seven intensity conditions - ICT, citizen, environmental sustainability, quality of life, social capital, economic and human capital.

Table 3: SCI

Conditions	Themes	Keywords included
Necessary conditions	Technology	Technology, data, sensors, activators, internet, ICT, IT, database, algorithm, grid, digital, solar panels, smart meters, WIFI, software, hardware, smart devices)
	City	City, urban, urban challenges, territory, place, geographical area
Intensity conditions	ICT	ICT
	Citizen	Citizen, inhabitants, people
	Environmental sustainability	Sustainability, green, environmental, ecological
	Quality of Life	Quality of life, liveability, prosperity, habitable, well-being
	Social Capital	Social capital, social, social wealth, inclusion, community
	Economic	Economic
	Human capital	Human capital, intelligence, skilled workers/jobs, (high) education, knowledge

Based on these first results, multiple robustness tests are carried out. In these robustness tests, our first results of the coding scheme are put into practice on the data retrieved on the start-ups of our theses. Each author individually codes the start-ups, based on their description. This description comes from the website. In most cases, the information gathered there is sufficient to be able to code the themes. Afterwards, the results are discussed. This way, we are able to validate our coding scheme. We gather information on whether the coding scheme is replicable, and whether it is even possible to code each of the variables. Changes to the coding scheme are made according to the results of the robustness tests.

3.2 Robustness tests

(1) To test the robustness of the coding scheme, we each applied it to companies from the dataset at our proposal. This dataset includes start-ups that have applied for incubation at UtrechtInc from 2014 till 2017. For each company, we coded over the nine variables - two necessary and seven intensity conditions - using the description of the company used on the website. During the discussion of our individual results, small irregularities were found. We thus decided to make the following adjustments. First, for the themes of human and social capital, we used the following definitions:

Human Capital. In Laroche, Mérette, and Ruggeri (1999, p.89), human capital is defined as the "aggregation of the innate abilities and the knowledge and skills that individuals acquire and develop throughout their lifetime". Thus, the theme of human capital has to do with the attraction and appeal to skilled labour forces in the context of smart city. Therefore, we clustered the keywords intelligence, skilled jobs, (high) education and knowledge under this theme. Stated in Hollands (2008), human capital also has to do with creativity.
Social Capital. The Healy and Côté (2001, p.41) defines social capital as "networks together with shared norms, values and understandings that facilitate co-operation within or among groups". Social capital entails various keywords form our definitions, namely, social, social wealth, inclusion and community.

However important they are for a smart city, we were not able to code these variables based on the descriptions of companies we looked at. In light of large databases, acquiring these variables would become too unstructured and thus not robust enough. We, therefore, decided to take them out of the intensity factors. Secondly, the definition of the themes quality of life and citizens needed some more funnelling, to make the difference between the two clearer. Finally, we decided to adjust the theme sustainability. A company would not only be seen as sustainable if products and services offered are sustainable but also if the general goal of the company is to make people more sustainable. An example here is the website Nature Today, which is not sustainable an sich, however, the information they spread awareness of nature and what has to be preserved.

(2) Since some adjustments were made in the first robustness test, we did a second test. This time, the dataset of start-ups in Gothenburg were used. These start-ups all are incubated at Chalmers Ventures between 2015 and 2020. We coded ten companies. This time we coded seven variables - two necessary conditions and five intensity conditions. The descriptions of the companies that were present on the Chalmers Ventures website are used. A downside of these descriptions is that they are fairly short and straight-forward. This made the coding of the start-ups more challenging. Although the descriptions were short, we managed to get quite similar results. During the discussion, it became clear that the variable of quality of life will only be coded 1 when the start-up has a direct effect on the quality of life of people. As incorporating the indirect effect of quality of life in this variable, would be a great source of interpretation and subjectivity. Which would make it hard to replicate the coding. Additionally, it became clear in the discussion that the definition of technology is way broader than many people have in mind. Therefore, before coding, it is important that you have a good understanding of what technology actually entails. This allows for a more accurate replication when using the algorithm.

(3) Based on our first two robustness tests, we decided that for this test, the dataset of start-ups in Gothenburg is used. Coding this dataset was more challenging because of the shorter descriptions of the start-ups. Therefore, it would be more useful to test our coding scheme after the changes using this dataset. We used twelve start-ups to check our coding. The results we individually obtained were again similar, with only a few discrepancies. This means that the coding scheme is replicable. When discussing the results, we agreed that to be able to code the variable technology as 1, new academic knowledge or R&D should be put forward by this start-up. We acknowledge that this makes technology time-dependent. This can create a bias. However, it will be the most reliable way of coding technology, since it is most closely to the definition. This means that the technology should be based on new knowledge, or academic research. Besides that, it was challenging to code the variable ICT. It is a broad concept, and we agreed that it should be able to collect, store, use and send or share data electronically (ICT, n.d.). Another discussion we had was about the variable economy. After the test, we decided that economics entails both the direct effect on the start-up itself, for example cost reduction, but also the indirect effect on the customers of the start-up. These customers can be businesses or consumers, so it is valid for both B2B and B2C start-ups. As mentioned in the previous results of the robustness test, we decided to code the variable quality of life as 1 when the effect of the start-up is directly on the quality of life. Since it is more challenging to code the indirect

effect on quality of life then the indirect effect on the economic component, we decided to not include this. The indirect effect on the quality of life is more prone to interpretation, this would limit the replicability of our coding scheme. Another thing we decided is that we are only able to code the variable citizens as a 1 when we are able to code the variable city as 1. Because, these two variables are connected to each other. Lastly, we agreed that when there are terms or concepts in the definition, which we are not familiar with, we are allowed to look up the definition. One example was the word ‘biopharmaceuticals’ which was present in one of the descriptions of the start-ups. When discussing our results, we all were not certain about the definition of this. Therefore, we searched for this definition. This made it easier to code this start-up. Being able to search for terms or concepts that are unclear, makes sure the coding is done correctly according to what the start-up really entails.

4. Results

Based on the keywords and the percentages of how many times they were present, unweighted and weighted with the number of citations, we identified two necessary conditions and various intensity conditions. With the use of robustness tests, we changed our first results into our final coding scheme. First, the necessary conditions that are needed for a start-up to be defined as a smart city start-up. The necessary conditions are “technology” and “city”. We defined these themes a follows:

Technology. Defined as “the use of scientific knowledge or processes in business, industry and manufacturing” (Cambridge dictionary, 2020). Technology is the umbrella term for various terms that can be present for a smart city start-up. Some examples of these keywords included in the theme technology are “database”, “solution”, “operating system”, “sensors” and “algorithm”.
City. The city is defined as an urban challenge and “it outlines how the humanitarian community is adapting to address the challenges posed by urban areas” (Knox et al., 2012). Defined as an urban challenge, this means that a start-up needs to be working on or creating a solution or service for an urban challenge, to conform to this necessary condition. Some keywords that are included in the term “city”, are “urban challenges”, “territory”, and “geographical area”.

Additionally, we added various intensity conditions. As a start-up complies to one or more of the intensity conditions of being a smart city start-up their intensity rating enhances. Ultimately, we defined five intensity conditions, namely ICT, citizen, environmental sustainability, quality of life and economic.

ICT. It stands for Information and Communication Technology and is defined as “the use of computers and other electronic equipment and systems to collect, store, use, and send or share data electronically” (ICT, n.d.). These technological tools and resources include computers, the Internet (websites, blogs, and emails), live broadcasting technologies (radio, television, and webcasting), recorded broadcasting technologies (podcasting, audio and video players and storage devices) and telephony (fixed or mobile, satellite, visio/video-conferencing, etc.)” as well as computer software and hardware (Unesco, 2020). Some examples that are included in the term “community” and “platform”.

Important note: as “ICT” is coded as 1, “Technology” also has to be coded as 1, since “ICT” is a part of “Technology”.

Citizen. This theme includes the keywords citizen, inhabitant and people. The implications a smart city has the need to result in practices that are beneficial in any way for its inhabitants and should improve their trust in urban institutions (Dameri, 2013). Thus, they are the beneficiaries of the solutions that a smart city offers.

Important note: "Citizen" is a condition that can only exist if “City” is coded as 1, thus also fulfilled.

Environmental sustainability. This is defined according to the definition of Gleeson and Low (2000) and Inoguchi et al. (1999) where environmental sustainability refers to the ecological and ‘green’ implications of urban growth and development. Some examples that are included in the term “energy”, “renewable”, “reduce waste”, “reduce emissions”, “bio” and “LED”.

Quality of Life. Everything that has to do with the improvement of life and wellbeing and making the environment more habitable and livable for its inhabitants was therefore put under this theme. Economic prosperity is also key to improving the quality of life (Hollands, 2008). The quality of life needs to be improved directly by the product or service offered by the start-up. Some examples that are included in the term “help”, “health”, “simplifies everyday life” and “medical solution”.

Economic. Economy is defined as the activities of production and consumption of limited resources. This theme, therefore, includes the tackling of economic challenges by using cost reductive, optimization techniques in a sustainable way. These optimization processes in terms of costs should be beneficial for its consumers, in other words, businesses that buy their product or service. Some examples that are included in the term “cost saving”, “cheaper”, “loss reduction”, “cost efficient” and “low cost”.

In Table 4 the necessary and intensity conditions are displayed, with the keywords included in each theme. For each condition, start-ups are coded a 0 or 1. After the coding, a formula (1) is used to calculate whether the start-up is a smart city start-up and what the intensity is. Within the formula, all the intensity conditions are equally weighted. The following formula is used:

1. *SCI = (technology*city)*(1+ICT +citizen+environmental sustainability+quality of life+economic)*

NC(x) = 0 if not; NC(x) = 1 if yes

IC(x) = 0 if not; IC(x) = 1 if yes

Based on formula (1), start-ups are granted a score between 0 and 6, with the following meaning per score:

0 = At least one of the NCs is = 0
1 = All the NCs, none of the ICs
2 = NCs + (ICT or citizens or environmental sustainability or quality of life or economic)
3 = NCs + MAX 2 (ICT and/or citizens and/or environmental sustainability and/or quality of life and/or economic)
4 = NCs + MAX 3 (ICT and/or citizens and/or environmental sustainability and/or quality of life and/or economic)
5 = NCs + MAX 4 (ICT and/or citizens and/or environmental sustainability and/or quality of life and/or economic)
6 = NCs + MAX 5 (ICT and/or citizens and/or environmental sustainability and/or quality of life and/or economic)

Table 4: Final SCI

Conditions	Themes	Keywords included
Necessary conditions	Technology	Technology, data, sensors, activators, internet, ICT, IT, database, algorithm, grid, digital, solar panels, smart meters, WIFI, software, hardware, smart devices)
	City	City, urban, urban challenges, territory, place, geographical area
Intensity conditions	ICT	ICT
	Citizen	Citizen, inhabitants, people
	Environmental sustainability	Sustainability, green, environmental, ecological
	Quality of Life	Quality of life, liveability, prosperity, habitable, well-being
	Economic	Economic

5. Discussion

The aim of this paper was to develop a classification scheme for smart city startups based on 73 definitions found in the literature. In the literature, there is no common definition of the concept smart city, even though there is a growing interest in the concept. Various terms are used interchangeably with the term “smart city” in the literature, such as digital city or intelligent city (Tan, 1999; Krisna Adiyarta, 2020; Sun & Poole, 2010; Ismagilova et al., 2019; Fietkiewicx et al., 2017; Sproull & Patterson, 2004; Stolfi & Sussman, 2001). However, these terms are not identical to the concept of smart city. The definitions of smart cities are based on different themes, elements and dimensions (Giffinger et al., 2007: Winkowska, Szpilko, &

Pejić, 2019; Silva, Khan & Han, 2018). These various elements were used in creating the coding scheme. Following the method of Eckinger and Sanders (2019), we listed the main keywords present in each definition of smart city. Based on these keywords, we identified the most recurring keywords and overarching themes. Based on these results, we developed an index with necessary conditions for "smart city" and intensity conditions for "smart city". Ultimately, the results consisted of two necessary conditions - "technology" and "city" - and five intensity conditions - "ICT", "citizen", "environmental sustainability", "quality of life" and "economic". After each step, robustness tests were carried out to test the results of the coding scheme. Based on these tests, various changes were made along the way, finally resulting in the classification scheme stated above. There are some limitations to the paper. First, when it comes to the themes, we defined them in a way that makes sense today. However, the concept of smart city is constantly evolving, therefore making the scheme subject to different interpretations over time. Secondly, the term quality of life, which is essential when talking about smart cities, can be interpreted differently by different parties coding it. We attempted to make the definition as clear as possible, however, noticed for this theme it remained difficult. Finally, the paper lacks in certain more systematic robustness scores. These will be carried out later. Overall, with this paper, we tried to clarify the meaning of the concept smart city and find a way to code projects as smart and non-smart city endeavours. We hope it can be useful for this purpose and more, such as research in other fields than start-ups.

6. References

Adiyarta, K., Napitupulu, D., Syafrullah, M., Mahdiana, D., & Rusdah, R. (2020). Analysis of smart city indicators based on prisma: systematic review. In *IOP Conference Series: Materials Science and Engineering* (Vol. 725, No. 1, p. 012113). IOP Publishing.

Alkandari, A., Alnasheet, M., & Alshaikhli, I. F. T. (2012). Smart cities: survey. *Journal of Advanced Computer Science and Technology Research*, *2*(2), 79-90.

Anthopoulos, L., Janssen, M., & Weerakkody, V. (2019). A Unified Smart City Model (USCM) for smart city conceptualization and benchmarking. In *Smart cities and smart spaces: Concepts, methodologies, tools, and applications* (pp. 247-264). IGI Global.

Bakıcı, T., Almirall, E., & Wareham, J. (2013). A smart city initiative: the case of Barcelona. *Journal of the knowledge economy*, *4*(2), 135-148.

Batty, M., Axhausen, K. W., Giannotti, F., Pozdnoukhov, A., Bazzani, A., Wachowicz, M., ... & Portugali, Y. (2012). Smart cities of the future. *The European Physical Journal Special Topics*, *214*(1), 481-518.

Barrionuevo, J. M., Berrone, P., & Ricart, J. E. (2012). Smart cities, sustainable progress. *Iese Insight*, *14*(14), 50-57.

Barth, J., Fietkiewicz, K., Gremm, J., Hartmann, S., Ilhan, A., Mainka, A., & Stock, W. (2017). Informational urbanism. A conceptual framework of smart cities.

Bartoli, A., Hernández-Serrano, J., Soriano, M., Dohler, M., Kountouris, A., & Barthel, D. (2011). Security and privacy in your smart city. In *Proceedings of the Barcelona smart cities congress*, 292, 1-6.

Bélissent, J. (2010). Getting clever about smart cities: New opportunities require new business models. *Cambridge, Massachusetts, USA*, *193*, 244-77.

Calderoni, L., Maio, D., & Palmieri, P. (2012). Location-aware mobile services for a smart city: Design, implementation and deployment. *Journal of theoretical and applied electronic commerce research*, *7*(3), 74-87.

Cambridge dictionary (2020). "Technology (Business English)". Accessed on May 6, 2020: https://dictionary.cambridge.org/dictionary/english/technology

Caragliu, A., Del Bo, C., & Nijkamp, P. (2011). Smart cities in Europe. *Journal of urban technology*, *18*(2), 65-82.

Chang, S., Saha, N., Castro-Lacouture, D., & Yang, P. P. J. (2019). Multivariate relationships between campus design parameters and energy performance using reinforcement learning and parametric modeling. *Applied energy*, *249*, 253-264.

Chatterjee, S., Kar, A. K., & Gupta, M. P. (2018). Success of IoT in smart cities of India: An empirical analysis. *Government Information Quarterly*, *35*(3), 349-361.

Chen, T. M. (2010). Smart grids, smart cities need better networks [Editor's Note]. *IEEE Network*, *24*(2), 2-3.

Chong, M., Habib, A., Evangelopoulos, N., & Park, H. W. (2018). Dynamic capabilities of a smart city: An innovative approach to discovering urban problems and solutions. *Government Information Quarterly*, *35*(4), 682-692.

Corbett, J., & Mellouli, S. (2017). Winning the SDG battle in cities: how an integrated information ecosystem can contribute to the achievement of the 2030 sustainable development goals. *Information Systems Journal*, *27*(4), 427-461.

Cretu, L. G. (2012). Smart cities design using event-driven paradigm and semantic web. *Informatica Economica*, *16*(4), 57.

Dameri, R. P. (2013). Searching for smart city definition: a comprehensive proposal. *International Journal of Computers & Technology*, *11*(5), 2544-2551.

David, M., & Koch, F. (2019). "Smart Is Not Smart Enough!" Anticipating Critical Raw Material Use in Smart City Concepts: The Example of Smart Grids. *Sustainability, 11*(16), 4422.

De Lima, J. P. C., Becker, L. B., Siqueira, F., Morales, A. S., & de Araujo, G. M. (2020). From a Smart House to a Connected City: Connecting Devices Services Everywhere. *Anais do VIII Simpósio Brasileiro de Computação Ubíqua e Pervasiva*, 100-109.

Eckinger, C., & Sanders, M.W. J. L. (2019). User Innovation and Business Incubation. *USE Working Paper series, 19*(16).

Eger, J. M. (2009). Smart growth, smart cities, and the crisis at the pump a worldwide phenomenon. *I-WAYS-The Journal of E-Government Policy and Regulation, 32*(1), 47-53.

El-Haddadeh, R., Weerakkody, V., Osmani, M., Thakker, D., & Kapoor, K. K. (2019). Examining citizens' perceived value of internet of things technologies in facilitating public sector services engagement. *Government Information Quarterly, 36*(2), 310-320.

Gascó-Hernandez, M. (2018). Building a smart city: lessons from Barcelona. *Communications of the ACM, 61*(4), 50-57.

Giffinger, R., Fertner, C., Kramar, H., & Meijers, E. (2007). City-ranking of European medium-sized cities. Cent. Reg. Sci. *Vienna UT*, 1-12.

Gil-Garcia, J. R., Zhang, J., & Puron-Cid, G. (2016). Conceptualizing smartness in government: An integrative and multi-dimensional view. *Government Information Quarterly, 33*(3), 524-534.

Gleeson, B. and Low, N. (2000). "Cities as consumers of worlds environment". *In Consuming Cities: The Urban Environment in the Global Economy after the Rio Declaration*, Edited by: Low, N., Gleeson, B., Elander, I. and Lidskog, R.1–29. London: Routledge.

Grant (2020). "Sustainability". Investopedia. Accessed on May 6, 2020: *Investopedia*, https://www.investopedia.com/terms/s/sustainability.asp

Gretzel, U., Werthner, H., Koo, C., & Lamsfus, C. (2015). Conceptual foundations for understanding smart tourism ecosystems. *Computers in Human Behavior, 50*, 558-563.

Guan, L. (2012). Smart Steps To A Battery City. *Government News 32*, 2, 24-27.

Hall, R. E., Bowerman, B., Braverman, J., Taylor, J., Todosow, H., & Von Wimmersperg, U. (2000). The vision of a smart city(No. BNL-67902; 04042). Brookhaven National Lab., Upton, NY (US).

Harrison, C., Eckman, B., Hamilton, R., Hartswick, P., Kalagnanam, J., Paraszczak, J., & Williams, P. (2010). Foundations for smarter cities. *IBM Journal of research and development, 54*(4), 1-16.

Heaton, J., & Parlikad, A. K. (2019). A conceptual framework for the alignment of infrastructure assets to citizen requirements within a Smart Cities framework. *Cities, 90*, 32-41.

Healy, T., & Côté, S. (2001). The Well-Being of Nations: The Role of Human and Social Capital. Education and Skills. In: *Organisation for Economic Cooperation and Development*, OECD: Paris. Retrieved from http://www.oecd.org/site/worldforum/33703702.pdf

Heo, T., Kim, K., Kim, H., Lee, C., Ryu, J. H., Leem, Y. T., & Ko, J. (2014). Escaping from ancient Rome! Applications and challenges for designing smart cities. *Transactions on Emerging Telecommunications Technologies, 25*(1), 109-119.

Hernández-Muñoz, J. M., Vercher, J. B., Muñoz, L., Galache, J. A., Presser, M., Gómez, L. A. H., & Pettersson, J. (2011). Smart cities at the forefront of the future internet. In The future internet assembly, 447-462. Springer, Berlin, Heidelberg.

Hollands, R. G. (2008). Will the real smart city please stand up? Intelligent, progressive or entrepreneurial?. *City, 12*(3), 303-320.

Huovila, A., Bosch, P., & Airaksinen, M. (2019). Comparative analysis of standardized indicators for Smart sustainable cities: What indicators and standards to use and when?. *Cities, 89*, 141-153.

Hussain, A., Wenbi, R., da Silva, A. L., Nadher, M., & Mudhish, M. (2015). Health and emergency-care platform for the elderly and disabled people in the Smart City. *Journal of Systems and Software, 110*, 253-263.

ICT. (n.d). Cambridge dictionary online. Retrieved May 14, 2020, from https://dictionary.cambridge.org/dictionary/english/ict

Inoguchi, T., Newman, E.and Paoletto, G. (1999). Cities and the Environment: New Approaches for Eco-societies, New York: UN University Press.

Ismagilova, E., Hughes L., Dwivedi, Y. K. & Raman, R. (2019). Smart cities: Advances in research – An information systems perspective. *International Journal of Information Management, 47,* 88-100.

Khatoun, R., & Zeadally, S. (2016). Smart cities: concepts, architectures, research opportunities. *Communications of the ACM, 59*(8), 46-57.

Knox P. & Ramalingam, B. (2012) Meeting the urban challenge: Adapting humanitarian efforts to an urban world. AlnAp meeting paper. London: AlnAp/odi

Komninos, N. (2011). Intelligent cities: Variable geometries of spatial intelligence. *Intelligent Buildings International, 3*(3), 172-188.

Komninos, N., Bratsas, C., Kakderi, C., & Tsarchopoulos, P. (2019). Smart city ontologies: Improving the effectiveness of smart city applications. *Journal of Smart Cities, 1*(1), 31-46.

Kourtit, K., & Nijkamp, P. (2012). Smart cities in the innovation age. *Innovation: The European Journal of Social Science Research, 25*(2), 93-95.

Kourtit, K., Nijkamp, P., & Arribas, D. (2012). Smart cities in perspective–a comparative European study by means of self-organizing maps. *Innovation: The European journal of social science research, 25*(2), 229-246.

Lara, A. P., Da Costa, E. M., Furlani, T. Z., & Yigitcanla, T. (2016). Smartness that matters: towards a comprehensive and human-centred characterisation of smart cities. *Journal of Open Innovation: Technology, Market, and Complexity, 2*(2), 8.

Laroche, M., Mérette, M., & Ruggeri, G. (1999). On the Concept and Dimensions of Human Capital in a Knowledge-Based Economy Context. *Canadian Public Policy / Analyse De Politiques, 25*(1), 87-100.

Lazaroiu, G. C., & Roscia, M. (2012). Definition methodology for the smart cities model. *Energy, 47*(1), 326-332.

Lee, J., & Lee, H. (2014). Developing and validating a citizen-centric typology for smart city services. *Government Information Quarterly, 31*, S93-S105.

Lee, J. H., Hancock, M. G., & Hu, M. C. (2014). Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco. *Technological Forecasting and Social Change, 89*, 80-99.

Lombardi, P., Giordano, S., Farouh, H., & Yousef, W. (2012). Modelling the smart city performance. *Innovation: The European Journal of Social Science Research, 25*(2), 137-149.

Mahizhnan, A. (1999). Smart cities: the Singapore case. *Cities, 16*(1), 13-18.

Manville, C., Cochrane, G., Cave, J., Millard, J., Pederson, J. K., Thaarup, R. K., & Kotterink, B. (2014). Mapping smart cities in the EU.

Marsal-Llacuna, M. L., Colomer-Llinàs, J., & Meléndez-Frigola, J. (2015). Lessons in urban monitoring taken from sustainable and livable cities to better address the Smart Cities initiative. *Technological Forecasting and Social Change, 90*, 611-622.

Nam, T., & Pardo, T. A. (2011, June). Conceptualizing smart city with dimensions of technology, people, and institutions. In *Proceedings of the 12th annual international digital government research conference: digital government innovation in challenging times* (pp. 282-291).

Neirotti, P., De Marco, A., Cagliano, A. C., Mangano, G., & Scorrano, F. (2014). Current trends in Smart City initiatives: Some stylised facts. *Cities, 38*, 25-36.

Odendaal, N. (2003). Information and communication technology and local governance: understanding the difference between cities in developed and emerging economies. *Computers, Environment and Urban Systems, 27*(6), 585-607

Outlook, A. E. (2014). Early Release Overview. US Energy Information Administration.

Partridge, H. L. (2004). Developing a human perspective to the digital divide in the 'smart city'. Australian Library and Information Association Biennial Conference.

Paskaleva, K. A. (2009). Enabling the smart city: The progress of city e-governance in Europe. *International Journal of Innovation and regional development, 1*(4), 405-422.

Peng, G. C. A., Nunes, M. B., & Zheng, L. (2017). Impacts of low citizen awareness and usage in smart city services: the case of London's smart parking system. *Information Systems and e-Business Management, 15*(4), 845-876.

Pereira, G. V., Macadar, M. A., Luciano, E. M., & Testa, M. G. (2017). Delivering public value through open government data initiatives in a Smart City context. *Information Systems Frontiers, 19*(2), 213-229.

Piro, G., Cianci, I., Grieco, L. A., Boggia, G., & Camarda, P. (2014). Information centric services in smart cities. J*ournal of Systems and Software, 88*, 169-188.

Qian, Y., Wu, D., Bao, W., & Lorenz, P. (2019). The internet of things for smart cities: Technologies and applications. *IEEE Network, 33*(2), 4-5.

Rana, N. P., Luthra, S., Mangla, S. K., Islam, R., Roderick, S., & Dwivedi, Y. K. (2019). Barriers to the development of smart cities in Indian context. *Information Systems Frontiers, 21*(3), 503-525.

Rios, P. (2012). Creating" The Smart City" (Doctoral dissertation).

Samarakkody, A. L., Kulatunga, U., & Bandara, H. M. N. D. (2019). What differentiates a smart city? a comparison with a basic city.

Schaffers, H., Ratti, C., & Komninos, N. (2012). Special issue on smart applications for smart cities-new approaches to innovation: Guest editors' introduction. *Journal of theoretical and applied electronic commerce research, 7*(3), 2-5.

Schiavone, F., Paolone, F., & Mancini, D. (2019). Business model innovation for urban smartization. *Technological Forecasting and Social Change, 142*, 210-219.

Schuurman, D., Baccarne, B., De Marez, L., & Mechant, P. (2012). Smart ideas for smart cities: Investigating crowdsourcing for generating and selecting ideas for ICT innovation in a city context. *Journal of theoretical and applied electronic commerce research, 7*(3), 49-62.

Shafiullah, G. M., Oo, A. M., Jarvis, D., Ali, A. S., & Wolfs, P. (2010). Potential challenges: Integrating renewable energy with the smart grid. *In 2010 20th Australasian Universities Power Engineering Conference* (pp. 1-6). IEEE.

Silva, B. N., Khan, M., & Han, K. (2018). Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities. *Sustainable Cities and Society*, *38*, 697-713.

Sproull, L., & Patterson, J. F. (2004). Making information cities livable. *Communications of the ACM*, *47*(2), 33-37.

Sussman, F. S. G. (2001). Telecommunications and transnationalism: The polarization of social space. *The Information Society*, *17*(1), 49-62.

Sun, J., & Poole, M. S. (2010). Beyond connection: situated wireless communities. *Communications of the ACM*, *53*(6), 121-125.

Tan, M. (1999). Creating the digital economy: Strategies and perspectives from Singapore. *International Journal of Electronic Commerce, 3*(3), 105–122.

Thite, M. (2011). Smart cities: implications of urban planning for human resource development. *Human Resource Development International, 14*(5), 623-631.

Thuzar, M. (2011). Urbanization in southeast asia: developing smart cities for the future?. *Regional Outlook, 96.*

Toppeta, D. (2010). The smart city vision: how innovation and ICT can build smart,“livable”, sustainable cities. *The innovation knowledge foundation, 5*, 1-9.

Townsend, A. M. (2013). Smart cities: Big data, civic hackers, and the quest for a new utopia. *WW Norton & Company.*

Unesco, (2020). Information and CommunicationTechnologies. Accessed on May 6, 2020: http://uis.unesco.org/en/glossary-term/information-and-communication-technologies-ict

Van Zoonen, L. (2016). Privacy concerns in smart cities. *Government Information Quarterly, 33*(3), 472-480.

Washburn, D., Sindhu, U., Balaouras, S., Dines, R. A., Hayes, N., & Nelson, L. E. (2009). Helping CIOs understand “smart city” initiatives. *Growth, 17*(2), 1-17.

Winkowska, J., Szpilko, D., & Pejić, S. (2019). Smart city concept in the light of the literature review. *Engineering Management in Production and Services*, *11*(2), 70-86.

Winters, J. V. (2011). Why are smart cities growing? Who moves and who stays. *Journal of regional science, 51*(2), 253-270.

Xie, J., Tang, H., Huang, T., Yu, F. R., Xie, R., Liu, J., & Liu, Y. (2019). A survey of blockchain technology applied to smart cities: Research issues and challenges. *IEEE Communications Surveys & Tutorials, 21*(3), 2794-2830.

Yeh, H. (2017). The effects of successful ICT-based smart city services: From citizens' perspectives. *Government Information Quarterly, 34*(3), 556-565.

Yigitcanlar, T. (2015). Smart cities: an effective urban development and management model?. *Australian Planner, 52*(1), 27-34.

Yigitcanlar, T. (2016). Technology and the city: Systems, applications and implications. Routledge.

Yigitcanlar, T., Kamruzzaman, M., Buys, L., Ioppolo, G., Sabatini-Marques, J., da Costa, E. M., & Yun, J. J. (2018). Understanding ‘smart cities’: Intertwining development drivers with desired outcomes in a multidimensional framework. *Cities*, *81*, 145-160.

Zhao, J. (2011). Towards sustainable cities in China: analysis and assessment of some Chinese cities in 2008. *Springer Science & Business Media*.

Zhuhadar, L., Thrasher, E., Marklin, S., & de Pablos, P. O. (2017). The next wave of innovation—Review of smart cities intelligent operation systems. *Computers in Human Behavior, 66*, 273-281.

Zygiaris, S. (2013). Smart city reference model: Assisting planners to conceptualize the building of smart city innovation ecosystems. *Journal of the knowledge economy, 4*(2), 217-231.

7. Appendices

Appendix A

Author(s)	Year of publication	Times cited (total)	Times cited (per year)	Title	Journal/ Other
Albino, Berardi & Dangelico (2015)	2015	1566	261	Smart Cities: Definitions, Dimensions, Performance, and Initiatives	Journal of Urban Technology
Nam & Pardo (2011)	2011	1967	197	Conceptualizing Smart City with Dimensions of Technology, People and Institutions	12th Annual International Digital Government Research Conference
Ahvenniemi et al. (2017)	2017	484	121	What are the differences between sustainable and smart cities?	Cities
Meijer & Bolívar (2016)	2016	575	115	Governing the smart city: a review of the literature on smart urban governance	International review of administrative sciences
Cocchia (2014)	2014	621	89	Smart and digital city: A systematic literature review	Smart City
Silva, Khan & Han (2018)	2018	247	82	Towards sustainable smart cities: A review of trends, architectures, components, and open challenges in smart cities	Sustainable Cities and Society
Ismagilova et al. (2019)	2019	105	53	Smart cities: Advances in research- An information systems perspective	International Journal of Information Management
Yigitcanlar et al. (2018)	2018	111	37	Understanding 'smart cities': Intertwining development drivers with desired outcomes in a multidimensional framework	Cities
Hojer & Wangel (2014)	2014	256	37	Smart Sustainable Cities: Definition and Challenges	ICT Innovations for Sustainability
Allam & Newman (2018)	2018	93	31	Redefining the Smart City: Culture, Metabolism and Governance	Smart City
Wilhelm & Ruhlandt (2018)	2018	73	24	The governance of smart cities: a systematic literature review	Cities
Eremia, Toma, & Sanduleac (2017)	2017	86	22	The smart city concept in the 21st century	Procedia Engineering
Dameri & Rosenthal-Sabroux (2014)	2014	90	13	Smart City and Value Creation	Smart City
Cavada, Hunt, & Rogers (2014)	2014	59	8	Smart Cities: Contradicting Definitions and Unclear Measures	World Sustainability Forum
Hasija, Shen, & Teo (2020)	2020	3	3	Smart City Operations: Modeling Challenges and Opportunities	Manufacturing & Service Operations Management
Winkowska, Szpilko, & Pejić (2019)	2019	4	2	Smart city concept in the light of the literature review	Engineering Management in Production and Services
Bleus, & Crutzen (2018)	2018	1	0	Business Model and Smart City, a Literature Review	ISPIM Innovation Conference
Abdi & Shahbazitabar (2020)	2020	0	0	Smart City: A review on concepts, definitions, standards, experiments, and challenges	Journal of Energy Management and Technology
Adiyarta et al. (2020)	2020	0	0	Analysis of smart city indicators based on prisma: systematic review	IOP Conference
Samarakkody, Kulatunga & Dilum Bandara (2019)	2019	0	0	What differentiates a smart city? A comparison with a basic city	Proceedings 8th World Construction Symposium

Appendix B

Author(s)	Year of Publication	Times cited (total)	Times cited (per year)	Title	Journal/ Other	Definition of smart city	Keywords in definition
Caragliu, Del Bo, & Nijkamp (2011)	2011	3325	332.50	Smart Cities in Europe	Journal of Urban Technology	A city is smart when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic growth and a high quality of life, with a wise management of natural resources, through participatory governance	Human capital, social capital, investment, modern, ICT, sustainable, economic, growth, quality of life, resource management, governance, city, transport
Townsend (2013)	2013	1617	202.13	Smart cities—big data, civic hackers and the quest for a New Utopia	Book	Smart cities are places where information technology is combined with infrastructure, architecture, everyday objects, and even our own bodies to address social, economic and environmental problems	IT, infrastructure, social wealth, place, social, economic, environmental
Neirotti et al. (2014)	2014	1381	197.29	Current trends in smart city initiatives–some stylised facts	Cities	Smart cities are characterized by a pervasive use of Information and Communication Technologies (ICT), which, in various urban domains, help cities make better use of their resources	ICT, urban, resource management
Hollands (2008)	2008	2439	187.62	Will the real smart city please stand up?	City: analysis of urban trends, culture, theory, policy, action	Smart city as (1) a celebratory label, (2) a marketing hype rather than a practical engine for infrastructural change, and (3) a loaded term carrying an uncritical, pro-development stance. For the author serious smart city projects consider human capital as the most important component.	City, monitoring, integration, optimization, resource management, maintenance, security, citizen, services, infrastructure, energy
Backici et al. (2012)	2012	727	80.78	A Smart City initiative: The Case of Barcelona	Journal of the Knowledge Economy	Smart city as a high-tech intensive and advanced city that connects people, information and city elements using new technologies in order to create a sustainable, greener city, competitive and innovative commerce, and an increased life quality.	Technology, social, city, information, sustainable, green, innovation, competition, quality of life, business
Harrison et al. (2010)	2010	861	78.27	Foundations for Smarter Cities	IBM Journal of Research and Development	A city connecting the physical infrastructure, the IT infrastructure, the social infrastructure, and the business infrastructure to leverage the	City, IT, social, infrastructure, intelligence, business

						collective intelligence of the city	
Lombardi et al. (2012)	2012	650	72.22	Modelling the Smart City Performance	Innovation: The European Journal of Social Science Research	The application of information and communications technology (ICT) with their effects on human capital/education, social and relational capital, and environmental issues is often indicated by the notion of smart city.	ICT, education, human capital, social capital, relational capital, environmental
Lee, Hancock, & Hu (2014)	2014	500	71.43	Towards an effective framework for building smart cities: Lessons from Seoul and San Francisco	Technological Forecasting and Social Change	A smart city aims to resolve various urban problems (public service unavailability or shortages, traffic, over-development, pressure on land, environmental or sanitation shortcomings and other forms of inequality) through ICT-based technology connected up as an urban infrastructure. The ultimate goal is to revitalize some of the city's structural (environmental and social) imbalances through the efficient redirection of information. Smart cities are envisioned as creating a better, more sustainable city, in which people's quality of life is higher, their environment more liveable and their economic prospects stronger.	Solutions, environmental, inequality, ICT, infrastructure, efficiency, sustainable, city, quality of life, livability, economic, social, information
Washburn & Sindhu (2010)	2010	683	62.09	Helping CIOs Understand "smart City" Initiatives: Defining the Smart City, Its Drivers, and the Role of the CIO	Cambridge, MA: Forrester Research, Inc.	The use of smart computing technologies to make the critical infrastructure components and services of a city- which include city administration, education, healthcare, public safety, real estate, transportation, and utilities - more intelligent, interconnected and efficient	Technology, infrastructure, services (administration, education, healthcare, public safety, real estate, transportation, utilities), intelligence, interconnected, efficiency
Gretzel et al. (2015, p. 559)	2015	343	57.17	Conceptual foundations for understanding smart tourism ecosystems	Computers in Human Behavior	A smart city is a city that uses advanced ICT to optimize resource production and consumption	ICT, resource management
Zygiaris (2013)	2013	451	56.38	Smart City Reference Model: Assisting Planners to Conceptualize the Building of Smart City	Journal of the Knowledge Economy	The term "smart city" is understood as a certain intellectual ability that addresses several innovative socio-technical and socio-economic aspects of growth.	Intelligence, innovation, technology, economic, growth, green, infrastructure, environment, interconnected, intelligence,

				Innovation Ecosystems		These aspects lead to smart city conceptions as "green" referring to urban infrastructure for environment protection and reduction of CO_2 emission, "interconnected" related to revolution of broadband economy, "intelligent" declaring the capacity to produce added value information from the processing of city's real-time data from sensors and activators, whereas the terms "innovating", "knowledge" cities interchangeably refer to the city's ability to raise innovation based on knowledgeable and creative human capital	information, data, sensors, activators, knowledge, creative, human capital, city
Lazaroiu & Roscia (2012)	2012	462	51.33	Definition Methodology for the Smart Cities Model	Energy	A community of average technology size, interconnected and sustainable, comfortable, attractive and secure.	Community, technology, sustainable, interconnected, comfortable, attractive, security
Antopoulos et al. (2019)	2019	101	50.50	A Unified Smart City Model (USCM) for smart city conceptualizatio n and benchmarking	Smart Cities and Smart Spaces: Concepts, Methodologies, Tools, and Applications	All means of innovations in the urban atmosphere (ICT-based, yet not necessarily) that purpose to improve the city dimensions including economy, people, government, mobility, environment and living	Innovation, urban, ICT, economy, people, government, mobility, environment, quality of life
Dameri (2013)	2013	360	45.00	Searching for smart city definition: A comprehensive proposal	International Journal of Computer Technology	A Smart City is a well-defined geographical area, in which high technologies such as ICT, logistic, energy production, and so on, cooperate to create benefits for citizens in terms of well-being, inclusion and participation, environmental quality, intelligent development; it is governed by a well-defined pool of subjects, able to state the rules and policy for the city government and development"	Geographical area, technology, energy, well-being, citizen, inclusion, participation, environmental, intelligence, development, rules, policy, governance, ICT, logistics
Marsal-Llacuna et al. (2015)	2015	258	43.00	Lessons in urban monitoring taken from sustainable and livable cities to better address the Smart City initiative	Technological Forecasting and Social Change	Smart Cities initiatives try to improve urban performance by using data, information and information technologies (IT) to provide more efficient services to citizens, to monitor and optimize existing infrastructure, to increase collaboration among	Urban, data, services, citizens, efficient, innovation, IT, monitoring, optimization, infrastructure, collaboration, economic, governance, performance, information

						different economic actors, and to encourage innovative business models in both the private and public sectors.	
Piro et al. (2014, p. 169)	2014	291	41.57	Information centric services in smart cities	Journal of Systems and Software	A smart city is intended as an urban environment which, supported by pervasive ICT systems, is able to offer advanced and innovative services to citizens in order to improve the overall quality of their life.	ICT, innovation, social, quality of life, urban, citizens, services
Hernandez-Munoz et al. (2011)	2011	409	40.90	Smart cities at the forefront of the future internet	The future internet assembly	A city that represents an extraordinary rich ecosystem to promote the generation of massive deployments of city-scale applications and services for a large number of activity sectors	City, ecosystem, services
Khatoun & Zeadally (2016, p. 46)	2016	202	40.40	Smart cities: Concepts, architectures, research opportunities	Communications of the ACM	A smart city is an ultra-modern urban area that addresses the needs of businesses, institutions and especially citizens	Urban, business, institutions, citizens, modern
van Zoonen (2016, p. 472)	2016	164	32.80	Privacy concerns in smart cities	Government Information Quarterly	In a smart city, ICT-infused infrastructures enable the extensive monitoring and steering of city maintenance, mobility, air and water quality, energy usage, visitor movements, neighbourhood sentiment, and so on.	ICT, monitoring, resource management, transportation, city, mobility, energy, maintenance, community
Winters (2011)	2011	310	31.00	Why are smart cities growing? Who moves and who stays	Journal of Regional Science	I consider "smart cities" to be metropolitan areas with a large share of the adult population with a college degree	Urban, citizens, high education
Gil-Garcia, Zhang, & Puron-Cid (2016)	2016	153	30.60	Conceptualizing smartness in government: An integrative and multi-dimensional view	Government Information Quarterly	A city is smart when there are actions taken towards innovation in management, technology, and policy, all of which entail risks and opportunities	Innovation, management, technology, policy, opportunities, risks, city
Toppeta (2010)	2010	318	28.91	How innovation and ict can build smart, "livable", sustainable cities	Innovation Knowledge Foundation	A city "combining ICT and Web 2.0 technology with other organizational, design and planning efforts to dematerialize and speed up bureaucratic processes and help to identify new, innovative solutions to city management complexity, in order to improve sustainability and livability	ICT, technology, design, planning, governance, innovation, solutions, sustainability, livability, efficiency, management, city, organization
Schuurman et al. (2012, p. 51)	2012	243	27.00	Smart ideas for smart cities: Investigating crowdsourcing	Journal of Theoretical and Applied Electronic	In smart cities collaborative digital environments facilitate the development of	Innovation, improvement, development, collaboration,

				for generating and selecting ideas for ICT innovation in a city context	Commerce Research	innovative applications, starting form the human capital of the city, rather than believing that the digitalization *in se* can transform can improve cities.	human capital, city, digital
Kourtit et al. (2012)	2012	240	26.67	Smart Cities in Perspective - a Comparative European Study by Means of Self-organizing Maps	Innovation: The European Journal of Social Science Research	Smart cities have high productivity as they have a relatively high share of highly educated people, knowledge-intensive jobs, output-oriented planning systems, creative activities and sustainability-oriented initiatives.	Productivity, education, (skilled) job, creativity, sustainability, planning, systems, activities
Huovila et al. (2019)	2019	51	25.50	Comparative analysis of standardized indicators for Smart sustainable cities: What indicators and standards to use and when?	Cities	An innovative city that uses information and communication technologies (ICTs) and other means to improve quality of life, efficiency of urban operation and services, and competitiveness, while ensuring that it meets the needs of present and future generations with respect to economic, social, environmental as well as cultural aspects	Innovation, city, ICT, quality of life, efficiency, services, competition, economic, social, environmental, cultural, sustainable
Hall et al. (2000)	2000	533	25.38	The vision of a smart city	2nd International Life Extension Technology Workshop (Paris)	An urban centre of the future, made safe, secure environmentally green, and efficient because all structures–whether for power, water, transportation, etc. are designed, constructed, and maintained making use of advanced, integrated materials, sensors, electronics, and networks which are interfaced with computerized systems comprised of databases, tracking, and decision-making algorithms	Urban, green, efficiency, integration, interface, ICT, algorithms, safety, security, transportation, energy, water, design, sensors, networks, technology, database
Lee & Lee (2014, p. 93)	2014	175	25.00	Developing and Validating a citizen-centric typology for smart city services	Government Information Quarterly	A city which develops and manages a variety of innovative services that provide information to all citizens about all aspects of city life via interactive and internet-based applications	City, innovation, information, services, ICT, technology, citizens, internet, livability
Belissent (2010)	2010	266	24.18	Getting clever about smart cities: New opportunities require new business models	Cambridge: Forrester	A city that uses ICTs to make the critical infrastructure components and services of a city–administration, education, healthcare,	ICT, infrastructure, services (administration, education, healthcare, public safety, real estate, transportation,

						public safety, real estate, transportation, and utilities–more aware, interactive, and efficient	utilities), interaction, efficiency
Pereira et al. (2017, p. 528)	2017	88	22.00	Delivering public value through open government data initiatives in a smart city context.	Information Systems Frontiers	A smart city encompass an efficient, technologically advanced, sustainable and socially inclusive city	Efficient, technology, sustainable, social, inclusion, city
Zhuhadar et al. (2017, p. 274)	2017	86	21.50	The next wave of innovation-Review of smart cities intelligent operation systems.	Computers in Human Behavior	Those cities that have the greatest quality of life and economic wellbeing for their citizens	Quality of life, economic, well-being, citizens, city
Paskaleva (2009)	2009	257	21.42	Enabling the smart city: The progress of city e-governance in Europe	International Journal of Innovation and Regional Development	A city that takes advantages of the opportunities offered by ICT in increasing local prosperity and competitiveness–an approach that implies integrated urban development involving multi-actor, multi-sector and multi-level perspectives	ICT, development, competition, opportunities, collaboration, city, prosperity
Komninos (2011)	2011	214	21.40	Intelligent Cities: Variable Geometries of Spatial Intelligence	Intelligent Buildings International	(Smart) cities as territories with high capacity for learning and innovation, which is built-in the creativity of their population, their institutions of knowledge creation, and their digital infrastructure for communication and knowledge management.	Territories, learning, innovation, creativity, knowledge, digital, citizens, ICT
Kourtit & Nijkamp (2012)	2012	187	20.78	Smart Cities in the Innovation Age	Innovation: The European Journal of Social Science Research	Smart cities are the result of knowledge-intensive and creative strategies aiming at enhancing the socio-economic, ecological, logistic and competitive performance of cities. Such smart cities are based on a promising mix of human capital (e.g. skilled labor force), infrastructural capital (e.g. high-tech communication facilities), social capital (e.g. intense and open network linkages) and entrepreneurial capital (e.g. creative and risk-taking business activities).	City, economic, ecological, logistic and competitive performance, human capital, social capital, entrepreneurship, creativity, knowledge, infrastructure, business
Odendaal (2003)	2003	366	20.33	Information and communication technology and local governance: understanding the difference	Computers, Environment and Urban Systems	A city that capitalises on the opportunities presented by ICTs in promoting its prosperity and influence.	City, opportunities, ICT, capitalization, prosperity

				between cities in developed and emerging economies			
Xie et al. (2019)	2019	37	18.50	A Survey of Blockchain Technology Applies to Smart Cities: Research Issues and Challenges	IEEE Communications Surveys and Tutorials	Upgraded quality of life, sustainable urban environment, use of advanced ICT, public government openness, encouraged community participation, effective management of traffic and public transport, intelligent device control, optimum resource utilization, improved environmental protection, and improved public services	Quality of life, sustainable, urban, ICT, governance, community, participation, efficiency, transport, resource management, environmental, public services
Lara et al. (2016)	2016	92	18.40	Smartness that matters: Towards a comprehensive and human-centred characterisation of smart cities	Journal of Open Innovation: Technology, Market, and Complexity	A community that systematically promotes the overall wellbeing for all of its members, and flexible enough to proactively and sustainably become an increasingly better place to live, work and play	Community, well-being, livability, sustainability, proactive, citizens, flexibility, quality of life
Yeh (2017, p. 556)	2017	72	18.00	The effects of successful ICT-based smart city services: From citizens' perspectives	Government Information Quarterly	A general definition involves the implementation and deployment of information and communication technology (ICT) infrastructures to support social and urban growth through improving the economy, citizens' involvement and government efficiency	ICT, social, growth, urban, economy, efficiency, citizen (involvement), government
Hussain et al. (2015, p. 253)	2015	107	17.83	Health and emergency-care platform for the elderly and disabled people in the smart city	Journal of Systems and Software	The smart cities are using digital technologies to enhance the quality and performance of urban services	Digital, technology, quality, performance, urban, services
Ygitcanlar (2015)	2015	100	16.67	Smart cities: an effective urban development and management model?	Australian Planner	A city in which the traditional services and networks based on digital technologies are made more efficient for the benefit of its businesses, services, and inhabitants	City, technology, digital, efficiency, businesses, services, networks, inhabitants
Gascó-Hernandez (2018, p. 50)	2018	45	15.00	Building a smart city: lessons from Barcelona	Communications of the ACM	A smart city is an umbrella term of how information and communication technology can help improve the efficiency of a city's operations and its citizens' quality of life while also promoting the local economy	ICT, efficiency, improvement of operations, quality of life, citizens, city

Barrionuevo, Berrone, & Ricart (2012)	2012	134	14.89	Smart Cities, Sustainable Progress	IESE Insight	Being a smart city means using all available technology and resources in an intelligent and coordinated manner to develop urban centers that are at once integrated, habitable, and sustainable.	Technology, resource management, intelligence, coordination, urban, integration, sustainable, habitable
Ygitcanlar (2016)	2016	73	14.60	Technology and the city: Systems, applications and implications	New York: Routledge	An ideal form to build the sustainable cities of the 21st century, in the case that a balanced and sustainable view on economic, societal, environmental and institutional development is realised.	City, sustainable, economic, societal, environmental, institutional, development
Mahizhnan (1999)	1999	313	14.23	Smart cities: The Singapore case	Cities	Information technologies represent the key concept. The vision of an intelligent city is not confined to economic excellence that can be led by information technologies, but an integral part of this vision is its concern for the quality of life for the ordinary citizen.	IT, quality of life, economic, citizen, city
Chatterjee, Kar, & Gupta (2018)	2018	38	12.67	Success of IoT in Smart Cities of 2018 Journal India: An empirical analysis	Government Information Quarterly	Smart Cities where the citizens are expected to use Information and Communication Technology with the help of internet.	ICT, citizen, internet
Rana et al. (2018, p. 1)	2018	37	12.33	Barriers to the development of smart cities in Indian context	Information Systems Frontiers	Smart cities can be defined as a technologically advanced and modernised territory with a certain intellectual ability that deals with various social, technical, economic aspects of growth based on smart computing techniques to develop superior infrastructure constituents and services	Technological, intelligence, social, technical, economic, infrastructure, modern, services, growth, territory
Komninos et al. (2015)	2015	72	12.00	Smart city ontologies: Improving the effectiveness of smart city applications	URENIO Research	Smart cities are created by a convergence of top-down and bottom-up processes, wherein market forces and strategic planning come together to build broadband networks, urban operational systems, embedded systems, and software, all of which change the functioning and life in cities.	Top-down, bottom-up, planning, network, operational, systems, software, quality of life, city
Giffinger et al. (2007)	2007	148	10.57	Smart cities: ranking of European	Vienna: Centre of Regional Science - Vienna UT	A city well performing in a forward-looking way in economy,	Economy, people, governance, mobility,

				medium-sized cities		people, governance, mobility, environment, and living, built on the smart combination of endowments and activities of self-decisive, independent and aware citizens	environment, livability, awareness , citizens, activities, self-decisive, city
Thite (2011)	2011	105	10.50	Smart Cities: Implications of Urban Planning for Human Resource Development	Human Resource Development International	Creative or smart city experiments [. . .] aimed at nurturing a creative economy through investment in quality of life which in turn attracts knowledge workers to live and work in smart cities. The nexus of competitive advantage has [. . .] shifted to those regions that can generate, retain, and attract the best talent.	Creativity, economic, quality of life, livability, competitive advantage, talent acquirement, knowledge
Cretu (2012)	2012	84	9.33	Smart Cities Design Using Event-driven Paradigm and Semantic Web	Informatica Economica	A smart city has well designed ICT infrastructure, transforms real time data into meaningful information, a smart city allows inhabitants to predefine automated actions in response to events	ICT, data, information, inhabitants, automation, events
Eger (2009)	2009	110	9.17	Smart growth, smart cities, and the crisis at the pump a worldwide phenomenon	The Journal of E-Government Policy and Regulation	A particular idea of local community, one where city governments, enterprises and residents use ICTs to reinvent and reinforce the community's role in the new service economy, create jobs locally and improve the quality of community life	Community, governance, technology, livability, productivity, ICT, quality of life, city, businesses, inhabitant, economy
Bartoli et al. (2011)	2011	85	8.50	Security and privacy in your smart city	Proceedings of the Barcelona smart cities congress	The main topics are SCs are related to of their smart inhabitants, quality of social interaction, educational degree, integration with public life, as well as openness to the wider world.	Inhabitants, social, education, integration, openness
Peng, Nunes & Zheng (2017)	2017	32	8.00	Impacts of low citizen awareness and usage in smart city services: the case of London's smart parking system	Information Systems and e-Business Management	Smart cities are essentially built by utilising a set of advanced information and communication technologies (ICT), including smart hardware devices (e.g. wireless sensors, smart meters, smart vehicles, and smartphones), mobile networks (e.g. WIF, 3G/4G/5G network), data storage technologies (e.g. data warehouse, cloud platform), and software applications (e.g. back-office	ICT, data, network, technology, software, hardware, devices

						control systems, mobile apps, big data analytical tools)	
Chen (2010)	2010	88	8.00	Smart Grids, Smart Cities Need Better Networks	IEEE Network	Smart cities will take advantage of communications and sensor capabilities sewn into the cities' infrastructures to optimize electrical, transportation, and other logistical operations supporting daily life, thereby improving the quality of life for everyone	Communications, sensors, infrastructure, optimization, electricity, transportation, logistics, quality of life
Corbett and Mellouli (2017, p. 428)	2017	31	7.75	Winning the SDG battle in cities: How an integrated information ecosystem can contribute to the achievement of the 2030 sustainable development goals	Information Systems Journal	Smart cities seek to leverage advanced communication technologies and IS (information systems) in order to improve all areas of city administration, enhance citizens' quality of life, engage citizens and provide more sustainable and resilient public services	ICT, city, administration, quality of life, citizen (engagement), sustainable, services
Thuzar (2011)	2011	77	7.70	Urbanization in SouthEast Asia: developing smart cities for the future?	Regional Outlook	Smart cities of the future will need sustainable urban development policies where all residents, including the poor, can live well and the attraction of the towns and cities is preserved. […] Smart cities are […] cities that have a high quality of life; those that pursue sustainable economic development through investments in human and social capital, and traditional and modern communications infrastructure (transport and information communication technology); and manage natural resources through participatory policies. Smart cities should also be sustainable, converging economic, social, and environmental goals	Development, city, quality of life, policy, inhabitants, human capital, social capital, ICT, resource management, sustainable, economic, environmental, infrastructure, transport, modern
Schiavonea , Paolonec, & Mancinia (2019)	2019	15	7.50	Business model innovation for 2019 urban smartization	Technological Forecasting & Social Change	Smart cities are the result of a combination of investments made in resources (human, social, creative, infrastructural, technological and business capital) that encourage sustainable economic growth under the conditions of a strong management and governance	Investments, resources, sustainable, economic, growth, governance, human capital, social capital, creativity, infrastructure, business capital, technology

						system (Caragliu et al., 2011)	
Schaffers et al. (2012, p. 2)	2012	66	7.33	Special issue on smart applications for smart cities - new approaches to innovation: Guest editors' introduction	Journal of Theoretical and Applied Electronic Commerce Research	The smart city is an urban innovation ecosystem, a living laboratory acting as agent of change	Urban, innovation, ecosystem, laboratory
Zhao (2011)	2011	70	7.00	Towards sustainable cities in China: Analysis and assessment of some Chinese cities in 2008	Berlin: Springer	A city that improves the quality of life, including ecological, cultural, political, institutional, social, and economic components without leaving a burden on future generations.	City, quality of life, ecological, cultural, political, institutional, social, economic, sustainable
Heaton & Parkilad (2019)	2019	14	7.00	A conceptual framework for the alignment of infrastructure assets to citizen requirements within a Smart Cities Framework	Cities	The concept of Smart City engages with cities' stakeholders and encompasses all of the built and natural environment	City, stakeholders, environment
Rios (2012)	2012	62	6.89	Creating the smart city	Thesis	A city that gives inspiration, shares culture, knowledge, and life, a city that motivates its inhabitants to create and flourish in their own lives—it is an admired city, a vessel to intelligence, but ultimately an incubator of empowered spaces	City, culture, knowledge, life, intelligence, inhabitants, incubator
El-Haddadeh et al. (2018, p. 1)	2018	20	6.67	Examining citizens' perceived value of internet of things technologies in facilitating public sector services engagement	Government Information Quarterly	Smart cities are all about networks of sensors, smart devices, real-time data, and ICT integration in every aspect of human life	Network (of sensors, smart devices, real-time data), ICT, citizen
Qian et al. (2019)	2019	13	6.50	The Internet of Things for Smart Cities: Technologies and Applications (Guest editorial)	IEEE Network	Human and societal capital investments, modern-day communication, infrastructure, sustainable economic growth, participatory governance, natural resources management, and advanced infrastructure (physical, modern ICT, social, and business) integration to sustain the city's collective intelligence	ICT, communication, sustainable, economic, growth, governance, resource management, human capital, social capital, investment, physical infrastructure, business, integration, intelligence
Outlook (2014)	2014	43	6.14	Early Release Overview	US Energy Information Administration	A city that uses ICT to be more interactive, efficient, and making citizens more aware of what is happening in the city.	City, ICT, interaction, efficiency, awareness, citizens

Calderoni, Maio, & Palmieri (2012, p. 74)	2012	55	6.11	Location-aware mobile services for a smart city: Design, implementation, and deployment	Journal of Theoretical and Applied Electronic Commerce Research	A smart city is high-performance urban context, where citizens are more aware of, and more integrated into the city life, thanks to an intelligent city information system	Performance, urban, citizen, awareness, integration, IT
Partridge (2004)	2004	96	5.65	Developing a human perspective to the digital divide in the smart city	ALIA 2004 Biennial Conference: Challenging ideas, Gold Coast, Australia	A city that actively embraces new technologies seeking to be a more open society where technology makes easier for people to have their say, gain access to services and to stay in touch with what is happening around them, simply and cheaply	City, technology, quality of life, services, openness
Alkandari, Alnasheet, & Alshaikhli (2012)	2012	48	5.33	Smart cities: a survey	Journal of Advanced Computer science and Technology Research	A city that uses a smart system characterised by the interaction between infrastructure, capital, behaviours and cultures, achieved through their integration	Systems, interaction, integration, infrastructure, capital, behaviour, city, culture
Heo et al. (2014)	2014	35	5.00	Escaping from ancient Rome! Applications and challenges for designing smart cities	Transactions on Emerging Telecommunicatio ns Technologies	An urban environment which able to improve the quality of citizens' life by using ICT systems	Urban, quality of life, citizens, ICT
Chong et al. (2018, p. 10)	2018	14	4.67	Dynamic capabilities of a smart city: An innovative approach to discovering urban problems and solutions	Government Information Quaterly	Smart city is an integration of infastructures and technology-mediated services, social learning for strengthening human infrastructure, and governance for institutional improvement and citizen engagement	Integration, infrastructure, technology, services, social learning, human, governance, instiutional, improvement, citizen (engagement)
Guan (2012)	2012	41	4.56	Smart Steps To A Battery City	Government News	A city that is prepared to provide conditions for a healthy and happy community under the challenging conditions that global, environmental, economic and social trends may bring.	City, community, challenges, environment, economic, social, quality of life, global
Shafiullah et al. (2010)	2010	44	4.00	Potential challenges: integrating renewable energy with the smart grid	20th Australasian Universities Power Engineering Conference	Smart cities are characterized by the pervasive use of ICT to smartness application in natural resources and energy, transportation and mobility, buildings, living, government, economy, and people.	ICT, energy, transportation, mobility, buildings, living, government, economy, people, resource manageme nt
Chang et al. (september, 2019)	2019	5	2.50	Multivariate relationships between campus design parameters and energy performance using	Applied Energy	The main features of the smart city are smart economy, smart mobility, smart environment, smart people, smart living, and smart governance.	Economy, mobility, environment, people, living, governance

				reinforcement learning and parametric modeling			
European Parliament (2014)	2014	17	2.43	Mapping smart cities in the EU	Economic and scientific policy	A city seeking to address public issues via ICT-based solutions on the basis of a multi-stakeholder, municipally based partnership	City, ICT, solutions, issues, partnerships, municipality
David & Koch (2019)	2019	3	1.50	"Smart Is Not Smart Enough!" Anticipating Critical Raw Material Use in Smart City Concepts: The Example of Smart Grids	Urban Transformations Towards Sustainability	A city that tries to make resource production and allocation in urban areas more efficient, and thus more sustainable through new sociotechnical innovations such as smart grids, smart meters, or solar panels.	City, resource management, efficiency, sustainable, innovation, technology (solar panels, smart meters, smart grids), urban

Appendix C1

#	Themes	% of appearances in total number of definitions
1.	Technology (data, sensors, activators, internet, ICT, IT, database, algorithm, grid, digital, solar panels, smart meters, WIFI, software, hardware, smart devices)	80.9%
2.	City/ urban challenges (territory, place, geographical area)	75.6%
3.	Sustainability (green, environmental, ecological)	50.2%
4.	ICT (if 1, also add 1 to technology)	49.6%
5.	Social capital (social, social wealth, inclusion, community)	48.4%
6.	Economic (economy)	38.6%
7.	Quality of life (liveability, prosperity, habitable, well-being)	38.1%
8.	Human capital (intelligence, skilled workers/ jobs, (high) education, knowledge)	35.4%
9.	Resource management	34.8%
10.	Infrastructure	32.2%
11.	Citizen (inhabitants, people)	29.2%
12.	Transportation (mobility, transport)	23.4%
13.	Innovation	17.8%
14.	Growth	17.5%
15.	Efficiency (efficient)	14.3%
16.	Safety (security)	14.1%
17.	Energy	10.9%
18.	Business (entrepreneurship)	10.5%
19.	Integration	10.5%
20..	Collaboration (participation, partnership, relational capital, coordination, stakeholder)	9.5%
21.	Network (interconnected)	8.6%
22.	Creativity	5.8%

Appendix C2

#	Themes	% of appearances in total number of citations (per year)
1.	Technology (data, sensors, activators, internet, ICT, IT, database, algorithm, grid, digital, solar panels, smart meters, WIFI, software, hardware, smart devices)	74.0%
2.	City/ urban challenges (territory, place, geographical area)	72.6%
3.	ICT (if 1, also add 1 to technology)	43.8%
4.	Citizen (inhabitants, people)	42.5%
5.	Sustainability (green, environmental, ecological)	39.7%
6.	Quality of life (liveability, prosperity, habitable, well-being)	39.7%
7.	Social capital (social, social wealth, inclusion, community)	34.2%
8.	Economic (economy)	31.5%
9.	Human capital (intelligence, skilled workers/ jobs, (high) education, knowledge)	28.8%
10.	Infrastructure	21.9%
11.	Efficiency (efficient)	17.8%
12.	Innovation	17.8%
13.	Transportation (mobility, transport)	16.4%
14.	Resource management	15.1%
15.	Business (entrepreneurship)	11.0%
16.	Collaboration (participation, partnership, relational capital, coordination, stakeholder)	11.0%
17.	Network (interconnected)	9.6%
18.	Integration	11.0%
19.	Growth	8.2%
20..	Creativity	8.2%
21.	Safety (security)	6.8%
22.	Energy	5.5%