IRIS Utrecht presenteert:

Smart City Start-ups: Performance after Business Incubation in Utrecht and Gothenburg

Auteurs/makers:

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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 at smart city startups and their performance in comparison to non-smart city startups after being incubated.

Kernvraag:

What is the difference between the performance of a “smart city start-up” in comparison to a “non-smart city start-up” after business incubation?

Samenvatting/opbrengst:

This study aims to estimate the relationship between incubated start-ups and their performance and estimate the differences between a “smart city start-up” and a “non-smart city start-up” for incubators in Utrecht and Gothenburg. The relationship between business incubation and performance yields contradicting results. Moreover, no previous research has been done looking at a “smart city start-up”. However, with the Smart City Index developed by Hermse et al. (2020), this is possible. This study is explorative and I estimated the relationship between incubated “smart city start-ups” and "non-smart city start-ups” their performance. Thereby, I looked at the differences between a “smart city start-up” and a “non-smart city start-up”. Data was used from the dataset created by Eveleens (2019), from UtrechtInc and Climate-KIC, and I collected data from the incubator Chalmers Ventures, located in Gothenburg, Sweden. Performance was measured with three variables, survival, investment and employment growth. For the former two a logit regression was applied, whereas for the latter variable a negative binomial regression was used. Results showed that being a “smart city start-up” affected the employment growth significantly and positively. Other control variables were found to have significant relationships that were in line with previous research. Incubator managers and cities can make use of these results by for example adjusting their policies to perform at their best. Future research could add a control group of non-incubated start-ups.

Tags:

Smart City, Start-ups, Performance, Business Incubation

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Master Thesis U.S.E.

Smart City Start-ups: Performance after Business Incubation in Utrecht and Gothenburg

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Abstract

This study aims to estimate the relationship between incubated start-ups and their performance and estimate the differences between a "smart city start-up" and a "non-smart city start-up" for incubators in Utrecht and Gothenburg. The relationship between business incubation and performance yields contradicting results. Moreover, no previous research has been done looking at a "smart city start-up". However, with the Smart City Index developed by Hermse et al. (2020), this is possible. This study is explorative and I estimated the relationship between incubated "smart city start-ups" and "non-smart city start-ups" their performance. Thereby, I looked at the differences between a "smart city start-up" and a "non-smart city start-up". Data was used from the dataset created by Eveleens (2019), from UtrechtInc and Climate-KIC, and I collected data from the incubator Chalmers Ventures, located in Gothenburg, Sweden. Performance was measured with three variables, survival, investment and employment growth. For the former two a logit regression was applied, whereas for the latter variable a negative binomial regression was used. Results showed that being a "smart city start-up" affected the employment growth significantly and positively. Other control variables were found to have significant relationships that were in line with previous research. Incubator managers and cities can make use of these results by for example adjusting their policies to perform at their best. Future research could add a control group of non-incubated start-ups.

Key words: smart city, start-ups, performance, and business incubation
JEL codes: C13, L25, M13

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1. Introduction

This paper aims to estimate the relationship between incubated start-ups and their performance, and estimate the differences between a "smart city start-up" and a "non-smart city start-up" for incubators in Utrecht and Gothenburg. Due to the population growth in urban areas, European cities face great challenges (IRIS smart cities, n.d.; Suresh, Renukappa & Shetty, 2019). Therefore, there is a growing interest in the concept of "smart city" in recent years (Caragliu, Del Bo & Nijkamp, 2011; Hall et al., 2000; Lee, Hancock & Hu, 2014).

Innovation is a useful tool in the development of a "smart city". Start-ups create value by the introduction of new innovations and thus are an important vehicle for innovation (Eveleens, 2019; Mason & Brown, 2013). Business incubation is a widespread form of support for startups. But what are the effects of business incubation on start-ups? Various studies on the effect of business incubation on performance yield contradicting results (Colombo & Delmastro, 2002; Dvoulety et al., 2018; Eveleens, 2019; Löfsten, 2010; Löfsten & Lindelöf, 2002; Westhead & Storey, 1997). One reason can be the fact that performance is a broad and imprecise concept (Eveleens, 2019; Lukes, Longo & Zouhar, 2019), which is challenging to measure (Garnsey, Stam & Heffernan, 2006). Therefore, most research makes use of a combination of measures. (Wiklund & Shepherd, 2003). Nevertheless, incubated firms are seen as one of the main drivers of job creation and innovation (Colombo & Delmastro, 2002).

To be able to evolve as a city into a "smart city", a "smart city start-up" is needed. Urban challenges are addressed with these innovations. The innovations might improve the livability, and enhance economic opportunities (Suresh et al., 2019). Even though the "smart city start-ups" are needed to solve the challenges cities are facing, there is a big research gap. Until now, most research has looked at the characteristics of the incubator when measuring the performance of incubation (Lukes et al., 2019; Mandaleno et al., 2018). However, less research has been done looking at the characteristics of the incubated startups (Eveleens, 2019). And there is no research done in the field of "smart city start-ups". Therefore, this paper focuses on a "smart city start-up", which is the independent variable in the model created. Moreover, this paper will compare the results from incubation programs in two cities in Europe, namely Utrecht and Gothenburg, both part of the IRIS project (IRIS smart cities, n.d.). The main research questions for this paper is: *What is the difference between the performance of a "smart city start-up" in comparison to a "non-smart city start-up" after business incubation?*

This research question will be answered with the use of the following steps. First, the dataset created from two incubators in Utrecht, UtrechtInc and Climate-KIC by Eveleens (2019) is used. Then I collect data from the incubator Chalmers Ventures in Gothenburg. Second, with the use of the Smart City Index (SCI) of Hermse, Nijland and Picari (2020), a "smart city start-up" is defined in these datasets.

By the creation of the dataset of incubated start-ups in Gothenburg and looking at properly defined "smart city startups" with the use of the SCI this research fills a gap. With the use of this paper, societal impact is made. This paper will help cities solve their challenges, by understanding how the incubation process may support smart city start-ups, thereby promoting smart city innovation. Such understanding will be useful in urban planning and policy making.

I created a dataset of the start-ups incubated at Chalmers Ventures and I found that being an incubated "smart city start-up" significantly positively affects the employment growth of the start-up. Moreover, these performance indicators significantly are affected by the different incubators. With these insights I make the following contributions to the literature. First, the development of a new dataset of incubated start-ups creates more opportunities. Second, these results make "smart city start-up" relevant in the literature.

The remainder of this thesis is structured as follows. First the theoretical background is discussed in the next section. Thereafter, I address my empirical strategy, results and the discussion.

2. Research Context

Business incubation is perceived as a tool to help start-ups and their performance. Literature on business incubation started in the eighties, however it gained real interest from around the year 2000 (Albort-Morant & Ribeiro-Soriano, 2016; Mian, Lamine & Favolle, 2016; Temali & Campbell, 1984). Additionally, there is an increasing academic interest in the concept of smart cities in recent years (Caragliu et al., 2011; Hall et al., 2000; Lee et al., 2014;). However, there is no consensus on how a "smart city start-up" should be defined. Even though there are various studies available on the performance of start-ups (Daskalopoulou et al., 2010; Eveleens, 2019; Hackett & Dilts, 2004), this has not been linked to a "smart city start-up". There is only limited evidence on the contribution of incubation to smart city development (Blanck, Ribeiro & Anzanello, 2019).

2.1 Business incubation and business incubators

In the literature there has been a debate on the meaning of the concept of business incubation (Aernoudt, 2004; Allen & Mccluskey, 1991; Bergek & Norrmann 2008; Bruneel et al., 2012; Tavoletti, 2013). Various business incubators are defined and various taxonomies and classifications of business incubators have been proposed (Arnoudt, 2004; Barbero et al., 2014; Grimaldi & Grandi, 2005; Kurathko & LaFolette, 1987; Maital et al., 2008). The definition used is from Baraldi and Havenvid (2016, p.53), who defined a business incubator as *"an organizational entity which performs a set of activities or services for incubated firms, such as facility renting, coaching, training, and networking"*. Bergek and Norrman (2008) add to the services of business incubation that the office space can also be extended to a 'virtual space', and that the pool of shared support services reduces costs for the start-up. The emphasis on each of the services and components of the business incubator can differ between the definitions of business incubation (Tavoletti, 2013).

Business incubator programs differ between countries, cities and incubators (Blanck et al., 2019). They rely on different mechanisms, such as incubators, accelerators and science parks (Mian et al., 2016). Due to the variety of mechanisms, business incubation varies within Europe. The mechanisms are adjusted to the specific business policies, local opportunities, weaknesses and bottlenecks in the local ecosystem (Blanck et al., 2019). Different EU countries emphasize different instruments depending on their talents (Daskalopoulou et al., 2010). For example, Northern Europe focuses on the development of "technoparks", which requires a broad background in knowledge creation and an environment to generate, diffuse and commercialize knowledge. Whereas, Central and Eastern Europe tend to focus on the development of more specialized and local business incubators (Daskalopoulou et al., 2010).

Business incubation is a widespread form of support for start-ups. The ventures are heterogeneous and some of the ventures focus on smart technologies. Urban challenges are addressed with these innovations. A "smart city start-up" may improve the livability, and enhance economic opportunities (Suresh et al., 2019). According to Ratinho et al. (2020) the heterogeneity of new ventures needs to be acknowledged and understood better.

2.2 Smart city start-up

The concept of smart cities increasingly interests researchers, because it is a relevant topic for different stakeholders, such as governments, policy makers and start-ups (Ismagilova et al., 2019). The definition of a "smart city", however, is not unified in the literature. Alternative terms for smart cities are used, such as *wired cities*, *intelligent cities* and more recently *sensing cities* (Ismagilova et al., 2019; Mone, 2015; Tan, 1999; Targowski, 1990). However, the concept of a "smart city" is not equivalent to the alternative terms (Samarakkody, Kulatunga & Bandara, 2019; Yigitcanlara et al, 2018;). There are various definitions of a "smart city" and some of the characteristics of these definitions and descriptions are common to most conceptualizations of a "smart city" (Giffinger et al., 2007; Yigitcanlara et al., 2018). The most commonly focused aspects are quality of life, well-being, Information and Communication Technologies (ICT) and the economic-, social- and environmental aspects. Some definitions focus on one of the aspects (Lara et al., 2016; Neirotti et al., 2014), while other definitions try to incorporate multiple aspects of a smart city into their definition (Huovila, Bosch & Airaksinen, 2019; Ortiz-Fournier et al., 2010). Based on the variety of definitions of a "smart city" it is hard to define a "smart city start-up". In Hermse et al. (2020) we created an algorithm and coding scheme for a "smart city start-up" (see Appendix A). Following the method developed by Eckinger and Sanders (2019), we analyzed 73 definitions of a "smart city" and zoomed in on the common aspects in these definitions. Then, we defined necessary and intensity conditions. With the use of this method, I am able to define a "smart city start-up" for the purpose of this paper in a consistent way.

To be able to develop smart cities with the use of a “smart city start-up”, the “smart city start-up” needs to be successful. Business incubation is expected to help start-ups create jobs, commercialize new technologies, transfer technology and knowledge from corporates and universities, and overall strengthen the local and national economy (Tavoletti, 2013). However, the question arises whether business incubation really enhances performance of a “smart city start-up”.

2.3 Business incubation and start-up performance

In previous literature there are contradicting outcomes on whether business incubation positively affects the performance of the incubated start-up. Studies about the relationship of business incubation and start-up performance in different countries do not give a definite answer. Research concluded that business incubators in Italy, UK and the Netherlands made start-ups benefit from this experience (Colombo & Delmastro, 2002; Eveleens, 2019; Westhead & Storey, 1997). Whereas, limited impacts of business incubation on start-up performance were found in Sweden (Löfsten, 2010). According to Dvoulety et al. (2018) incubated start-ups even had worse financial results in comparison to not incubated start-ups in the Czech Republic.

The contradicting results are partly caused by the various measures of performance that are used in research (Maital, 2008). Researchers agree that assessing the performance after business incubation is a challenging task (Hackett & Dilts, 2004). Since various approaches in business incubation are used, there are several ways of approximating the impact of the business incubator on the performance of the start-up after business incubation (Daskalopoulou, Liargovas & Petrou, 2010). Various measures are used such as employment growth, sales, financial results and investments (Colombo & Delmastro, 2002; Dvoulety et al., 2018; Eveleens, 2019; Löfsten, 2010; Westhead & Storey, 1997). The variety of measures can cause identification and selection bias. Additionally, as early business development depends on so many factors, it is hard to control for every factor that influences the relationship of business incubation and start-up performance.

Even though, previous research does not give an absolute answer. There are several reasons identified why start-ups might be helped with a business incubation program. Foremost, is that business incubation provides the start-up with for example, an office space and business assistance. This decreases costs for the start-up in a typically liquidity constrained stage of business development. Moreover, the performance of the start-up after business incubation can be affected by the fact that, before initiatives are accepted to the business incubation program, they go through a selection process (Luke et al., 2019). This results in self-selection and selection bias. For the former it could be that experienced entrepreneurs do not apply for such programs because they associate with it negatively (McAdam & Marlow, 2011). However, start-ups that need more investment before they create revenue, such as high-tech start-ups, may be more inclined to join business incubator programs. As a result, it might be that less viable start-ups apply for business incubation programs. The self-selection bias may also work in the other direction, when only viable ventures go through the trouble of applying for the incubator programs. This would lead to only viable ventures applying for the incubation program. Additional selection bias can then emerge in the selection process of the incubator. Incubators obviously will try to only select the start-ups that will be successful in their programs. Both the self-selection and selection bias may bias the estimated impact on performance due to incubation.

Based on the literature there is no clarity on whether the business incubation affects the performance of a start-up. This, of course, also holds for the performance of a "smart city start-up". However, results show a negative relationship between business incubation and survival rates of the start-ups (Luke et al., 2019; Madaleno et al., 2018). An explanation can be that the high-technology start-ups may need more time to launch in the market, because of their radical innovation (Luke et al., 2019). This would imply that in the long-run incubated start-ups can outperform the non-incubated start-ups (Ferguson and Olofsson, 2004; Luke et al., 2019; Madaleno et al., 2018;). In Hermse et al. (2020), we argue that one of the necessary conditions to be defined as a "smart city start-up" is technology. As a "smart city start-up" is by definition characterized by the use of technology, the above argumentation may apply in the case of a "smart city start-up".

Since this study is explorative, no explicit hypotheses are formulated. However, I want to estimate the relationship between incubated "smart city start-ups" and "non-smart city start-ups" their performance. Thereby, I look at the differences between a "smart city start-up" and a "non-smart city start-up". Also, I look if there are differences with respect to different incubators, located in two cities in Europe.

3. Empirical Strategy

In this part I discuss how I collected my data and how I analyzed the data in order to answer my research question. Data was collected from incubation programs in Utrecht and Gothenburg.

3.1 Data collection & Sample

The research sample consists of start-ups that were part of incubation programs in three incubators. Data was used from two incubators in Utrecht, which was gathered by Eveleens (2019). Additionally, I collected data from an incubator located in Gothenburg, Sweden. Incubators in these cities were used, since both cities are part of the IRIS smart city project (IRIS smart cities, n.d.)[1].

The data of the start-ups in Utrecht was collected from two business incubators located on the Utrecht Science Park, UtrechtInc and Climate-KIC. UtrechtInc started in 2009 and creates an open working area to build businesses. According to the UBI World Incubator Raking, UtrechtInc was placed in the world top 10 university business incubators in 2019 (Meyer & Sowah, 2019). UtrechtInc has connections with knowledge institutions in Utrecht, such as the Utrecht University (UtrechtInc, n.d.). Climate-KIC, is an incubator specialized in innovations that help society mitigate and adapt to climate change. The incubator started in 2010 (Climate-KIC, n.d.) and is the largest climate innovation accelerator in Europe (Climate-KIC, 2018). Eveleens (2019) created the dataset of the incubators in Utrecht. This dataset has been used in previous studies (Eckinger & Sanders, 2019; Eveleens, 2019). To compile this dataset, archival data from start-ups that applied to incubation programs at UtrechtInc or Climate-KIC was used. Additionally, web scraping was used to collect more data on the performance of the start-up. The sample consists of 259 start-ups and covers applications from 2014 to 2017. This dataset includes start-ups that were and were not selected for the incubation program. As this research focuses on incubated start-ups, these start-ups were left out.

To be able to complement the data from Eveleens (2019), and to not be restricted to only one city, I created a dataset for an incubator in Gothenburg. This data was collected based on the incubated firms from Chalmers Ventures. Chalmers Ventures is the university incubator based on Chalmers' campus in Gothenburg, Sweden. Chalmers Ventures is an incubator based on a

[1] IRIS is a HORIZON 2020 EU funded project for the co-creation of smart and sustainable cities. Utrecht and Gothenburg are both "Lighthouse cities" that act as a good example for follower cities (IRIS smart cities, n.d.)

merger in 2015 of two successful incubators. Namely, Chalmers Innovation, an incubator that has been active since 1999, and Encubator, an incubator from the Chalmers School of Entrepreneurship that was founded in 1997. Nowadays, Chalmers Ventures is ranked as the third best incubator in Europe, according to the UBI World incubator ranking (Chalmers Ventures, n.d.).

Based on archive websites incubated firms at Chalmers Ventures were identified. With the use of the start-ups that were presented on the website during the time period of 2015 to March 2020, 192 start-ups have been collected. Based on the archive websites, the start-ups, small descriptions and websites were collected. It turned out that some start-ups were identical but were operational under various names. Therefore, various start-ups were merged in the dataset.

There are no archives where data can be collected, so the majority of the data was collected via web scraping. My aim was to have similar variables as those that are present in the Utrecht dataset. Therefore, a similar method as of Eveleens (2019) was used to collect data. First, for the majority of the start-ups' websites were gathered via the website archives of Chalmers Ventures. Based on the websites I coded the start-ups that survived. Moreover, sometimes data was gathered about the founding year, founders or the social media channels. Second, LinkedIn was used. I looked up the companies on LinkedIn, to see whether they survived. Then I gathered the employment based on the amount of LinkedIn employees. Moreover, the LinkedIn pages were used to look up the founders of the start-ups. The founders of a start-up could be identified with the use of employees registered in LinkedIn, or via information on the start-up's website. Based on LinkedIn the founders, the founding year and survival of the start-up were gathered. Also, when a start-up did not survive, via LinkedIn a year could be collected when the start-up went out of business. Just like in the Netherlands, LinkedIn is often used in Sweden. Therefore, it was a valuable source of information. Third, other social media channels of the start-up were gathered, such as Facebook and Twitter accounts. Based on these accounts, information about the survival of the start-ups was completed. Fourth, information about investments of the company was gathered via CrunchBase. CrunchBase is a database of innovative companies listing, among other things, what investments they got (Dalle, Den Besten & Menon, 2017). When there was information in CrunchBase, besides investments, about the start-up that was not yet found with the use of the previous steps, this information was added to the database. Finally, when there was not enough data available for some start-ups based on the above steps, I searched for the company on Google. Sometimes, this way more information was collected, for example via “www.pitchbook.com” or via news reports more information was gathered. Similar to the data of the incubators in Utrecht, I classified the start-ups from Chalmers Ventures with the coding scheme and algorithm developed by Hermse et al. (2020).

Based on this, the data consists of 157 start-ups from Chalmers Ventures, 45 of UtrechtInc and 68 of Climate-KIC. The total sample size consists of 270 start-ups. In table 1, I listed the exact definition and source for the data. Moreover, the data from Gothenburg and Utrecht is separated to be able to see the mean, maximum and minimum for each variable. One of the biggest differences between the data of Utrecht and Gothenburg, is the mean of investment. The mean of investment is 0.757 for Gothenburg, whereas it is 0.133 for Utrecht. This could be due to the fact that Chalmers Ventures itself, also provides funding for some of the start-ups that they are incubating.

Table 1: Descriptive statistics dataset Gothenburg (Chalmers Ventures)

Variable	Mean	Std. Dev.	Min.	Max.	Obs.	Definition	Source
Survival	0.701	0.459	0	1	157	Is the start-up still operational. If a start-up was acquired but it still operational it was also coded as a survived start-up (binary variable)	Website start-up, LinkedIn, Facebook, Twitter, CrunchBase
Investment	0.757	0.431	0	1	107	Did the start-up receive external funding (binary variable)	CrunchBase
Employment Growth	1.352	1.770	0	9	136	The employment at the time of the data collection divided by the age of the start-up	LinkedIn, Website start-up, CrunchBase
Smart City Score	0.293	0.982	0	5	157	Score based on the necessary and intensity conditions of the SCI (score between 0-6)	SCI
Smart City Score (0/1)	0.089	0.286	0	1	157	Score based on the necessary conditions of the SCI (binary variable)	SCI
Founding team size	1.926	0.891	1	5	136	The number of founders in the initial founding team	Website start-up, LinkedIn, CrunchBase
Percentage Males	0.818	0.327	0	1	136	The percentage of males found in the initial founding team	Website start-up, LinkedIn, CrunchBase
Age Start-up	6.589	5.197	1	20	151	For start-ups that are still operational: the year the data was gathered minus the founding year. For the start-up that are non-operational: year the start-up stopped minus the founding year	Website start-up, LinkedIn, Facebook, Twitter, CrunchBase
Market type (B2C)	0.217	0.413	0	1	157	Whether the start-up is active for the business to business market (B2B) or the business to consumer market (B2C). (Dummy variable)	Website start-up, LinkedIn, Facebook, Twitter, CrunchBase

Table 2: Descriptive statistics dataset Utrecht (UtrechtInc + Climate-KIC)

Variable	Mean	Std. Dev.	Min.	Max.	Obs.	Definition	Source
Survival	0.770	0.423	0	1	113	Is the start-up still operational. If a start-up was acquired but it still operational it was also coded as a survived start-up (binary variable)	Website start-up, LinkedIn, Facebook, Twitter, CrunchBase
Investment	0.133	0.341	0	1	113	Did the start-up receive external funding (binary variable)	CrunchBase
Employment Growth	1.751	1.873	0	8	93	The employment at the time of the data collection divided by the age of the start-up	LinkedIn, Website start-up, CrunchBase
Smart City Score	0.850	1.649	0	5	113	Score based on the necessary and intensity conditions of the SCI (score between 0-6)	SCI
Smart City Score (0/1)	0.221	0.417	0	1	113	Score based on the necessary conditions of the SCI (binary variable)	SCI
Founding team size	2.106	0.976	0	6	113	The number of founders in the initial founding team	Website start-up, LinkedIn, CrunchBase
Percentage Males	0.894	0.247	0	1	105	The percentage of males found in the initial founding team	Website start-up, LinkedIn, CrunchBase
Age Start-up	4.370	1.771	1	11	92	For start-ups that are still operational: the year the data was gathered minus the founding year. For the start-up that are non-operational: year the start-up stopped minus the founding year	Website start-up, LinkedIn, Facebook, Twitter, CrunchBase
Market type (B2C)	0.345	0.478	0	1	113	Whether the start-up is active for the business to business market (B2B) or the business to consumer market (B2C). (Dummy variable)	Website start-up, LinkedIn, Facebook, Twitter, CrunchBase

3.2 Variables

Within this section the measures used in the analysis are addressed. Appendix B shows the operationalization from the dependent variable, start-up performance and the independent variable in a table.

The dependent variable is start-up performance after incubation. Since the different performance measures can yield different results, I use a combination of measures (Wiklund & Shepherd, 2003). In this paper three ways of measuring performance were used based on Eveleens (2019). First, survival, which shows whether the start-up is still operating. This is a binary variable. This measure was collected from various sources to increase the reliability. Based on the website, LinkedIn, Facebook, Twitter and CrunchBase the survival variables were coded. Start-ups that were acquired by another company but are still operating were also seen as start-ups that survived. Second, investments were used, which show whether a start-up was able to raise external equity. This is a binary variable. Since, it is hard to know the exact amount of investments. Third, employment growth of the start-up, which is measured as increase in employment during the years the start-up is active. For the data the employment was gathered from LinkedIn, based on the amount of LinkedIn employees. The employment was divided by the years the start-up is active. For start-ups that did not survive, the employment was coded 0. Therefore ,the employment growth for non-operational start-ups was 0. Measuring performance with these three indicators will increase the validity of this study.

The independent variable used in the model is whether a start-up can be defined as a "smart city start-up". The start-ups were coded with the use of the SCI (Hermse et al., 2020). This is an coding scheme and algorithm developed to code "smart city start-ups" based on the number of times keywords were present in the definitions of smart city. The coding scheme consists of two necessary conditions, and five intensity conditions. To be identified as a smart city start-up, the start-up needs to satisfy at least the necessary conditions. When the start-up also satisfies one or more of the intensity conditions, the score goes up, ranging from a score between 0-6. The necessary conditions are that the start-up is based on technology and addresses an "urban challenge" ("city"). "Technology" contains key words such as ICT, blockchain, AI and digital infrastructure. The key word urban environment is incorporated in the necessary condition of a city. When a start-up meets these conditions, they are defined as 1. When the start-up does not meet these conditions, they are defined as 0, which is a "non-smart city startup". Additional conditions are identified that entail the intensity of the start-up being a "smart city start-up". The following intensity conditions are identified, "ICT", "citizen", "environmental sustainability", "quality of life" and "economic". When a start-up satisfies one or more of the intensity conditions, their score on the scale of smart city start-ups increases. With the use of the following formula, the score of the Smart City Index (SCI) is defined. All intensity conditions are equally weighted:

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

Based on this method, the start-ups were coded in the datasets for Utrecht and Gothenburg. For the data of the start-ups in the incubators in Utrecht, the cleaned text was used to code the start-ups. For the start-ups of Chalmers Ventures, various descriptions were available for various start-ups. Such as descriptions from the Chalmers Ventures website, LinkedIn or the start-ups' website. First, I used the descriptions and updated descriptions of the Chalmers Ventures website. When these descriptions were not available or did not give the clarification needed to code the start-up, I turned to the description on the start-up's website. Again, if this description was not available or did not give enough clarification, the description from the LinkedIn page or in CrunchBase was used. There were only a few start-ups that did not have any description. Therefore, it was not possible to code them on the SCI and they have been dropped from the analysis. Moreover, to increase the reliability of the results, two persons executed the coding separately. After that, some deviating results were discussed and changed accordingly.

To increase the validity of the results of the analysis, control variables were added. Based on the literature, and the research of Eveleens (2019) and Leendertse (2018), the following control variables were added to the model. First, this research includes various incubators. There are differences between these incubators, for example Chalmers Ventures is an university incubator (Meyer & Sowah, 2019), whereas Climate-KIC focuses on innovations that help society mitigate and adapt to climate change (Climate-KIC, n.d.). Therefore, the three incubators are added as separate dummy variables in the model. Second, team size of the founding team is added as a control variable. According to research team size and the start-up performance have a positive significant relationship. As bigger teams can more easily mobilize resources and with the greater variance in experience, more innovative solutions can be yielded (Jin et al., 2017; Klepper, 2001; Leonard & Sensiper, 1990; Soetanto & Jack, 2013). Third, gender differences in the founding team is added, since research found that male-founded businesses outperform female-founded businesses (Gottschalk & Niefert, 2013; Kalleberg & Leicht, 1991). This variable was operationalized by including the percentage of males in the initial founding team. Additionally, the squared of this variable is added to the model. This allows for a more accurate prediction of the effect of gender. Fourth, age of the start-up is added to the model. A significant positive relationship is found between the age of the start-up and their performance (Soetanto & Jack, 2013; Song et al., 2008). For the dataset this was calculated as the time when the data was collected minus the founding year. If a start-up did not survive, this was calculated as the year when the start-up stopped minus the founding year. Fifth, market type was added. Literature showed that the market environment and the type of industry influence start-up performance (Sandberg & Hofer, 1987; Song et al., 2008; Wright & Stigliani, 2012). This difference is added with a dummy variable.

Some other control variables were explored. I explored entrepreneurial experience, because a positive significant relationship was found between start-up experience of the founding team and survival chances (Delmar & Shane, 2006). However, it was not possible to find a reliable measure for entrepreneurial experience via web scraping. Moreover, I explored the specific incubator programs as a control variable. Since, within the incubators there are various programs that the start-ups can participate in. However, this was not available for this research, and could therefore not be added to the analyses.

3.3 Descriptive statistics and Smart City Index (SCI)

Start-ups that had no information about all three performance measures were excluded from the analyses. Additionally, start-ups that had information for one of the performance measures, but did not have a description and therefore could not be given a smart city coding were excluded. Also, the start-ups that were only founded in 2020 were excluded from the analyses. Because these start-ups are too young to find useful measures. Additionally, three outliers were removed for the purpose of the assumptions of the models. That left us with a total sample size of 270 start-ups, from which 157 were incubated at Chalmers Ventures, 45 at UtrechtInc, and 68 at Climate-KIC.

Table 3 shows the number mean, maximum, minimum, standard deviation and the number of observations for each variable. Based on the descriptive statistics, we can see that the majority of the start-up has survived. Additionally, we see that most of the companies were led by male founders.

Table 3: Descriptive Statistics

	Mean	Max.	Min.	Std. Dev.	Obs.
Survival	0.730	1	0	0.445	270
Investment	0.497	1	0	0.436	220
Employment Growth	1.514	9	0	1.819	229
Smart City Score	0.522	5	0	1.324	270
Smart City Score (0/1)	0.144	1	0	0.352	270
Gothenburg	0.581	1	0	0.494	270
UtrechtInc	0.167	1	0	0.374	270
Climate-KIC	0.252	1	0	0.435	270
Chalmers Ventures	0.581	1	0	0.494	270
Founding team size	2.008	6	0	0.933	249
Percentage Males	0.851	1	0	0.297	241
Percentage males^2	0.812	1	0	0.347	241
Age Start-up	5.749	20	1	4.368	243
Market type (B2C)	0.270	1	0	0.445	270

Table 4: Results SCI

	Chalmers Ventures	UtrechtInc	Climate-KIC	Total
City	14	6	19	39
	(8.92%)	(13.33%)	(27.94%)	(14.44%)
Technology	149	43	68	260
	(94.90%)	(95.56%)	(100%)	(96.30%)
Quality of Life	34	8	20	62
	(21.66%)	(17.78%)	(29.41%)	(22.96%)
Citizen	5	4	9	18
	(3.18%)	(8.89%)	(13.24%)	(6.67%)
Sustainability	33	7	60	100
	(21.02%)	(15.56%)	(88.24%)	(37.04%)
ICT	97	38	19	154
	(61.78%)	(84.44%)	(27.94%)	(57.04%)
Economic	41	20	55	116
	(26.11%)	(44.44%)	(80.88%)	(42.96%)
#Smart city start-up	14	6	19	39
	(8.92%)	(13.33%)	(27.94%)	(14.44%)
Average SCORE	3.29	3.67	3.84	3.62
Observations	157	45	68	270

Note: Percentages based on total of start-ups are reported below the # of start-ups.

Table 4 shows the results of the smart city index (SCI). The results show that the necessary condition "city" was the differentiating condition. As only 14.44% of the start-ups were associated with urban challenges. There are big differences between the incubators, since Climate-KIC (27.94%) scored higher on the city condition, then Chalmers Ventures (8.92%). Only 6.67% of the start-ups were associated with "citizen". Even though this also fluctuates between incubators, it is the intensity condition that has scored lowest. This could be due to the fact that "citizen" could only be coded as 1 when "city" was coded as 1. Since, only a small percentage of the start-ups were associated with urban challenges, this can cause the low percentage of the intensity condition of "citizen". In total 39 start-ups were identified as a "smart city start-up", this is 14.44% of all the start-ups in the sample. The number of "smart city start-ups" also varied greatly between the incubators. For Climate-KIC 27.94% of the start-ups were defined as a "smart city start-up", whereas for Chalmers Ventures this is only 8.92%. The score of the "smart city start-up" lies between 1-6. The average score of a "smart city start-up" is 3.62. The average scores per incubator are close to each other.

3.4 Data Analyses

For the analysis, I use cross-sectional data. The data was analyzed with a set of general linear regression models. As I have three performance measures, I follow Eveleens (2019) and estimate three different models. A logistic regression model is estimated for the performance measures of investments and survival. The performance measure of employment growth is estimated with a negative binomial regression. This model was applicable, since the variable consists of a count variable. Additionally, I tested for overdispersion by looking at the histogram of the employment growth, and the goodness of fit of the Poisson model. Also, the variance was larger than the mean of the employment growth. Based on these tests, it was clear that there was overdispersion, and the negative binomial regression was most applicable (Lawless, 1987).

With the use of the McFadden R^2, the model fit is determined. The model has a good fit, when the McFadden R^2 has a value between 0.2 and 0.4 (McFadden, 1977). Additionally, I perform the likelihood-ratio test (LR-test). This test shows whether adding the independent variable, "smart city score", enhances the model fit.

The appropriate assumptions of each of the analyses are verified (see Appendix C). I test for multicollinearity using the Spearman's correlations (Table 5). Notable is the correlation between Chalmers Ventures and Investment is 0.656. After that, I also looked at the variational inflation factors (VIF). All the VIF scores were below 2, which means there is no further issue with multicollinearity in the model (Field, Miles & Field, 2012). Additionally, based on the scatterplots I removed three outliers from the model.

Table 5: Correlation matrix

		1	2	3	4	5	7
1	Survival	-	-	-	-	-	-
2	Investment	0.047	-	-	-	-	-
3	Employment Growth	0.419	0.222	-	-	-	-
4	Smart City Score	0.074	-0.087	0.076	-	-	-
5	Smart City Score (0/1)	0.073	-0.069	0.094	0.964	-	-
7	UtrechtInc	0.144	-0.378	0.062	-0.043	-0.058	-
8	Climate-KIC	0.068	-0.385	-0.112	0.186	0.180	-0.331
9	Chalmers Ventures	-0.177	0.656	0.055	-0.139	-0.120	-0.487
10	Founding team size	-0.114	0.075	-0.081	0.031	0.045	-0.045
11	Percentage Males	0.200	-0.022	0.073	0.090	0.109	-0.000
12	Percentage Males^2	0.163	-0.016	0.066	0.072	0.096	-0.020
13	Age Start-up	0.154	0.305	0.008	-0.065	-0.051	-0.244
14	Market type (B2C)	-0.137	-0.125	-0.012	0.141	0.069	0.147

		8	9	10	11	12	13	14
1	Survival	-	-	-	-	-	-	-
2	Investment	-	-	-	-	-	-	-
3	Employment Growth	-	-	-	-	-	-	-
4	Smart City Score	-	-	-	-	-	-	-
5	Smart City Score (0/1)	-	-	-	-	-	-	-
7	UtrechtInc	-	-	-	-	-	-	-
8	Climate-KIC	-	-	-	-	-	-	-
9	Chalmers Ventures	-0.653	-	-	-	-	-	-
10	Founding team size	0.003	0.033	-	-	-	-	-
11	Percentage Males	0.151	-0.140	-0.068	-	-	-	-
12	Percentage Males^2	0.165	-0.137	-0.131	0.975	-	-	-
13	Age Start-up	-0.107	0.293	-0.133	0.138	0.156	-	-
14	Market type (B2C)	-0.047	-0.073	-0.049	0.032	0.023	-0.243	-

Note: N=174

4. Results

4.1 Regression Analyses

The results of my regression analyses are shown in table 6. The models (1), (4), and (7) only contain control variables. Model (2), (5), and (8) contain the independent variable of smart-city, whereas model (3), (6), and (9) contain the independent variable of smart-city as a binary variable.

Table 6: Results of regression models

	Dependent variable								
		Survival			Investments			Employment Growth	
		Logistic			Logistic			Negative binomial	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Smart City		0.288	0.972		0.028	0.083		0.093*	0.356*
		(0.206)	(0.743)		(0.157)	(0.584)		(0.055)	(0.208)
UtrechtInc	2.907***	2.958***	2.955***	-3.367***	-3.366***	-3.364	0.321	0.326	0.330
	(1.053)	(1.060)	(1.069)	(0.680)	(0.680)	(0.680)	(0.207)	(0.206)	(0.206)
Climate-	1.167**	1.065*	1.082*	-2.782***	-2.796***	-2.792	-0.117	-0.172	-0.165
KIC	(0.551)	(0.562)	(0.560)	(0.473)	(0.480)	(0.478)	(0.188)	(0.190)	(0.189)
Founding	-0.115	-0.172	-0.170	0.418*	0.416*	0.416	0.170*	0.164*	0.161*
team size	(0.251)	(0.254)	(-0.254)	(0.242)	(0.242)	(0.242)	(0.094)	(0.093)	(0.093)
Percentage	5.048*	5.520*	5.538*	-2.012	-2.026	-2.018	1.518	1.456	1.502
males	(2.770)	(2.843)	(2.837)	(3.115)	(3.113)	(3.113)	(1.330)	(1.322)	(1.321)
Percentage	-3.381	-3.884	-3.893	2.289	2.291	2.284	-0.849	-0.835	-0.880
$males^2$	(2.477)	(2.562)	(2.555)	(2.686)	(2.681)	(2.682)	(1.099)	(1.092)	(1.092)
Age start-	0.437***	0.454***	0.450***	0.057	0.057	0.057	-0.019	-0.019	-0.019
up	(0.105)	(0.108)	(0.108)	(0.056)	(0.056)	(0.056)	(0.023)	(0.023)	(0.023)
Market type	-0.176	-0.286	-0.253	-0.490	-0.498	-0.492	-0.008	-0.061	-0.043
(B2C)	(0.439)	(0.448)	(0.445)	(0.480)	(0.481)	(0.479)	(0.178)	(0.179)	(0.178)
Constant	-2.062**	-2.064**	-2.071**	-0.014	-0.010	-0.011	-0.457	-0.435	-0.443
	(0.813)	(0.814)	(0.814)	(0.897)	(0.900)	(0.897)	(0.397)	(0.394)	(0.394)
Obs.	222	222	222	182	182	182	211	211	211
Log Likelihood	-77.240	-76.090	-76.275	-83.533	-83.518	-83.524	-351.110	-349.700	-349.652
Chi^2	60.88***	63.18***	62.81***	84.45***	84.48***	84.47***	13.41*	16.23**	16.33**
McFadden R^2	0.283	0.293	0.292	0.336	0.336	0.336	0.019	0.023	0.023
LR-test		2.30	1.93		0.03	0.02		2.82*	2.92*

Note: *p<0.10, **p<0.05: ***p<0.01;

Table 7: Marginal effects logistic regressions

	Dependent variable					
	Survival			Investment		
	(1)	(2)	(3)	(4)	(5)	(6)
Smart City		0.021	0.056*		0.007	0.020
		(0.015)	(0.033)		(0.039)	(0.145)
UtrechtInc	0.121***	0.115***	0.116***	-0.545***	-0.545***	-0.545***
	(0.034)	(0.033)	(0.033)	(0.058)	(0.058)	(0.058)
Climate-KIC	0.074**	0.065*	0.066**	-0.540***	-0.542***	-0.542***
	(0.034)	(0.033)	(0.034)	(0.066)	(0.067)	(0.067)
Founding team	-0.009	-0.013	-0.013	0.103*	0.102*	0.102*
size	(0.020)	(0.019)	(0.019)	(0.060)	(0.060)	(0.060)
Percentage	0.400*	0.411*	0.417*	-0.495	-0.499	-0.497
males	(0.226)	(0.217)	(0.219)	(0.766)	(0.766)	(0.766)
Percentage	-0.268	-0.289	-0.293	0.563	0.564	0.562
males^2	(0.198)	(0.192)	(0.193)	(0.661)	(0.660)	(0.660)
Age start-up	0.035***	0.033***	0.034***	0.014	0.014	0.014
	(0.007)	(0.007)	(0.007)	(0.014)	(0.014)	(0.014)
Market type	-0.014	-0.023	-0.020	-0.118	-0.120	-0.118
(B2C)	(0.037)	(0.037)	(0.037)	(0.112)	(0.112)	(0.111)

Note: *p<0.10, **p<0.05: ***p<0.01.

All the models created are found to be significant (1%, 5% and 10% levels). However, the McFadden R^2 are low for the negative binomial regressions. In table 7 the marginal effects of the logistic regressions are shown. In line with my expectations, the table 6 and 7 shows some significant estimators. On average chances of survival increase when a start-up is incubated at UtrechtInc in comparison to Chalmers Ventures, which is significant at a 1% level. This is also true for Climate-KIC, even though this difference is fairly small. Moreover, chances of survival increase when the age of the start-up increases, which is significant at a 1% level. This is in line with previous research (Soetanto & Jack, 2013; Song et al., 2008). Additionally, for the dependent variable investment, results are somewhat different. On average changes of investment decrease when the start-up was incubated at UtrechtInc or Climate-KIC in comparison to Chalmers Ventures. These relationships are significant at a 1% level. This could be due to the fact that Chalmers Ventures also offer funding for some of their incubated start-ups. In line with A larger founding team also significantly (10% level) increases chances of receiving investment for the start-up. For the negative binomial model with dependent variable of employment growth, a bigger founding team also increases the employment growth significantly (10% level). Therefore, the results are in line with previous studies (Jin et al., 2017; Klepper, 2001; Leonard & Sensiper, 1990; Soetanto & Jack, 2013).

Besides the significant effects of the control variables, I do observe a positive effect between the SCI score and the dependent variables. This relationship is significant for the negative binomial models for both the normal smart city score and the binary smart city score. This means that being a "smart city start-up" increases the employment growth significantly (10% level). Based on the LR-test, I see that for these two models, adding smart city as an independent variable does substantially improve the model fit (10% level). Additionally, the relationship between the binary smart city score variable and the dependent variable survival is significant (10% level). This means that when the start-up is defined as a "smart city start-up" chances of survival increase.

4.2 Robustness Check

To check the result presented, I performed a robustness test. There were three incubators, and only two dummy variables could be added to the model. Therefore, the first robustness test was created by adding another combination of incubators in the model. The results are shown in appendix E. For this model, UtrechtInc and Chalmers Ventures were added as incubators in the model. There were only some differences in the estimated coefficients of the incubators, since they were different. All the other coefficients remained the same as in the model presented in the result section. There were no differences in the significant results.

5. Discussion

The aim of this paper is to show whether and to what extent business incubation enhances the performance of a “smart city start-up” and look at the differences between Utrecht and Gothenburg. Therefore the following research question was formulated: *What is the difference between the performance of a “smart city start-up” in comparison to a “non-smart city start-up” after business incubation?*

5.1 Implications

This study has some theoretical implications. The empirical analysis found a significant positive relationship between a “smart city start-up” and the employment growth. Also, the results show that chances of receiving funding increase significantly when a start-up is a “smart city start-up”. However, no significant effects were found for the relationship of being a “smart city start-up” and survival. This is in line with the inconsistent results of the effect of incubation on performance (Colombo & Delmastro, 2002; Dvoulety et al., 2018; Eveleens, 2019; Löfsten, 2010; Westhead & Storey, 1997). The increased performance of a “smart city start-up” in terms of employment growth and investment could be explained by the following. Based on the SCI, city is the differentiating factor between a “smart city start-up” and a “non-smart city start-up”. The various incubators are located in cities. This could benefit the development of the “smart city start-up”, since for example the city network is close by. Additionally, some interesting and significant results were found concerning the control variables. Based on the control variables, it was clear that there was a significant difference between the different incubators in Gothenburg and Utrecht. However, the direction of the effect was different for the various dependent variables. For start-ups incubated at Chalmers Ventures chances of receiving investment increased significantly. This may be due to the fact that Chalmers Ventures also invests in some of their start-ups (Chalmers Ventures, n.d.). Besides that, chances of survival increased significantly when the start-up was part of one of the incubator programs located in Utrecht in comparison to Chalmers Ventures. This is in line with previous research. Since, Löfsten (2010) did find very limited connections between the start-up incubated in 16 incubators in Sweden and the start-up performance. However, Eveleens (2019) did find that the start-ups incubated in Climate-KIC and UtrechtInc did benefit from this experience. The results I found present the same outcomes. Additionally, the age of the start-up affected the performance measures of survival and growth of employees significantly. This relationship was positive for both survival and employment growth and the age of the start-up, as expected from earlier studies of Soetanto and Jack (2013) and Song et al. (2008).

These findings also have some consequences on a practical level. The findings confirm that there are significant differences in performance after incubation between the incubators. These findings are useful for start-ups and incubator owners. Start-ups are able to look at the particular performance measures the incubator performs best at that fits their start-up. For example, if the start-up is looking for investments, an incubator that also provides funding would be more suitable, such as Chalmers Ventures. Besides that, for incubator owners it is useful. More insights are given in what performance measures their incubator excels at or the other way around. This gives the incubator the opportunity to adjust policies if necessary.

5.2 Limitations and suggestions for future research

In this research there are various limitations. The first limitation is that there are multiple options in measuring performance. The results on the three performance measures are different. Even though I used three reliable measures of performance. However, other reliable measures are available, such as sales growth rate, profits and assets turnover of the start-up (Dvoulety et al., 2018; Löfsten, 2010; Peña, 2004) Another option is to use a longitudinal approach of measuring performance. Therefore, future research could build upon this paper by looking at other reliable performance measures and investigate whether the effects are similar or different. Second, this research was limited, because my dataset only consisted of incubated start-ups. However, being able to control for non-incubated start-ups gives the opportunity to determine if incubation really enhances performance in comparison to non-incubated (“smart city”) start-ups. Future research could make use of a dataset compiled of non-incubated and incubated start-ups, including “smart city start-ups”. This would build further on the work of Eveleens (2019) and Picari (2020). Third, more control variables could be added to the model, such as entrepreneurial experience. It has been shown that this variable has a positive significant relationship with the survival and sales of new ventures (Delmar & Shane, 2006). However, since the only means of collection data was via web scraping, collecting this variable was not possible. Future research could opt for working together with incubators to be able to collect this kind of data. Fourth, this research was limited to three incubators located in two cities. A more diverse database of various incubators would be interesting to use. Especially, since results show that there are differences between the incubators. This is also interesting for future

research since, there is still a research gap in why there are so many differences in the effect of business incubation in various countries and incubators (Colombo & Delmastro, 2002; Dvoulety et al., 2018; Eveleens, 2019; Löfsten, 2010; Westhead & Storey, 1997).
Besides, based on the significant results found in this study, further research is needed with the use of the SCI to find out more about "smart city start-ups".

5.5 Conclusion

All things considered, this study illustrates the relationship between performance after incubation and whether the start-up is a "smart city start-up". I find a positive significant relationship between being "a smart city start-up" and employment growth. Future research can investigate this model with a dataset with more "smart city start-ups" and add other control variables, such as entrepreneurial experience. This research has contributed by creating a useful dataset of the start-ups incubated at Chalmers Ventures, and taking the first steps in research on "smart city start-ups".

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7. Appendices

7.1 Appendix A: Smart City Index Working Paper (Hermse et al., 2020)

Universiteit Utrecht

Classification of Smart City Startups: Smart City Index

Working paper

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Data: 26-06-2020

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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

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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 CO2 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 conceptualization 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%

7.2 Appendix B: Operationalization table

Table 8: Operationalization table

Concept	Indicator	Calculation of scores	Measurement type
		Dependent variables	
Start-up Performance	Survival	0: start-up is not operating at the time data was gathered 1: firm was still operating when the data was gathered	Binary, 0 - 1
	Investment	0: firm did not external funding 1: start-up external funding	Binary, 0 - 1
	Employment Growth	The average yearly growth of employees. The current number of employees on the LinkedIn page at the time of data collection divided by the age of the start-up. Current number of employees coded 0 when the start-up was not operational anymore	Ratio, -∞ - + ∞
		Independent variables	
Smart City	The indication of whether a start-up is a "smart city start-up" and the intensity	A six-point scale assessment of whether a start-up qualified as a smart city start-up or not, and at what intensity: 0: no smart city 1: smart city 2: smart city plus one criterium 3: smart city plus two criteria 4: smart city plus three criteria 5: smart city plus four criteria 6: smart city plus all criteria	Categorical, 0 - ∞
Smart City	The indication of whether a start-up is a "smart city start-up"	A binary scale assessment of whether a start-up qualified as a smart city start-up or not: 0: no smart city start-up 1: smart city start-up	Binary, 0 – 1
		Control variables	
UtrechtInc	At which business incubator the start-up was located	0: start-up is not incubated at UtrechtInc 1: start-up is incubated at UtrechtInc	Dummy, 0 - 1
Climate-KIC	At which business incubator the start-up was located	0: start-up is not incubated at Climate-KIC 1: start-up is incubated at Climate-KIC	Dummy, 0 – 1
Chalmers Ventures	At which business incubator the start-up was located	0: start-up is not incubated at Chalmers Ventures 1: start-up is incubated at Chamers Ventures	Dummy 0 – 1

Size founding team	The number of founders	The number of founders at time of the founding date of the start-up	Count, 0 - ∞
Gender founding team	The percentage of males in the founding team	The percentages of males found in the founding team	Ratio, 0 - 1
Company age	The age of the start-up	Take the year of the data gathering minus the founding year. If a start-up failed, take the year start-up stopped minus the founding year	Count, 0 - ∞
Market type	Which market type the start-up is active in	0: start-up operates in a Business-to Business (B2B) market type 1: start-up operated in a Business-to-Consumer market type (B2C)	Dummy, 0 - 1

7.3 Appendix C: Verifying assumptions

Table 9: VIF-scores

Variable	VIF	1/VIF
Smart City	1.08	0.924
UtrechtInc	1.14	0.880
Climate-KIC	1.17	0.852
Founding team size	1.03	0.975
Percentage males	1.08	0.928
Age start-up	1.14	0.879
Market type (B2C)	1.09	0.915

7.4 Appendix D: Negative binomial model

To see what was the most suitable model, various steps were taken. First, the histogram of the dependent variable, growth employment was made to see if the variable was skewed. This was the case, after that the detailed descriptive statistics were created, to see if the variance was bigger than the mean. This could also imply there is overdispersion. After that the Poisson regression was executed, and after which the goodness of fit of the Poisson was calculated. The p-value is 0.00 which indicates that the Poisson model is not a good fit. Based on these three steps, it was clear that there was overdispersion and a negative binomial model was most suitable for this data.

Figure 1: Histogram of growth employment

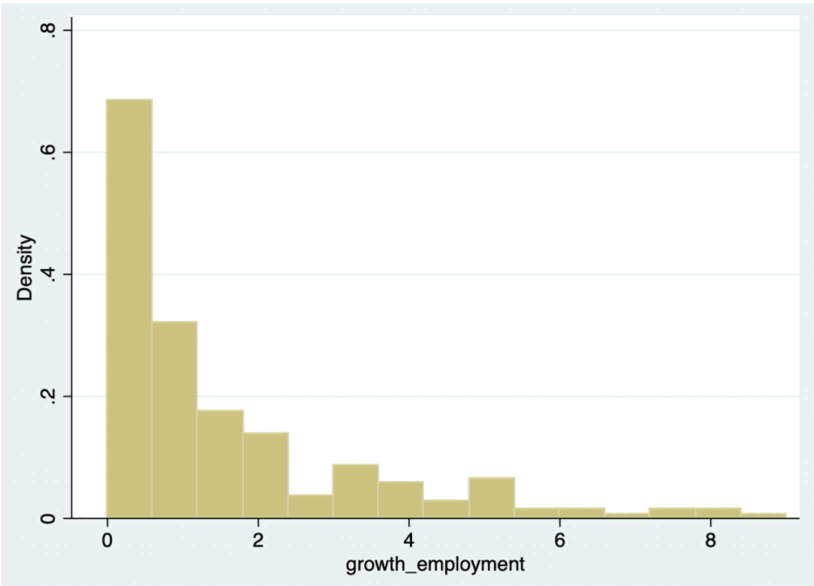

Table 10: Detailed descriptive statistics of Employment growth

	Mean	Std. Dev.	Variance	Obs.
Employment Growth	1.514	1.819	3.309	229

Table 11: Poisson goodness of fit

	Chi^2
Goodness of fit	374.974***

7.5 Appendix D: Robustness Test

Table 12: Robustness test with incubator UtrechtInc and Chalmers Ventures included

	Dependent variable								
		Survival			Investments			Employment Growth	
		Logistic			Logistic			Negative binomial	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Smart City		0.288	0.972		0.028	0.083		0.093*	0.356*
		(0.206)	(0.743)		(0.157)	(0.584)		(0.055)	(0.208)
UtrechtInc	1.740	1.893	1.873	-0.585	-0.570	-0.573	0.437*	0.498**	0.495
	(1.144)	(1.158)	(1.156)	(0.717)	(0.722)	(0.722)	(0.236)	(0.237)	(0.236)
Chalmers	-1.167**	-1.065*	-1.082*	2.782***	2.796***	2.792***	0.117	0.172	0.165
Ventures	(0.551)	(0.562)	(0.560)	(0.473)	(0.480)	(0.478)	(0.188)	(0.190)	(0.189)
Founding	-0.115	-0.172	-0.170	0.418*	0.416*	0.416*	0.170*	0.164*	0.161*
team size	(0.251)	(0.254)	(-0.254)	(0.242)	(0.242)	(0.242)	(0.094)	(0.093)	(0.093)
Percentage	5.048*	5.520*	5.538*	-2.012	-2.026	-2.018	1.518	1.456	1.502
males	(2.770)	(2.843)	(2.837)	(3.115)	(3.113)	(3.113)	(1.330)	(1.322)	(1.321)
Percentage	-3.381	-3.884	-3.893	2.289	2.291	2.284	-0.849	-0.835	-0.880
$males^2$	(2.477)	(2.562)	(2.555)	(2.686)	(2.681)	(2.682)	(1.099)	(1.092)	(1.092)
Age start-	0.437***	0.454***	0.450***	0.057	0.057	0.057	-0.019	-0.019	-0.019
up	(0.105)	(0.108)	(0.108)	(0.056)	(0.056)	(0.056)	(0.023)	(0.023)	(0.023)
Market type	-0.176	-0.286	-0.253	-0.490	-0.498	-0.492	-0.008	-0.061	-0.043
(B2C)	(0.439)	(0.448)	(0.445)	(0.480)	(0.481)	(0.479)	(0.178)	(0.179)	(0.178)
Constant	0.895	-0.999	-0.989	-2.796***	-2.806***	-2.803***	-0.574	-0.607	-0.608
	(0.984)	(0.988)	(0.987)	(0.985)	(0.987)	(0.987)	(0.417)	(0.416)	(0.416)
Obs.	222	222	222	182	182	182	211	211	211
Log Likelihood	-77.240	-76.090	-76.275	-83.533	-83.518	-83.524	-351.110	-349.700	-349.652
Chi^2	60.88***	63.18***	62.81***	84.45***	84.48***	84.47***	13.41*	16.23**	16.33**
McFadden R^2	0.283	0.293	0.292	0.336	0.336	0.336	0.019	0.023	0.023
LR-test		2.30	1.93		0.03	0.02		2.82*	2.92*

Table 13: Marginal effects logistic regressions of incubators UtrechtInc and Chalmers Ventures included

	Dependent variable					
	Survival			Investment		
	(1)	(2)	(3)	(4)	(5)	(6)
Smart City		0.021	0.056*		0.007	0.020
		(0.015)	(0.033)		(0.039)	(0.145)
UtrechtInc	0.089**	0.088**	0.088**	-0.139	-0.135	-0.136
	(0.037)	(0.035)	(0.035)	(0.160)	(0.162)	(0.162)
Chalmers	-0.086*	-0.074*	-0.076*	0.593***	-0.595***	0.595***
Ventures	(0.044)	(0.043)	(0.043)	(0.075)	(0.076)	(0.076)
Founding team	-0.009	-0.013	-0.013	0.103*	0.102*	0.102*
size	(0.020)	(0.019)	(0.019)	(0.060)	(0.060)	(0.060)
Percentage	0.400*	0.411*	0.417*	-0.495	-0.499	-0.497
males	(0.226)	(0.217)	(0.219)	(0.766)	(0.766)	(0.766)
Percentage	-0.268	-0.289	-0.293	0.563	0.564	0.562
males^2	(0.198)	(0.192)	(0.193)	(0.661)	(0.660)	(0.660)
Age start-up	0.035***	0.033***	0.034***	0.014	0.014	0.014
	(0.007)	(0.007)	(0.007)	(0.014)	(0.014)	(0.014)
Market type	-0.014	-0.023	-0.020	-0.118	-0.120	-0.118
(B2C)	(0.037)	(0.037)	(0.037)	(0.112)	(0.112)	(0.111)

Note: *p<0.10, **p<0.05: ***p<0.01.