Measuring the Smartness of Cities - points to be considered

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Abstract

The concept of Smart City is increasingly used. However, there is no clear consensus on the exact definition of the concept. Instead, the term is associated with different meanings in different contexts. What is common for the different definitions is that they all characterize a Smart City as one which is constantly investing in social and human capital as well as in modern infrastructure. These investments enable a Smart City to utilize new technology and information to improve its performance in different sectors, such as living conditions, mobility, governance and economy among other things. The nature of Smart Cities is that they are evolving constantly. There has been relatively little discussion on how the Smartness of cities can be measured. However, Smartness plays a big role when it comes to attracting people, businesses and investments to a city. It is an important concept in cities marketing strategies and setting long-term goals. Hence, finding suitable indicators for Smart Cities would be most welcomed. This paper discusses a few points that need to be considered in order to measure multi-dimensional phenomena such as Smart Cities. These include the need to operationalize the concept into measurable characteristics and to consider the reliability and validity of the indicators for these given characteristics. In this paper we suggest measuring both the smart investments, hence the city's efforts to improve its performance in an innovative way, as well as the outcome of these investments. We also discuss which role a National statistical institute can or should play when it comes to measuring Smartness of cities.

Keywords: Smart City, measurement, reliability, validity.

1. Introduction

The emergence of web 2.0 technology and availability of big/open data has opened new possibilities for cities to address public issues. Using ICT-based solutions to improve the city's public transportation, engaging citizens to public decision-making by using social media and opening datasets to be used for mobile applications are all innovative ways to address public issues. All these initiatives have led to a new concept: Smart City.

It is not unusual that a city has a Smart City strategy or that the concept is used to attract people, businesses or investments. However, despite the concept of Smart City being increasingly used, there is no clear consensus on what the term exactly means. Obviously, this poses a challenge for measurement. It is impossible to say, whether a city has become "Smarter" if one can't tell, what "Smartness" mean in the first place!

This paper is structured as follows: we begin by discussing some suggested definitions for Smart Cities and how they can be operationalized into measurable characteristics. After this, we propose ways to measure the smartness of cities. What we suggest in this paper is to take into account two main dimensions of Smart Cities. First one need to measure how intensively a city is engaged in using new technology and information to address public issues. The second is the city's performance in key areas, such as economy, environment and living. We propose some indicators and discuss fundamental concepts of measuring, namely reliability and validity. We end our paper with ideas on how national statistical institutes (NSI's) can contribute in measuring Smartness of cities.

2. There is no single way to define a Smart City

As mentioned earlier, there are multiple ways to define a Smart City. The following definitions can, among others, be found from the literature:

A smart city is one that uses information and communications technologies to make the critical infrastructure components and services of a city – administration, education, healthcare, public safety, real estate, transportation and utilities – more aware, interactive and efficient. (Belissant et al., 2010).

A city connecting the physical infrastructure, the IT infrastructure, the social infrastructure and the business infrastructure to leverage the collective intelligence of the city. (Harrison et al., 2010).

A city can be defined as "smart" when investments in human and social capital and traditional (transport) and modern (ICT) communication infrastructure fuel sustainable economic development and a high quality of life, with a wise management of natural resources, through participatory action and engagement. (Caragliu et al., 2009).

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. (Toppeda, 2010).

As one can see, some of the definitions (such as Belissant et al. (2010) or Toppeda (2010)) are more focused on ICT as a technology driver and enabler for a city to become smart. Other definitions (like that of Garagliu et al. 2009) take a broader view and include socio-economic, governance and multi-stakeholder aspects such as social participation.

Despite the diversity of definitions, one can identify some common elements. First, one can see that a Smart City needs a range of building blocks to address public issues in an innovative way. These building blocks can include new technologies, physical/ICT infrastructure and knowledge input. They may already be present or may be created through investments. A second characteristic is that a Smart City is utilizing new information and technology and therefore is constantly evolving. The ultimate aim of these innovative actions is to enhance sustainability, quality of life and urban welfare.

3. How Smart Cities have been measured so far?

In order to measure abstract and multi-dimensional phenomena one first needs to operationalize the concept into (measurable) characteristics. Hence, the first step would then be to look at the different definitions of a Smart City and try to identify these elements. Once this is done, one can construct measurable indictors.

There are a few attempts to measure the smartness of cities. The work of both Giffinger et al. (2007) and Cohen (2014) is based on defining Smart Cities along six characteristics, namely:
1. Smart Economy
2. Smart Mobility
3. Smart Environment
4. Smart People
5. Smart Living
6. Smart Governance.

Each of these characteristics is described with about a dozen of indicators. For example, Giffinger et al. (2007) measure Smart Economy by the Gross Domestic Product (GDP) per employed person, the unemployment rate and the patent applications per inhabitant, among others. Cohen (2014), on the other hand, measures Smart People by looking at the percentage of households with Internet connection, the number of higher education degrees per 100 000 inhabitants and the percentage of people born in a foreign country, among others.

Giffinger et al. (2007) present 74 indicators altogether, Cohen (2014), on the other hand, collected 62 indicators to his study in 2014. Both studies compute an overall score for the Smartness of the city after first normalizing the values of each indicator and then aggregating them to a composite index. As an outcome, both studies create a lists in which cities are ranked according to their Smartness.

The indicators used in the Smart Cities study were collected by the project team whereas Cohen (2014) challenged 120 cities to fill a survey with information on the needed indicators. Despite the number of indicators being limited, only 11 cities around the globe managed to respond to Cohen's (2014) survey. Giffinger et al. (2007) evaluated as many as 70 cities. The study, however, was based only partly on local indicators (35/74). For many indicators, only regional (13/74) or national (26/74) values were available.

The following challenges are easy to identify from the aforementioned studies:
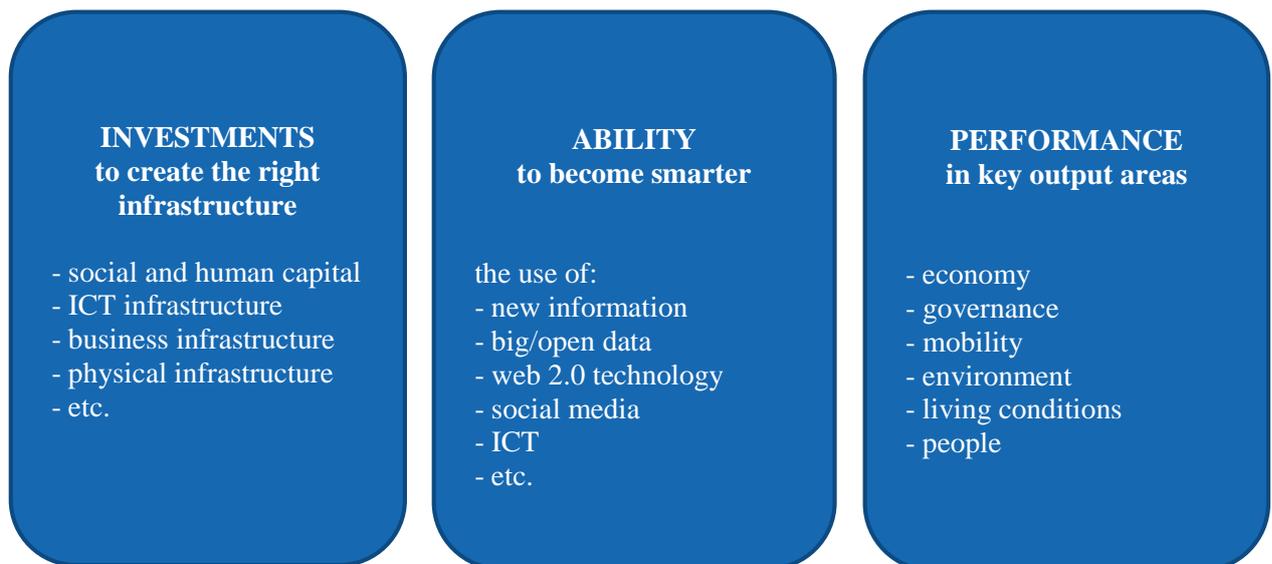
1. First, **finding suitable data** for the indicators seems to be challenging. Only 11 of the 120 cities managed to respond to Cohens (2014) study and less than a half of the indicators used by Giffinger et al. (2007) were available at local level. All these local indicators were from 2001, despite the study was done in 2007. The lack of up-to-date data at local level was clearly a challenge.
2. Aggregating the results to a composite index might be tempting but there is a serious risk of oversimplifying a phenomena which is complex and multi-dimensional. Ranking-lists easily draw the attention of the public but they don't necessary provide useful information for municipalities to evaluate their Smart City policies. Hence, **the way the statistical information is presented**, could be improved.
3. The six dimensions mentioned earlier – economy, mobility, environment, people, living and governance – are all public issues a city wishes to address. This is certainly important, but many of the definitions of the underline the importance of *how* these issues are addressed. Making investments in human/social capital, ICT infrastructure and the ability to utilize new technology and information appear in numerous Smart City definitions. **Creating these building blocks** should be somehow taken into account in measuring the smartness of cities.

In the rest of the study we try to give suggestions on how to overcome these challenges.

4. Addressing the relevant dimensions with up-to date indicators

A Smart City makes investments in social/human capital and (ICT) infrastructure to be able to address public issues via ICT-based solutions. Utilizing new information (such as big/open data) and using Web 2.0 technology are examples of utilizing the new technology and information in an innovative way.

We suggest that one should extent the previous studies by taking this aforementioned dimension into account, namely the city's investments to create the right infrastructure and its ability to utilize new information and technology to become smarter. What we do next is to propose some measurable and effective indicators to describe these dimensions.

INVESTMENTS
to create the right
infrastructure

- social and human capital
- ICT infrastructure
- business infrastructure
- physical infrastructure
- etc.

ABILITY
to become smarter

the use of:
- new information
- big/open data
- web 2.0 technology
- social media
- ICT
- etc.

PERFORMANCE
in key output areas

- economy
- governance
- mobility
- environment
- living conditions
- people

Indicators are effective if they are relevant in the sense that they show something about the system that one needs to know. Good indicators are easy to understand, even by people who are not experts. Ideally indicators are based on accessible data and can be produced soon after the reference period.

As investments in social and human capital are concerned one can use indicators such as the student/teacher ratio in schools, the number of traineeships offered by local businesses or the number of datasets made publicly available by the city. Opening up municipal/regional data can increase citizens' engagement in public decision-making and increase openness. It can also encourage new forms of creativity and innovation as well as fuel up the use of ICT and Web 2.0 technology among developers of mobile applications. Hence, measuring the number datasets made publicly available or the times they have been downloaded could be potential indicators.

A city can invest in ICT infrastructure by setting WLAN bases to provide free and high-speed WiFi connection. The city can engage citizens and stakeholder to public discussion by making city planning initiatives public through the web in an interactive fashion. The number of citizens using the opportunity to comment on city initiatives through Web 2.0 could be very well measured. Another measurable aspect could be the number of messages city bureaus send through social media and the attention they obtain.

The city's investments in business infrastructure can be measured e.g. by looking at the number of events/services provided for (startup) companies and the number of people using them. One could look whether a city provides online networking channels for companies and measure the number of enterprises using these services.

What is common for these suggested indicators is that they are all related to the city's own initiatives and investments. Hence the city can produce them itself. Many of the indicators are based on data, which is easy to collect, validate and analyze. This means that a city can produce almost real-time indicators on its own investments in smart city building blocks. The suggested indicators are easy to understand and are linked to the characteristics they are supposed to describe.

The proposed quantitative indicators can be described as reliable, that is, one can trust the information that the indicator is providing. A measure is said to have a high reliability if it produces similar results under consistent conditions. Hence, a reliable measure does not suffer from high measurement error or uncertainty in measurement: it is an accurate measure.

Reliability does not imply validity. That is, a reliable measure that is measuring something consistently is not necessarily measuring *what* you want to be measuring. This issue can be tackled by complementing some of the quantitative indicators with qualitative indicators. This would help to shed more light on the different dimensions of the phenomena being measured. For example, if one is interested in measuring the impact of services and infrastructure offered to startup enterprises one should not only focus on the amount of services but also the quality of it. This can be done by means of satisfactory surveys.

5. How to present and disseminate the information?

There are numerous examples on good ways to present and disseminate information on complex, multi-dimensional phenomena. These examples can be used as inspiration when it comes to considering good ways to present indicators on Smart Cities.

Measuring well-being shares the same challenges as measuring Smartness of cities. Both are multi-dimensional phenomena in which the use of composite indicators have been discussed (e.g. Cuneo, 2013). In order to avoid over-simplification, we suggest that statistical information related to Smart Cities should not be aggregated to a composite index. A better way to present the information would be by means of a visual scoreboard. Such a visualization could be used to give a quick overview on the development of the indicators by e.g. benchmarking each indicator to its previous or targeted value.

There are some nice examples on such scoreboards. The Digital Agenda for Europe initiative has a good way of presenting how different digitalization initiatives have reached their goals. In addition their website (http://digital-agenda-data.eu/) includes more than 100 indicators, divided into thematic groups, which illustrate some key dimensions of the European information society. One is able to analyze interactively one or several indicators across time and countries.
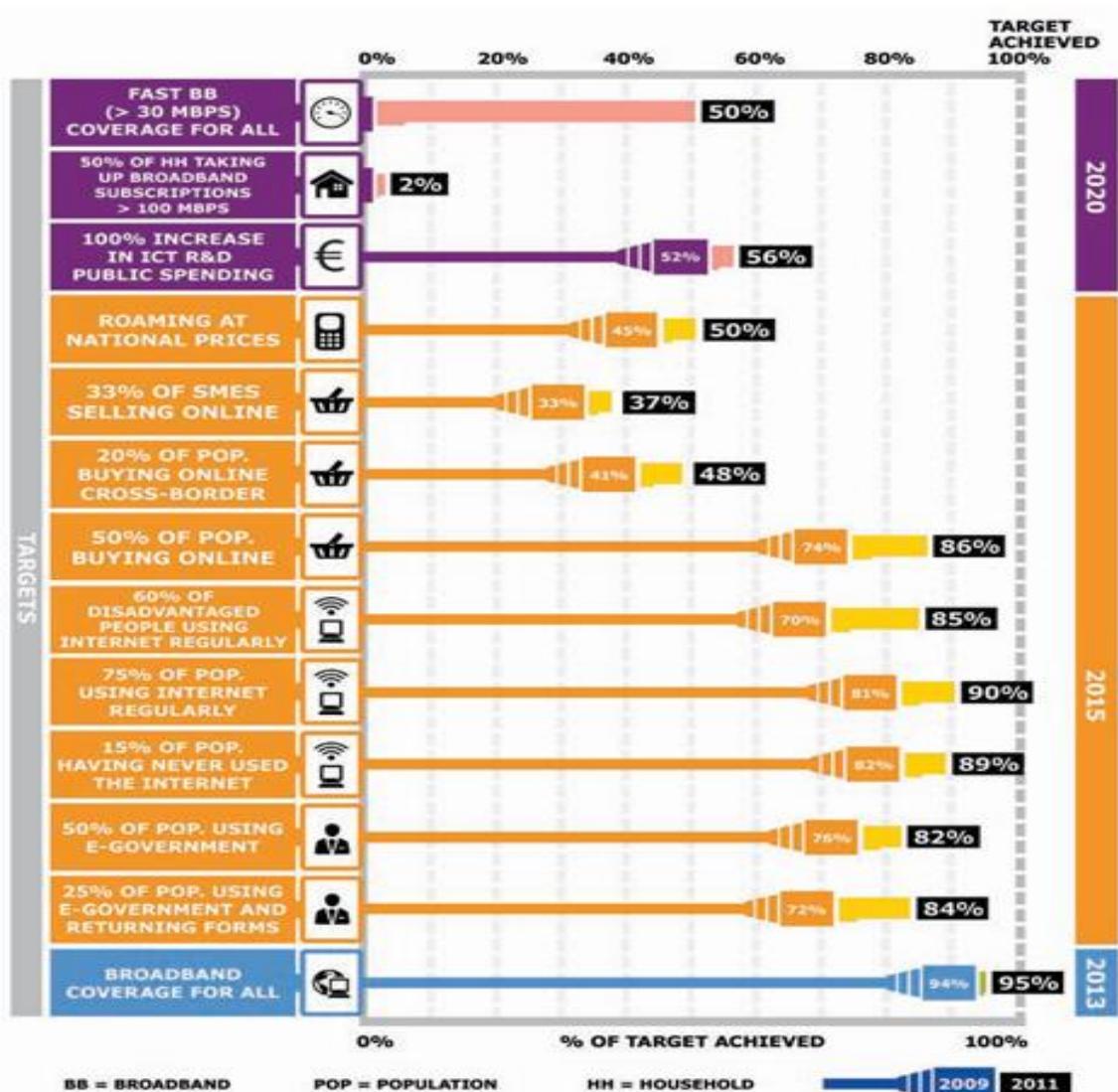
Graph 1: *A way to visualize a multidimensional phenomenon: EU averages on a number of variables, bench-marked to their target values from the digital agenda for Europe.* http://digital-agenda-data.eu/datasets/digital_agenda_scoreboard_key_indicators/thumbnail

Another good example of visual scoreboards is the Wheel of well-being by the Office for National Statistics (ONS). The web site (www.ons.gov.uk/well-being) includes information on 40 different indicators related to 10 different dimensions of well-being. The portal allows the user to benchmark the most recent indicators to its previous value and hence gives a hint on the direction of each indicator.

Some of the Smart City indicators we have suggested in this paper are based on data collected by the city, whereas some other indicators might be produced by a national statistical institute or other statistical authority. A good way to disseminate information from different authorities would be to create a portal from which most of the indicators would be found by linking them to original sources. This portal could be either international, national or regional and include information on multiple Smart Cities. A good (national) example of a collective portal is Findikaattori (www.findikaattori.fi) which collects up-to-date social indicators – all being related to Finland – from 19 different authorities.

6. How can NSI's contribute to measuring Smart Cities?

An NSI can also take an active role in computing statistics on new, multidimensional phenomena such as Smart Cities. This would imply creating new products and services, or adjusting the classification of existing ones to

improve the availability of data on a municipality level. In fact the European Statistical Systems (ESS) Vision 2020 underlines responsiveness to the needs of users of statistics. Keeping the portfolio of products and services up-to-date is in the interest of the ESS. NSI's experience from measuring and multi-dimensional phenomena, such as well-being, could well be useful when it comes to visualizing and disseminating the information.

An NSI can also invest in opening new data sets. If the raw data is available and of good quality then NSIs can develop suitable indicators in a collaborative fashion between different stakeholders. This can be promoted by putting efforts to improve statistical literacy. Opening dataset would also enable policy-relevant research on Smart Cities and hence help municipalities to evaluate their performance in relevant areas.

Probably the most fruitful outcome would result from a combination of these suggestions. Collecting relevant indicators from different sources under one portal would provide both the cities and different stakeholders with a chance to evaluate a city's performance. While some indicators could be computed by an NSI or a city, others can be based on open data and be produced in a collaborative fashion between data providers and users.

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