The role of smart economy in developing smart cities

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Abstract. Smart cities are often linked to development projects to achieve the level of smartness that city governments aspire to. There are several studies looking at how to evaluate smart city performance using different methodologies and evaluation criteria. Although there is no standard method on how to perform such an evaluation, we have observed that the Smart Economy is the most dominant dimension in evaluating smart cities. Of the 30 studies we analyzed between 2015 and 2020, smart economy was cited in 25 of them as a key dimension in evaluating smart cities. Therefore, in this paper we highlight the role of the Smart Economy dimension in smart city development and show how it is measured and evaluated in different assessment tools. In this article, we look in more detail at smart economy-related indicators used in different assessment tools. We draw on a theoretical approach with a combination of quantitative and qualitative analysis to explore commonalities and correlations among the top performing cities in the smart economy.

1. Introduction

Increasingly, cities need to evolve as smarter and more efficient models based on the challenges they face, such as population growth, limited space and resources. The concept and dynamics of the emergence of the smart city have evolved over time, like any new technology or technological concept, there was a lot of confusion in the beginning about what a smart city should look like and what it actually means in practice. Therefore, the first generation of smart cities "smart city 1.0" was driven more by technology providers, such as giant technology companies, to present use cases of what a smart city can address and promote their solutions to city leaders. The second generation of "smart city 2.0" followed the opposite approach, where cities were more driven by a vision of what a smart city should look like, as requirements in coordination with technology providers, with these requirements based on the needs, problems and priorities of the city, such as improving quality of life. More recently, the third generation has come along and developed this approach by taking into account the citizens' opinion and encouraging their involvement and participation in the development of the smart city [8].

When it comes to defining what a smart city is, there are several definitions with common characteristics of what a smart city should have, such as ICT infrastructure, smart people and smart

governance. One of the first definitions was shared by TU Wien as follows: “A smart city is a city with smart industries in the field of ICT and regard the education of its inhabitants and the relation between the city government administration and its citizen. Smart City is furthermore used to discuss the use of modern technology in everyday urban life.” [14].

Another definition comes from Gartner and defines smart cities as: “A smart city is based on intelligent exchanges of information that flow between its many different subsystems. This flow of information is analyzed and translated into citizen and commercial services. The city will act on this information flow to make its wider ecosystem more resource-efficient and sustainable. The information exchange is based on a smart governance operating framework designed for cities sustainable.” [18].

As already mentioned, the two definitions we have presented here share several characteristics along with other definitions, which are the focus on advanced ICT infrastructure that enable urban services and economic grow, empowering citizens through digital services, and at the same time smart governance using all the data flowing around.

In this article, we look at one of the key drivers of smart city development, which is the Smart Economy. The latter is often referred to as a critical dimension for evaluating the success of any smart city project. In the following sections, we define what the Smart Economy dimension is, how it is evaluated using a detailed list of indicators, and how the most successful cities are measured in terms of their Smart Economy dimension. To the best of our knowledge, there is no study addressing smart cities from this perspective, so we believe that our paper provides unique value and useful findings for stakeholders involved in smart city development.

2. Smart Economy Dimension in Smart City Assessment

There are a growing number of smart cities around the world, which often start as a development project with its own objectives and indicators. To be successful, it should achieve its initial objectives, which essentially measure the efficiency and level of smartness of a geographical area at scale.

Based on our research, we found several frameworks developed for evaluating such development projects. Quantitative methods are a common assessment approach, and the results of such assessment will help people involved in the development of geographic spaces, specifically city managers and policy makers to focus their efforts, time and resources, while allowing them to define and track what the long-term plan would be and communicate it to various stakeholders including citizens [3], [4].

Among the many evaluation frameworks that assess the performance of a smart city [2], [22], [25], [27], we have observed some commonalities that include the following six core dimensions: Smart Economy, Smart Environment, Smart People, Smart Governance, Smart Technology, Smart Mobility, Smart living, and Smart Infrastructure. The economy dimension measures certain economic characteristics related to economic development, business environment, investment and entrepreneurship through indicators such as GDP, GDP per capita, wages, number of startups and ease of starting business, which are the focus of this study.

Smart Economy. As far as the definition of Smart Economy is concerned, the concept of smart economy promotes innovation, green economy and maximizes the overall use of human capital, including skills knowledge and creativity [23].

ICT infrastructure has always been a key player in driving smart cities and related dimensions. Advances in ICT enable faster development and realization of several benefits such as new and digital

products and services, better and more efficient resource management, which in turn enhance the economy and quality of life.

3. Research Methodology

Our research methodology was guided by Web of Science database search on topics related to “smart city assessment”, “smart city evaluation”, “smart city performance”, “smart city index”, “smart city framework”, “smart city indicators”, “smart city tool”, and “smart city ranking” published in the last five years (2015 - 2020), as we believe that there has been an increasing amount of work on smart city development and consequently related research and studies in the last five years, which should provide us with the most up-to-date and reliable findings and also focus our efforts on the most relevant data.

Our search resulted in 85 articles, and after reviewing them, we excluded 67 articles on the grounds that they were not directly related to smart city assessment or were very narrowly focused on one dimension or geography. We then analyzed 18 selected articles and other 12 articles that we obtained from other search tools, such as google scholar, and specific targeted industry reports, such as [22] and [11]. In total, we analyzed 30 different articles related to smart city assessment, 25 of which dealt with the Smart Economy dimension that is the focus of this paper (Figure 1).

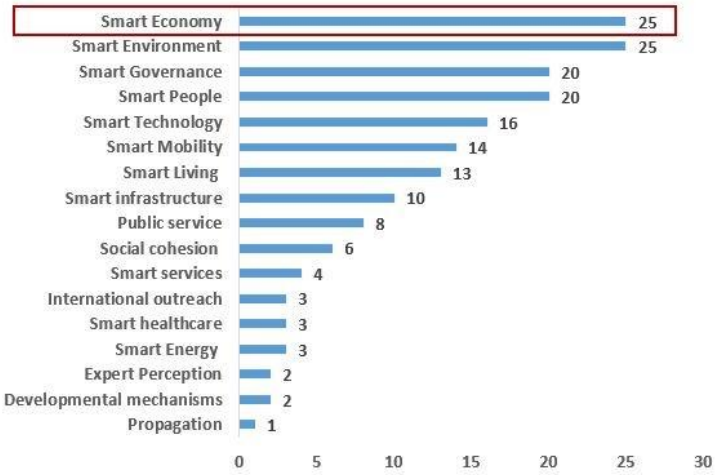

Figure 1. Frequency of assessment dimensions found in the analyzed studies

Figure 2. Word cloud describing the Smart Economy dimension

4. Results

Based on our analysis, the Smart Economy has a major impact on the development of smart cities. We found the Smart Economy as a key dimension in 25 of the 30 studies we shortlisted that address smart city assessment methodologies. In fact, the Smart Economy emerged as the most common dimension of assessment, as shown in Figure 1.

The number of indicators evaluating the Smart Economy dimension varied across studies, with a maximum of 13 indicators included in [27] and [26]. The Smart Economy dimension deals with indicators related to the strength, efficiency, and progress of the economy. Figure 2 shows the word cloud with different names used to measure the Smart Economy dimension, with the word "economy" being used the most frequently in the 25 studies, 20 times, either alone or in combination with other words, for example, the word "smart economy" was used 8 times.

Based on our analysis, 24 of the 25 studies addressing the Smart Economy dimension elaborated in more detail on the indicators used to assess this dimension. The indicators are often referred to as the lowest level in the assessment framework. We have consolidated these indicators to a total of 91 indicators, and also divided them into 11 categories, as shown in Table 1. The largest number of indicators was under employment with a total of 14 different indicators. Within the employment category, we could see that productivity was the most commonly used indicator. Other dominant indicators were also related to employment and unemployment rates and the share of employees in various services.

Following the employment category, we can see a high number of indicators focusing on economic strength and its characteristics with a total of 11 different indicators. Several indicators were also related to entrepreneurship as well as facilities and infrastructure covering physical services, energy consumption levels and the representation of different entities, with a total of 10 and 11 indicators respectively. Other categories with a high number of indicators were technology, policies and regulations. The medium to low categories in terms of number of indicators are three categories with 6-7 indicators in each category, namely investment, ecosystem, living standards and global outreach. We also recorded 2 indicators related to environment which are are green economy and green area per capita.

Table 1. An overview of the smart economy indicators shown in the analyzed studies

Category	Indicator	Source
Economic strength	GDP, Nominal GDP, Gross product	IESE 2020, Liao 2017, GPCI 2019, Tariq 2020
	GDP per capita, Per capita disposable income	GPCI 2019, Li 2019, Shen 2018, Feng 2017, Theng 2016, Lu 2015, EasyPark 2019
	Stock Market Capitalization	GPCI 2019
	World's Top 500 Companies	GPCI 2019
	Tertiary industry in GDP %	Li 2019, Lu 2015
	Center of economy	Firmanyah 2017
	Industry index	Firmanyah 2017
	Economic performance	Airaksinen, 2017
	Service sector share of GDP	Feng 2017
	Local fiscal revenue	Feng 2017

	Rate of GDP growth	PWC 2016
Ecosystem	Business environment	Bloom 2017
	Strategic sectors	Bloom 2017
	Socio economic factors	Bloom 2017
	Number of companies per 100 inhabitants	Dall'O 2019
	Number of co-working space per 100 inhabitants	Dall'O 2023
	Attractiveness & competitiveness	Airaksinen, 2017, Ericsson 2016
Employment	Registered unemployment rate, Unemployment rate (trend), Unemployment rate	2, Ogrodnik 2020, Tariq 2020, Dall'O 2017
	Self-employed trend	Tariq 2020
	Wage price index	Tariq 2020
	Productivity	IESE 2020, ASCIMER 2017, PWC 2016, Ericsson 2016, Monzon , UN ECE 2015
	Employment, Total employment, Percentage of full time employed	GPCI 2019, Zhang,2019, Airaksinen, 2017, UN ECE 2015, Akande 2019
	Employees in business support services, Financial and business services employment	GPCI 2019, PWC 2016
	Wage level, Hourly wage in US dollars	GPCI 2019, IESE 2020
	Availability of Skilled Human Resources	GPCI 2019
	Variety of Workplace Options	GPCI 2019
	Annual salary	EasyPark 2019
	Employment rate in high technology and innovation industries	Shen 2018
	Flexibility of labour market	ASCIMER 2017
	Employment growth	PWC 2016
	Flexibility of labour market	Monzon 2015
Entrepreneurs hip	Natural persons running a business per 1,000 inhabitants	Ogrodnik 2020
	Share of newly registered creative sector entities in the total number of newly registered entities	Ogrodnik 2020
	Trade and patent mark apps rate/trend	Tariq 2020, Akande 2019
	Motivation that people have to undertake early-stage entrepreneurial activity	IESE 2020
	Entrepreneurship; Quantity of new ventures	Carrizo 2020, ASCIMER 2017. Monzon 2015, Liao 2017
	Number of registered startups per city	EasyPark 2019
	Number of blockchain startups per city	EasyPark 2019
	Enterprises in hi-tech industry development zone number	Li 2019
	Urban innovation and entrepreneurship level	Shi 2018
	Quality of entrepreneurship and the level of innovation	Shen 2018
Environment	Green economy	Airaksinen, 2017
	Green area per capita	Zhang,2019
Facilities & Infrastructure	Entities registered in the REGON register per 10,000 inhabitants	Ogrodnik 2020

	Units newly registered in the REGON register per 10,000 inhabitants	Ogrodnik 2020
	Building approvals trend	Tariq 2020
	Dwelling worth	Tariq 2020
	Number of headquarters	IESE 2020
	urban sewage treatment capacity	Zhang 2019
	Energy consumption level of economic output	Shi 2018
	Industrial planning/industrial upgrading	Liao 2017
	Education	Firmanyah 2017
	Number of global 500 headquarters	PWC 2016
	Physical infrastructure (sub-topics: piped water, health, electricity, transport, and buildings)	UN ECE 2015, Akande 2019, Firmanyah 2017 Zhang 2019
Global outreach	Foreign capital per capita of working age	Ogrodnik 2020
	Collaborative economy	IESE 2020
	International events held	Carrizo 2020
	Integration in the global market, Local and global interconnectedness, imports/exports	Liao 2017, ASCIMER 2017, Monzon 2015, UN ECE 2015
	Foreign direct investment	Theng 2016, Li 2019
	Foreign trade export	Theng 2016
Investment	Total new businesses	Tariq 2020
	Total large businesses	Tariq 2020
	Total businesses trend	Tariq 2020
	Business entry rate	Tariq 2020
	Gross fixed capital (trend)	Tariq 2020
	Mortgage	IESE 2020
	investment in Innovation, research, and development	Carrizo 2020, Akande 2019
Living standards	Average gross monthly salary, income level	Ogrodnik 2020, Zhang,2019
	House worth	Tariq 2020
	Purchasing power	IESE 2020
	fast food meal, restaurant meal, monthly rent, monthly transport ticket) average	EasyPark 2019
	Residential area per capita	Zhang 2019
	Social security	Zhang 2019
Policies & regulations	Ease of starting a business	IESE 2020, PWC 2016
	Time required to start a business	IESE 2020
	Equity	Airaksinen 2017
	Economic Freedom	GPCI 2019
	Corporate Tax Rate	GPCI 2019
	Political, Economic and Business Risk	GPCI 2019
	Number of 14001 audits (or similar) per 100 companies	Dall'O 2017
	Attracting FDI	PWC 2016
	Resolving insolvency	PWC 2016

Technology	Number of blockchain transactions per country	EasyPark 2019
	Export value of high-tech enterprises 104 dollars	Li 2019
	Level of Internet industry development	Shi 2018, Akande 2019
	Level of E-commerce	Liao 2017, UN ECE 2015, Akande 2019
	Input and development level of information industry	Liao 2017
	Innovation index	ASCIMER 2017, EasyPark 2019, Airaksinen, 2017, Monzon 2015, UN ECE 2015, Liao 2017
	Number of IT companies per number of total companies	Dall'O 2017
	Thematic web portal for culture and tourism	Dall'O 2017
	ICT infrastructure	UN ECE 2015, Carrizo 2020

5. Discussion and Conclusion

Our comprehensive analysis in Table 1 shows a broad list of diverse indicators used to assess the Smart Economy dimension in the analyzed studies, totaling 91 different indicators. This is an extensive list of indicators that includes rich and large datasets as input data. Some of the indicators are similar in nature and it could be argued that they all serve the same purpose or are strongly correlated with each other, and therefore one of such a group might be sufficient to assess a particular area of economic performance. For example, we recommend purchasing power, income levels and commodities prices.

All 91 indicators in the 11 categories listed in Table 1 above were reported as economy-related in the studies we analyzed. However, we believe that several of them would have been better suited to other dimensions of the assessment, for example, green area per capita in the environment category, as well as ICT infrastructure and the level of development of the Internet industry in the technology category, could have been assigned to Smart Environment and Smart Technology dimensions, as has been shown in several other studies.

In addition, in some studies, we have observed indicators that we believe are related to the economy being incorrectly mapped to another dimension, such as GDP per capita, which has been mapped to the living standards dimension instead of the innovation economy dimension [15]. These observations again draw our attention to the lack of consistency and standardization in smart city assessment methodologies.

Some of the studies we analyzed produced overall rankings of smart cities and by each of the assessment dimensions, such as [26], when we looked at the top 10 cities in the ranking of the economy dimension, we found that 6 of the cities in the top 10 cities were also in the overall top 10 ranking. In addition, we looked at the ranking of the top 20 cities in both the economy dimension and the overall ranking of the study [36] and our comparison resulted in 18 of the top 20 cities being common to both the economy dimension and the overall city ranking. Based on these observation, we can confirm the important role of Smart Economy in driving the development of smart cities.

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