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The Global Liveability Index and Smart Cities across Europe

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ABSTRACT

In the context of new economic, pandemic and geo-political challenges, the development of smart cities becomes an essential objective for solving complex problems, ensuring sustainability and increasing the quality of urban life. The main objective of the research is to provide a useful framework for supranational, national and local decision-makers to adopt effective urban management measures that are compatible with development, environment and people's well-being. The research methods used are literature meta-analysis, comparative-critical analysis of indicators and cluster analysis. The main conclusion of the analysis is that urban development disparities are strongly influenced by the overall level of economic development and become vulnerable under conditions of economic, social, political and military stress.

1. Introduction

Even if historically, the smart city concept dates back to the 60s and 70s of the last century, its actuality is strongly sustained under the vulnerabilities created by economic, pandemic and geo-political crises. The importance of smart cities has also skyrocketed due to the fact that 54% of the world's population now lives in cities. Official forecasts predict that this percentage of the urban population will rise to 66% by 2050 (TWI, 2022) . The evolution of urban population worldwide is shown in Figure 1.

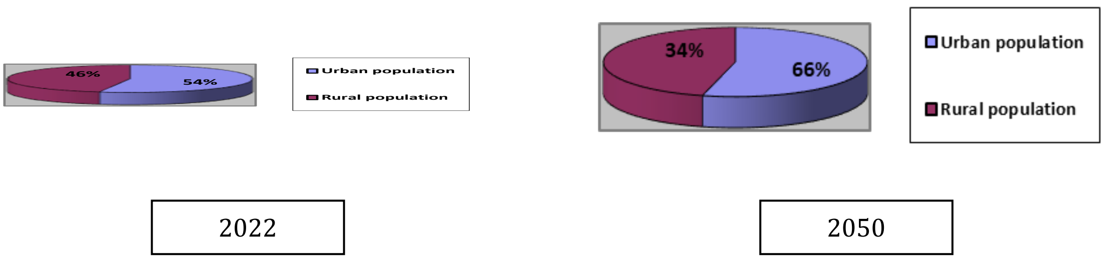

Figure 1. Global urban population change (%)
Source: author's contribution using (TWI, 2022)

Smart city development is seen as a source of economic growth and improving the quality of life of urban residents. In this context, we can define smart city as an administrative entity able to use information and communication technologies (ICT) to disseminate them to citizens, improve the efficiency of public services and ensure the well-being of its inhabitants.

Smart city management has to cover a wide range of issues related to environmental issues, transport infrastructure, continuous urban development, ensuring jobs and adequate living conditions for citizens and large-scale implementation of the latest technologies. The smart city characteristics are shown in Figure 2.

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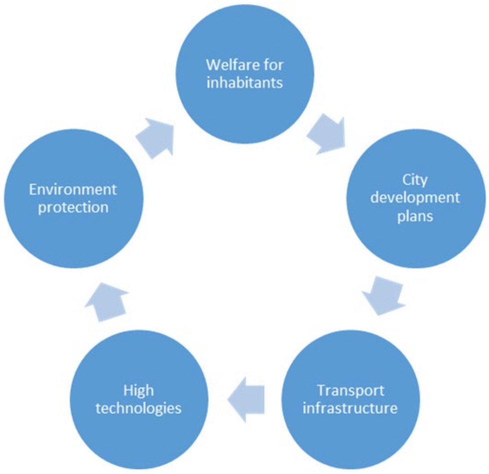

Figure 2. Smart city concept.
Source: author's contribution

Smart city development is strongly linked to sustainability and efficiency in urban agglomerations and to improving the well-being of citizens. This cannot be achieved without real collaboration between the public and private sectors and citizens in favour of urban development.

The common element of smart city implementation is the use of data portals and/or mobile applications to make it easier for urban residents to pay taxes, pay taxes, use sustainable transport and use less polluting energy sources. In this context, achieving connectivity across millions or tens of millions of Internet of Things (IoT) is the main challenge for smart urban management.

This unprecedented growth in urban connectivity also requires adequate measures to protect against cyber attacks and hackers by implementing physical data vaults, ID solutions and resilient authentication management.

In April 2022, the EU launched the "100 climate-neutral and smart cities" initiative, to be completed in 2030 (European Commission Directorate-General for Research and Innovation, 2022). A second phase of this initiative aims to make all EU cities climate-neutral cities by 2050.

Under this initiative, European cities will benefit from advice, funding, encouraging R&D for innovation and pilot projects, setting up a coordination network, promoting best practices in the field, increasing the visibility of the selected cities and involving citizens in urban management decisions.

While out of the sample of 100 smart cities Luxembourg, Croatia, Malta, Estonia, Czech Republic and Cyprus participate with only one city in this project, France participates with 10 such cities.

In this context, the main objective of this paper is to analyse the dynamics of European smart cities and the quality of life of their citizens.

2. Literature review

The interest for researchers to study the concept, implementation and evolution of smart cities is extremely high. The EU increasingly supports this urban management approach as a viable solution to the problems faced by conurbations.

Smart city development in the context of e-government in the European Union is the subject of research undertaken by the authors Lytras & Șerban (Lytras & Şerban, 2020). The authors target European convergence in e-government services, based on the hypothesis that economic development gaps between Member States stimulate the growth rate of e-government in less developed countries. The analysis notes that elements such as education, digital skills and internet access directly influence the e-government process and proposes a re-adaptation of e-government services to the digital skills of European citizens.

An important issue in smart city development is smart energy solutions which, according to the authors Giourka et al. (Giourka et al., 2020), can efficiently address the needs of cities in this area. The study focuses on two cities in the European Union (Evora and Alkmaar) and concludes that the elements influencing this process are related to quality, motivation, integration, cost reduction, information and urban management. The authors offer proposed solutions for policy makers to promote urban energy sustainability.

The same theme of smart energy is addressed by the authors Șerban & Lytras (Şerban & Lytras, 2020), who focus on renewable energy and artificial intelligence. The authors analyse the state of implementation of artificial intelligence in the renewable energy sector in the European Union. The indicators analysed quantify the efficiency of renewable energy transformation processes in the energy chain, the change in the structure of renewable energy by source, labour productivity in the renewable energy sector, and the impact of investments in the sector and the implications of adopting artificial intelligence for renewable energy.

Building on the European initiative "Clean Energy for All Europeans", authors Tantau & Șanta (Tantau & Şanta, 2021) highlight issues related to the European Commission's "European Innovation Partnership on Smart Cities and Communities". According to this approach, new business models involving the use of technology are emerging in European cities. These modern technologies have benefits in terms of improving the quality of life for residents, reducing the impact of climate change and creating jobs in the IT industry. The authors base their research on a questionnaire and case studies from Austria, Finland, and Romania. The common element of smart cities in these countries is the trend towards sustainability.

In the context of smart development of European cities, innovative procurement can support the efficiency and effectiveness of public services. Some authors, such as Manika (Manika, 2020) support the introduction of innovation in strategic public procurement in line with the public procurement legislative framework implemented at EU level. A first finding of this analysis is that many public authorities still prefer traditional public procurement procedures citing budgetary considerations. The analysis focuses on innovative public procurement in Greece and finds a procrastination in the process of public procurement innovation, the main cause being insufficient knowledge of the available legal framework. The main outcome of this analysis is to provide smart cities with the information they need to make strategic use of innovative procurement.

The security of smart city related information against cyber and physical assets associated with the power grid is the subject of research by authors Das et al. (Das et al., 2020), in the context of defining and quantifying smart grid resilience. The authors start from a resilience matrix and develop practical scenarios of current challenges.

Another scientific approach addresses the vulnerabilities of Smart Grids to cyber attackers. Authors Syrmakesis et al. (Syrmakesis et al., 2022) perform a classification of proposed cyber resilience methods against cyber attacks for Smart Grids. Furthermore, they provide descriptions of significant aspects of cyber resilience and propose new research areas to improve the cyber resilience of smart city networks.

Some authors such as Ramirez Lopez & Grijalba Castro (Ramirez Lopez & Grijalba Castro, 2021) support the idea of smart urban planning from the perspective of environmentally sustainable planning. In their approach, the authors cover four essential themes: urbanism and urban planning; sustainability; resilience; and smart cities. Using a meta-analysis of 87 articles in the field and VOSviewer®, the authors conclude that European cities should be approached as complex systems that work as a whole. Within this framework, the synchronisation of decisions between inter-urban and intra-urban processes becomes essential for central and local government in supporting sustainable urban development.

The sustainable development of the smart city is also addressed by the author Șanta (Șanta, 2022), who refers to the need to create new energy consumption patterns in the context of the paradigm shift from consumers to urban prosumers. In their analysis, the authors start from the premise that prosumers have a new mindset related to urban sustainability. The main conclusion of the analysis is that smart cities are becoming social hubs capable of improving the living standards of urban dwellers and ensuring sustainability in development and consumption.

The resilience of smart cities is also studied by authors Zhou et al. (Zhou et al., 2021), in the context of improving their capacity for development and resilience to disasters of all kinds. The authors look at urban resilience under the following aspects: economic resilience, social resilience, environmental resilience and infrastructure resilience. The analysis showed that smart city development improves social resilience. On the other hand, the same urban development has no obvious effect on economic and ecological resilience. In contrast, smart city development negatively affects infrastructure resilience. In addition, high urban resilience is associated with an efficient industrial structure, a highly skilled workforce and efficient urban firms.

The topic of urban resilience in connection with disaster management is addressed by authors Kim et al. (Kim et al., 2021) from the perspective of road network reconfiguration for disaster evacuation planning. The authors use a model for generating an evacuation plan for large objects, where in addition to the cost constraint they introduce the safety criterion.

Other authors such as Samarakkody et al. (Samarakkody et al., 2022) start from the idea that disasters are inevitable and that great attention should be paid to resilience in smart cities. As a result, they propose that smart cities should develop their own intelligence criteria in the context of urban resilience, which is the result of an extensive meta-analysis conducted by the authors. The research highlights that urban resilience is structured along six smart city dimensions:" smart economy, smart governance, smart people, smart mobility, smart living and smart environment."

Smart urban governance from an ICT perspective is supported by Jiang (Jiang, 2021), who believes that demand-driven urban management based on technological intelligence can respond efficiently to current development challenges.

Smart city development is influenced by social infrastructure and human capital. As a result, authors Masik et al. (Masik et al., 2021) conduct an analysis of 6 smart cities in Poland (Warsaw, Kraków, Łódź, Wrocław, Poznań and Gdańsk) and their metropolitan areas. The analysis was followed by interviews,

specific seminars and an exploratory study of the cities of Gdańsk and Gdynia. The results of the analysis highlight the progress made by these cities at institutional, participatory governance and digitisation levels.
Advances in smart cities related to the semantic web, cloud computing, mobile services, mobile gadgets and the Internet of Things (IoT) are highlighted by authors Liu et al. (Liu et al., 2021) in connection with policy and flexibility of urban infrastructures to achieve an urban decision model. The authors start from a questionnaire addressed to 201 urban managers and planners, the information obtained being processed with dedicated software (SPSS25 and SMART-PLS 3.2). The results of the analysis reflect the positive impact that cloud services, near field communication and IoT services have had on urban planners.

Assessing the resilience and livability of smart cities is the subject of the analysis by (Kutty et al., 2022), which uses multivariate distance metric analysis combined with machine learning. The study uses statistical data for 35 European smart cities over the period 2015-2020 covering social, economic, infrastructure and built environment and institutional resilience. Fuzzy c-means clustering method is used to classify smart cities based on the degree of performance. The results of the analysis indicate that the Gradient Boosting machine model is the best classification and prediction model for assessing the resilience, livability and aggregate performance of smart cities. Smart cities such as Copenhagen, Geneva, Stockholm, Munich, Helsinki, Vienna, London, Oslo, Zurich and Amsterdam show the best performance.

Another feature of the smart city is smart urban logistics, which the authors Büyüközkan & Ilıcak (Büyüközkan & Ilıcak, 2022) believe must be integrated with modern technologies. The authors start from a meta-analysis covering academic as well as industry literature on urban smart logistics and find that there are a multitude of gaps in the analysis of subtopics and technologies in the field.

The literature review reveals the importance and topicality of the proposed research topic and supports our scientific approach.

3. Methods

This paper proposes as ***research hypotheses***:
H1. The degree of livability in smart cities is directly influenced by economic and pandemic crises. This hypothesis is also supported by the works of the authors Kim et al., Samarakkody et al., Zhou et al., (Kim et al., 2021; Samarakkody et al., 2022; Zhou et al., 2021).
H2. Smart cities in Eastern Europe are less livable amid increasing geopolitical risks. Research by authors like Lytras & Şerban, Manika, Tantau & Şanta (Lytras & Şerban, 2020; Manika, 2020; Tantau & Şanta, 2021) support this hypothesis.
H3. Smart cities in Western Europe show higher livability due to high vaccination rates against COVID-19, relaxation of restrictions and robust economic growth in cutting-edge areas. The hypothesis is built on the authors' research findings as Jiang, Kutty et al., Masik et al., Ramirez Lopez & Grijalba Castro (Jiang, 2021; Kutty et al., 2022; Masik et al., 2021; Ramirez Lopez & Grijalba Castro, 2021).
H4. The economic and energy crisis is affecting livability in all EU smart cities. This hypothesis is based on studies carried out by the authors Giourka et al., Şerban & Lytras (Giourka et al., 2020; Şerban & Lytras, 2020).

The analysis is based on the Economist Intelligence Unit – EIU (Economist Intelligence, 2022) reports on the global housing index in 2022, supported by the following categories of ***economic indicators***:

- Stability (weight: 25% of total);
- Healthcare (weight: 20% of total);
- Culture & Environment (weight: 25% of total);
- Education (weight: 10% of total);
- Infrastructure (weight: 20% of total).

Specific indicators correspond to each of the 5 categories above (see Table 1).

Table 1. Liveability indicators, 2022

Category	Indicator	Source
Stability (weight: 25% of total)	1. Prevalence of petty crime;	EIU rating
	2. Prevalence of violent crime;	
	3. Threat of terror;	
	4. Threat of military conflict;	
	5. Threat of civil unrest/conflict.	
Healthcare (weight: 20% of total)	1. Availability of private healthcare;	EIU rating
	2. Quality of private healthcare;	
	3. Availability of public healthcare;	
	4. Quality of public healthcare; 5. Availability of over-the-counter drugs;	
	6. General healthcare indicators.	World Bank
Culture &	1. Humidity/temperature rating;	Adapted from average weather

Category	Indicator	Source
Environment (weight: 25% of total)		conditions
	2. Discomfort of climate for travelers;	EIU rating
	3. Level of corruption;	Adapted from Transparency International
	4. Social or religious restrictions;	EIU rating
	5. Level of censorship;	EIU rating
	6. Sporting availability;	EIU field rating of 3 sport indicators
	7. Cultural availability;	EIU field rating of 4 cultural indicators
	8. Food and drink;	EIU field rating of 4 cultural indicators
	9. Consumer goods and services.	EIU rating of product availability
Education (weight: 10% of total)	1. Availability of private education	EIU rating
	2. Quality of private education	
	3. Public education indicators	World Bank
Infrastructure (weight: 20% of total)	1. Quality of road network	EIU rating
	2. Quality of public transport	
	3. Quality of international links	
	4. Availability of good-quality housing	
	5. Quality of energy provision	
	6. Quality of water provision	
	7. Quality of telecommunications	

Source: author's contribution using (Economist Intelligence, 2022)

These indicators are translated to 173 smart cities worldwide. The data obtained is translated into a data matrix. Data processing with dedicated software allows the creation of individual profiles for each city in the sample. Finally, the cities in the sample are ranked according to the values of the calculated indicators. According to the Economist Intelligence Unit - EIU, the calculated indicators fall into one of the following categories (see Table 2):

Table 2. Categories of values for calculated indicators, 2022

Rating	Explanation
80-100%	There are few, if any, challenges to living standards 0
70-80%	Day-to-day living is fine, in general, but some aspects of life may entail
60-70%	Negative factors have an impact on day-to-day living 10
50-60%	Liveability is substantially constrained 15
<50%	Most aspects of living are severely restricted 20

Source: author's contribution using (Economist Intelligence, 2022)

The analysis of the 5 categories of indicators on the ranges of values shown in Table 2 leads to a ranking of the most liveable smart cities in the world according to the Global Liveability Index.

4. Results and discussions

In the top 10 cities in the world ranked by the Global Liveability Index in 2022 are 4 cities from the EU27, namely Vienna, Copenhagen, Frankfurt and Amsterdam, which are ranked 1, 2, 7 and 9 (see Figure 3).

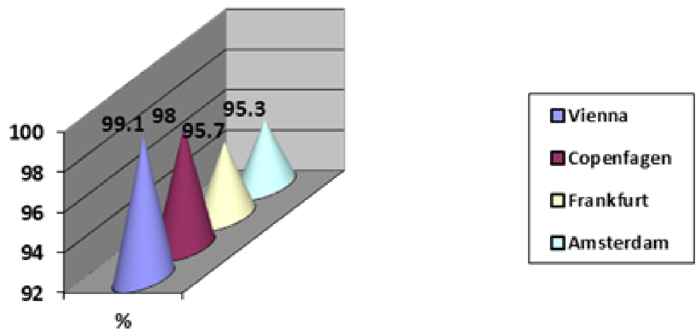

Figure 3. EU's smart cities in world top ten positions (total index, %).
Source: author's contribution using (Economist Intelligence, 2022)

These 4 European cities are characterised by high stability and excellent health conditions (see Figure 4).

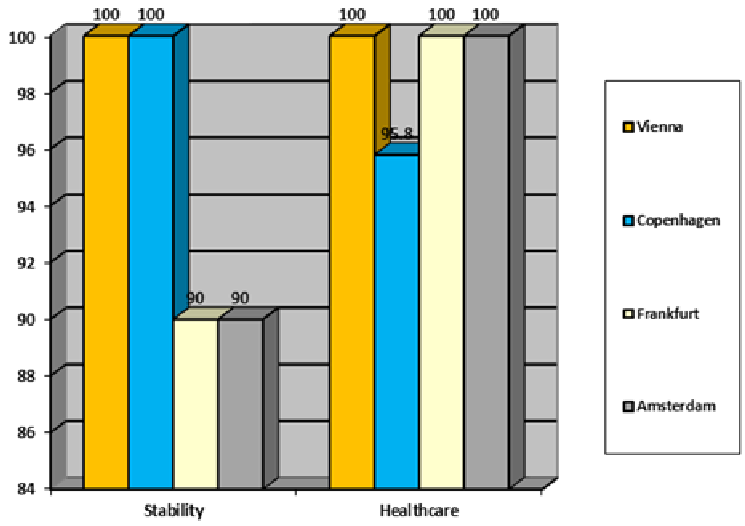

Figure 4. EU's smart cities in world top ten positions after stability and healthcare (%)

Source: author's contribution

According to Figure 4, Vienna, Frankfurt and Amsterdam show the highest percentages, followed at a gap of 4.2% by Copenhagen.

In the case of urban stability indicators, two clusters are possible. The first includes Vienna and Copenhagen, with maximum results, while the second cluster covers Frankfurt and Amsterdam, with gaps of 10% from the first two cities in the sample.

In the case of indicators related to culture, environment, education and infrastructure, the disparities at the level of the smart cities in the sample are smaller (see Figure 5).

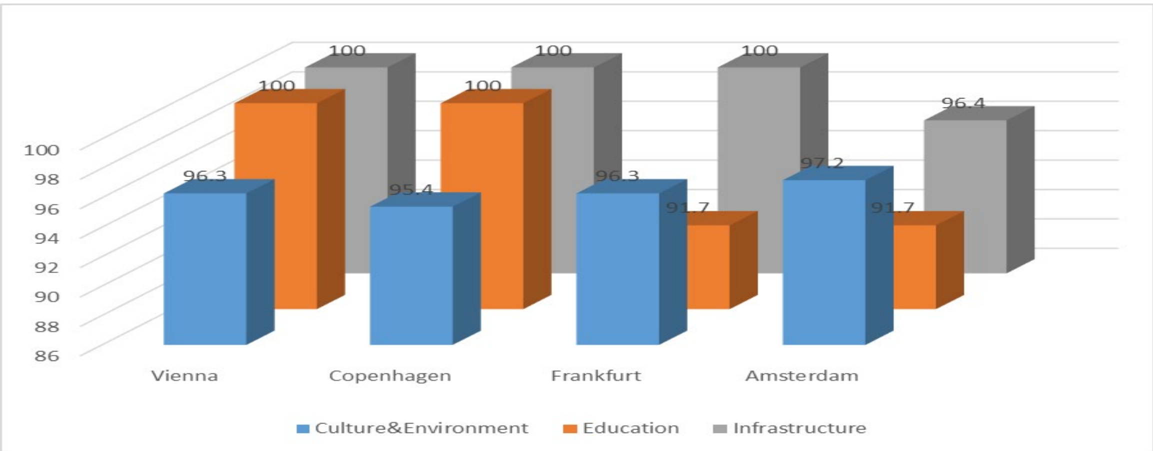

Figure 5. EU's smart cities in world top ten positions after culture, environment, education and infrastructure (%)

Source: author's contribution

Other EU27 cities, such as those shown in Table 3, rank among the world's smart cities.

Table 3. Indicatori de locuibilitate in EU smart cities, 2022

City	Country	World rank	Index
Vienna	Austria	1	99.1
Copenhagen	Denmark	2	98.0
Frankfurt	Germany	7	95.7
Amsterdam	Netherlands	9	95.3
Hamburg	Germany	16	94.4
Paris	France	19	93.6
Dusseldorf	Germany	22	93.0

City	Country	World rank	Index
Brussels	Belgium	24	92.7
Barcelona	Spain	35	89.1
Madrid	Spain	43	87.6
Athens	Greece	73	74.5

Source: author's contribution

Simply looking at the data in Table 3 in 2022 and comparing it to the same indicator in 2021 (Economist Intelligence, 2021) shows that the economic and pandemic crises have had a negative impact on living conditions in European smart cities. This evolution is in perfect agreement and verifies our research hypothesis H1. The degree of livability in smart cities is directly influenced by economic and pandemic crises.

It can also be noted that in the 73 positions of the smart city ranking there are no cities from the East of the EU. Living conditions in these cities bear the additional pressures inherent in the complicated geo-political situation related to the war in Ukraine.

This finding demonstrates the validity of research hypothesis H2. Smart cities in Eastern Europe exhibit lower livability amid increasing geopolitical risks.

The biggest advances in the top smart cities are recorded by German, British and French cities. If in 2021, these cities' positions in the top were weaker due to restrictions imposed by the COVID 19 pandemic, today this disease is becoming endemic, causing normality to be largely restored.

On the other hand, social protection and economic growth in Western EU27 countries are stronger, which has supported improved living conditions in Western cities.

These developments demonstrate the validity of research hypothesis H3. Smart cities in Western Europe show higher livability due to high vaccination rates against COVID-19, relaxation of restrictions and robust economic growth in cutting-edge areas.

Moreover, the new economic and energy crises have affected living conditions in many cities due to their impact on health infrastructure, transport and energy consumption, which in turn have put pressure on health, cultural and environmental conditions and education.

The overall impact is to affect the level of living conditions in urban areas. This development supports research hypothesis H4. The economic and energy crisis is affecting livability in all EU smart cities.

The developments presented above lead to the idea of a cluster approach to the evolution of the housing stock in smart cities in the EU.

5. Conclusions

The main objective of the present research was the comparative analysis of smart cities in the EU27 in the context of the Global Liveability Index. This composite index revealed significant disparities in the level of development and living conditions that European smart cities provide for their citizens.

The contradictory developments were influenced by the economic crisis, the pandemic and the war in Ukraine. In this context, the results of our research have demonstrated the study hypotheses we initially defined.

Furthermore, the analysis undertaken led to the conclusion of the cluster approach to smart cities in the EU27. According to this approach and taking into account the observed developments, we used the TwoStep cluster analysis, which uses as categorical variables the values of the economic indicators presented above. The distance measured is the logarithmic distance for neighbourhoods and the clustering criterion is BIC (Schwarz's Bayesian Criterion). Under these conditions we opted for two clusters as in Figure 6.

In this figure, the smart cities in the sample are shown as:

1 – Vienna,
2 – Copenhagen;
3 – Frankfurt;
4 – Amsterdam;
5- Hamburg;
6 – Paris;
7 – Dusseldorf;
8 – Brussels;
9 – Barcelona;
10 – Madrid;
11 – Athens.

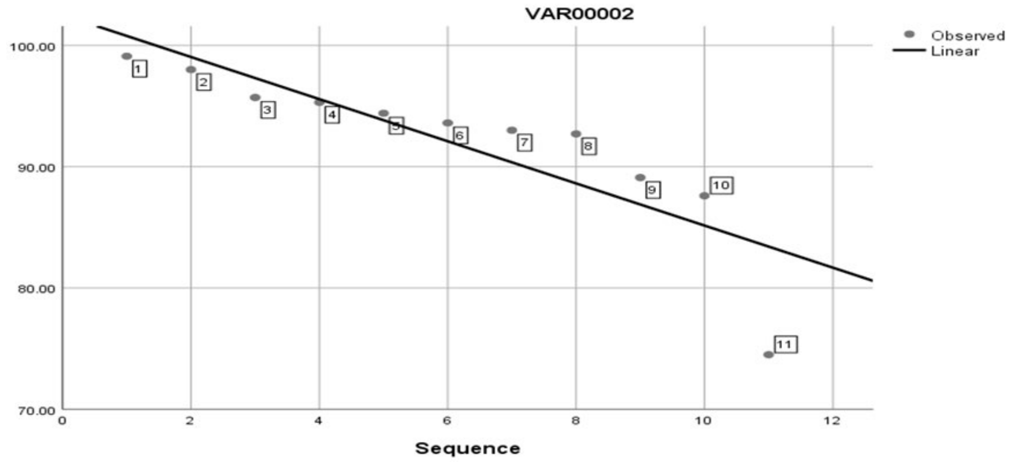

Figure 6. EU's smart cities under cluster approach.
Source: author's contribution using IBM-SPSS 25

According to Figure 6, the first cluster comprises Vienna, Copenhagen, Frankfurt, Amsterdam and Athens, while the second cluster covers Hamburg, Paris, Dusseldorf, Brussels, Barcelona and Madrid.
To check the validity of these two clusters, we apply the standard IBM-SPSS 25 software procedure, and the results are shown in Figure 7.

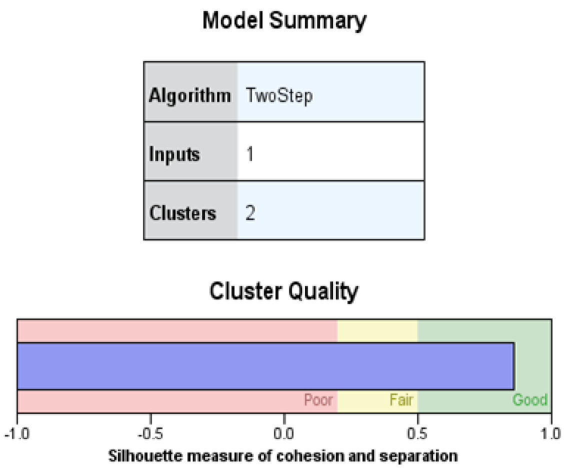

Figure 7. EU's smart cities under cluster approach quality.
Source: author's contribution using IBM-SPSS 25

According to Figure 7, average silhouette = 0.9, which expresses a good clustering approach and confirms our analysis.

Our analysis allows supranational decision-makers to get an overview of the smart city phenomenon at EU27 level and the living conditions provided by these cities to their citizens.

At national and local level, decision-makers can intervene in a timely manner to solve problems that have arisen in relation to the evolution of each indicator of the composite index.

The limitations of this study lie in the relatively small number of smart cities analysed. We are convinced that further analysis of this research theme will be much more extensive in terms of number of EU cities and time period.

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