

Article

The State-of-the-Art of Smart Cities in the European Union

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Abstract: Today, policymakers struggle to obtain information from specific smart city case studies. The literature lacks a unified view of current initiatives. This paper performs an empirical study with the aim of collecting evidence from the literature about existing smart city initiatives in the European Union (EU). The contribution of each paper and its geography are analyzed using content analysis to identify the number and type of initiatives in each country. A cluster analysis is performed to find relationships between countries and their development phase as well as the categories (areas) they are focused on. The results suggest that there are different levels of smart city development between the member states despite the initial year of their first result in the literature. Furthermore, 22 smart city categories clustered in four different groups were found. When compared to countries' socio-economic characteristics, the results suggest the development of smart cities is significantly related to the public budget balance, gross domestic product and EU structural funds. In summary, this paper portrays the state-of-the-art of smart city initiatives in the member states of the European Union. Moreover, it represents a valuable contribution to decision makers to discuss ways to standardize smart city approaches in the European scope. Furthermore, the method used in this paper can inspire the development of collaborative dashboards for the exchange of best practices and data accessibility about case studies' details.

Keywords: European Union; member states; smart city; categories; initiatives; case studies; best practices; country clusters



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1. Introduction

Smart cities emerged in the late 1990s, motivated by the vision of decision makers who have the capacity to simulate the urban environment in real time [1–3]. This vision was initially biased by the interests of technological companies to attach cities' strategies to their interests [4–6]. It has led cities to test solutions and implement pilots without a strategic direction. This challenged the existence of case studies in the literature and the exchange of best practices between cities. Although the concept has evolved to consider cities' sustainability, the quality of life of inhabitants and their involvement in the co-creation of strategies [7–10], policymakers have been struggling to access information on specific smart city implementations. This information exists but is spread across the literature. Thus, the literature lacks a unified view of the state-of-the-art in terms of current initiatives.

The creation of a successful smart city strategy depends on existing data and correct benchmarking [11,12]. Since the increase in attention to the topic in 2010 [13], there has been an exponential growth of publications with a strong multidisciplinary nature in their

subjects, dominated mainly by China, Italy, USA, Spain, and England [14]. However, no attention has been given to smaller countries which tend to have lower bibliometric indicators, less publications and a lower number of citations in the literature [15]. Correia, Teixeira and Marques [16] reviewed the state-of-the-art of smart cities in Portugal through content analysis of a Portuguese smart cities magazine (the leading journalistic source dedicated to the topic, distributed to all Portuguese cities) and found that the literature had only a small subset of existing initiatives. The authors concluded that cities with an integrative strategy usually have national or European funds, which explains the fact that cities are very dependent on public calls to support smart city approaches. In addition, it also explains the existing heterogeneity between cities of the same country and of different countries. Furthermore, through this magazine, Portuguese policymakers had only information about few flagship cities and case studies, namely Amsterdam, Barcelona, Bristol, Budapest, Columbus, Copenhagen, Coruña, Curitiba, New Deli, Dublin, Hamburg, London, Madrid, Medellin, Moscow, New York, Ontario, Riyadh, San Francisco, Santander, California, and Songdo. Thus, even from non-scientific sources, the available information for decision makers is scarce.

In this line of thinking, Ruohomaa et al. [17] point out that research on smart cities usually focuses on the transformation of big cities, with the topic being widely neglected for medium and small cities. Several examples can be found in the literature. Ojo, Curry and Janowski [18] present the findings and lessons from a study of ten smart city programs (Amsterdam, Malmö, Malta, Masdar, PlanIT Valley, Singapore, Curitiba, Songdo, Tianjin, and Yokohama). Chang and Kuri [19] analyze four case studies (Barcelona, Curitiba, Singapore, Hammarby Sjöstad) to merge features that are commonly fragmented, and created a broader perspective for designing strategies for urban renovations and sustainable development in Latin American cities. Angelidou [20] identifies 10 distinctive characteristics of smart cities and analyzes their presence in the smart city plans of 15 cities based on studies published in the literature (Amsterdam, Barcelona, London, PlanIT Valley, Stockholm, Cyberjaya, Singapore, King Abdullah Economic City, Masdar, Skolkovo, Songdo, Chicago, New York, Rio de Janeiro, and Konza). Giest [21] studied five cities (Copenhagen, London, Malmö, Oxford, and Vienna) to conclude that the complexity of big data integration limits the capacity of local government to set up data management structures, which is why current solutions focus on local pilot sites and outsourcing data analytics to private companies. Based on evidence of European projects, Camboim et al. [22] identified the elements and features to develop a smart city strategy and stressed that the challenge lies in defining how to coordinate these driving elements in each dimension to develop the urban innovation ecosystem (Amsterdam, Barcelona, Vienna, and Lisbon). Noori, Hoppe and De Jong [23] classified the pathways for smart city development according to design, governance, and implementation (Amsterdam, Barcelona, Dubai, and Masdar). Csukás and Szabó [24] positioned nine cities into four clusters (Environmental Efficiency, Quality of Life Applications, Citizen Engagement and Social Inclusion) to ultimately allocate them to four different types of smart cities depending on their focus (Amsterdam, Barcelona, London, Helsinki, New York, Vienna, Berlin, Budapest, and Moscow).

Furthermore, the characterization of current initiatives would give policymakers and researchers the knowledge about existing case studies based on the area/category and location, which would enhance the sharing of best practices and benchmarking within the sector. Thus, the aim of this paper is to portray the state-of-the-art in the European Union by identifying existing smart city initiatives throughout its member countries in the scientific literature.

To answer the research question “What are the smart city initiatives in the European Union?” a review of the literature was performed with a search in Scopus about evidence of smart city implementations in each territory to reach conclusions about the concept development phase of each country and the typology of existing projects.

2. Theoretical Background

This section provides an overview about the evolution of smart city initiatives in Europe and reviews the research studies that aim to define smart city categories. This literature review supports the importance of the study and discussion of the paper because it gives readers an overview about the classification of smart city categories and their associated projects.

2.1. Smart City Initiatives

Until 2010, the number of smart city studies reported in the literature was low. Only after the emergence of the smart city projects supported by the European Commission was a proliferation of writings and academic publications on the topic noted [25]. Moreover, the European Commission has been supporting and investing in smart city initiatives since its early days. In 2016 there were 34 dedicated projects in the European Union (EU) [26].

One of the first smart city references was the city of Barcelona. In 2011, the city was focused on experimentation and technological transformation via the introduction of new, innovative technologies, with a view to improving the operation and management of the city in general, promoting economic growth and strengthening the well-being of citizens [27]. The top-down approach benefited technology solution providers [28]. Among the initiatives implemented, there were new models of service management and relationship with citizens inspired by e-government principles as well as sustainable growth projects in the categories of smart lighting, mobility and energy, the installation of the municipal Wi-Fi network, and the creation of a living lab district “22@” [27,29].

Furthermore, in 2012, Lee and Hancock [30] mentioned the existence of 143 ongoing smart city projects. Of these, 47 were located in Europe and 30 in the US [31].

In China, according to the Chinese Smart Cities Forum, six provinces and 51 cities have included smart cities in their government plans [32].

Many projects and applications can be found in the literature about flagship cities such as Santander, Manchester, and London [33,34]. The references are primarily to the applications of sensors and network infrastructure for different categories. Among them are parking solutions, waste management, traffic control, air quality monitoring and Wi-Fi or IoT networks.

The capital of Finland, Helsinki, has a smart city development area, Smart Kalasatama, facilitated by Forum Virium Helsinki (FVH), which allows the implementation of agile smart city pilots with multi-stakeholder collaboration. However, it does not have a specific smart city strategy [35].

Gohari et al. [36] literature review stresses that although the Norwegian region has come as far as its European counterparts in terms of smart city applications and projects, strategies remain in the planning stages and are still very fragmented.

These two examples of developed northern European countries raise the concern of whether cities are still committing the past errors of neglecting strategic and social aspects and focusing on technological applications.

Jonek-Kowalska and Wolniak [37] studied 287 Polish cities and concluded that the implementation of smart cities in most cities has not been possible due to the unsatisfactory level of prosperity of the residents, the difficult financial condition of cities, and unfavorable demographic trends. Therefore, the priority areas are social infrastructure and human capital [38]. It may also reveal the discrepancy and heterogeneity between those cities with financial support and those without, which in this case is directly associated with their size. Thus, specific city interventions are related to national and European funding opportunities, with a lack of strategic planning for becoming a smart city in the official city documents [39]. Cities have embedded various forms of smart city-related projects in their digital strategies; however, only partial implementation of relevant initiatives in their daily operations is noticed [40]. The associated projects are typically supported by municipalities, funded by subsidies, and implemented in partnerships which fade out after the pilot stage. Thus, scaling is widely perceived as a major concern [41].

Smékalová and Kučera [42] studied the implementation of the smart city concept in the Czech Republic and concluded that the larger the city, the more intensive investment activity, confirming the relationship between the size and absorption capacity of European funds. Thus, cities have been focused on specific applications and themes to leverage their smart city approaches, rather than promoting holistic strategies. Examples can be found in Finland [43], Romania [44], Slovakia [45,46], Poland and Ukraine [47]. In the broader picture, municipalities have been prioritizing actions, mainly regarding the development of ICT infrastructures and e-government [48]. In addition, there are countries such as Hungary where the topic has still not brought meaningful change nor impacted urban policy practices [49]. A contrast between the national and the local levels is also noted, even for Sweden, which chose to invest in a national digitization council to decide whether local experimentations can move forward [50].

2.2. Smart City Categories

The smart city categories have expanded over the years in terms of scope and number. Several authors have reflected on and identified the main dimensions of smart cities in the literature [51].

Mahizhnan [52] defined four dimensions: IT education, IT infrastructure, IT economy and quality of life. Giffinger [53,54] considered six dimensions: smart economy, smart people, smart governance, smart mobility, smart environment and smart living. Albino, Berardi and Dangelico [55] considered the same dimensions and linked them with aspects of urban context such as industry, education, e-democracy, logistics and infrastructures, efficiency and sustainability, security, and quality. Eger [56] referred to technology, economic development, job growth, increased quality of life. Thuzar [57] considered the quality of life, sustainable economic development, management of natural resources through participatory policies, and the convergence of economic, social, and environmental goals. Nam and Pardo [58] mentioned economic, sociopolitical issues of the city, economic-technical-social issues of the environment, interconnection, instrumentation, integration, applications and innovations. Other studies have proposed: smart health, smart security systems, smart building, smart government, smart tourism, smart grid, smart transportation, smart environment, smart home and smart lifestyle [59–61]. Barrionuevo et al. [62] considered economic (GDP, sector strength, international transactions, foreign investment), human (talent, innovation, creativity, education), social (traditions, habits, religions, families), environmental (energy policies, waste and water management, landscape), and institutional aspects (civic engagement, administrative authority, elections). Kourtit and Nijkamp [63] stated 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). Chourabi et al. [64] considered management and organizations, technology, governance, policy context, people and communities, economy, built infrastructure, and natural environment. Neirotti et al. [65] presented twelve domains for urban development. Mohanty, Choppali and Kougianos [66] categorized smart cities into ten components: smart infrastructure, smart building, smart transportation, smart energy, smart healthcare, smart technology, smart governance, smart education, and smart citizens. Ahvenniemi et al. [67] considered ten sector categories: natural environment; built environment; water and waste management; transport; energy; economy; education, culture, science and innovation; well-being, health and safety; governance and citizen engagement; and ICT. Wolf et al. [68] suggested a unified framework combining some of the previous approaches, which include six different dimensions, structured on two levels (macro and micro). Level one: living (quality of life), economy (competitiveness) and environment (natural resources); and level two: institutions (governance/participation), digital systems (transport and ICT) and people (social and human capital).

After a systematic literature review, Camboim, Zawislak and Pufal [22] identified the most frequent words and categorized the main dimensions associated with the smart city concept. However, they organize this taxonomy into high-level dimensions (environ-urban,

techno-economic and social-institutional) and do not match the elements with existing project categories. Furthermore, it remains unclear what the existing categories and projects by country are.

3. Materials and Methods

As stated before, this study focused on the analysis of the current state of the European Union. For each of the 27 countries of the European Union, evidence was sought that could portrait the scope of the existing smart city initiatives. The methodology used for the analysis of the literature is demonstrated in Figure 1. Moreover, quantitative, and qualitative analyses were performed in order to find the smart city categories and existing country clusters.

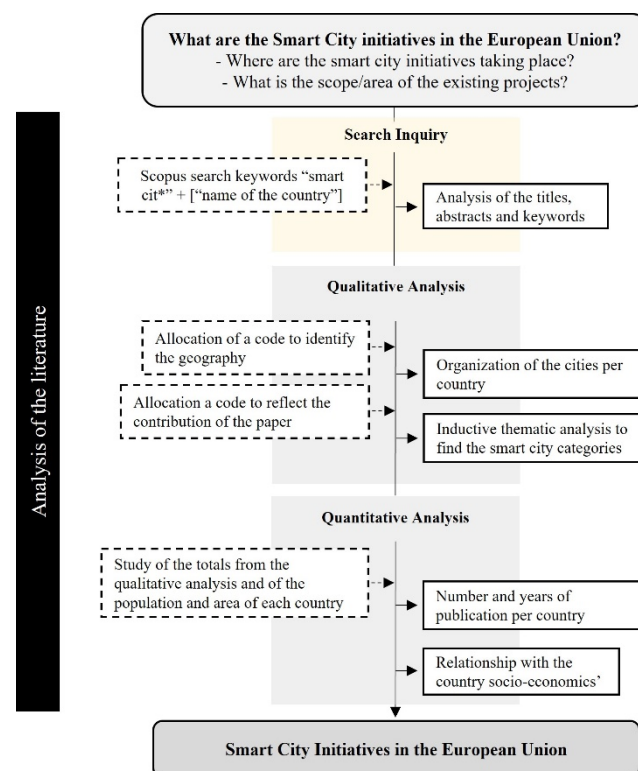


Figure 1. Methodological approach to analyze smart city initiatives in the EU.

Furthermore, a search on Scopus using the search keywords “Smart Cit*” + [“Name of the Country”]. In total, 27 queries were performed (one for each European Union member country). From the obtained results, the titles, abstracts and keywords were analyzed to allocate a first code connected to the identification of the city, and a second code concerning the contribution of the paper. This information was updated in a dedicated database (built in a spreadsheet) where the fields “City Location” and “Category Keywords” were filled, respectively. Furthermore, in terms of eligibility (inclusion and exclusion criteria) two exclusion filters were applied.

First, repeated and non-relatable papers (that do not fit the purpose of this research) were excluded from the sample, as were non-English manuscripts. Furthermore, only journal and conference papers were considered.

The second filter aimed to remove the articles that did not mention any specific city or case study. Furthermore, if there was no location in the title, abstract and keywords, the paper’s contribution was considered as being on the country, since the aim of this paper was to study the current situation of the country by the existing specific projects in the cities. The same happened if it was a generic study of numerous cities in the country. Nevertheless, these results were excluded from the final detailed analysis. Furthermore, if

the abstract mentioned a neighborhood or an urban district of the city, the initiative was given to that city. Double counting was only allowed when the paper referred to specific case studies in different cities, regardless of the country. In addition, each paper was only allocated to a single category.

The number of search results is illustrated in Figure 2. From an initial sample of 1665 papers, 945 results were considered in the present study (56.76%).

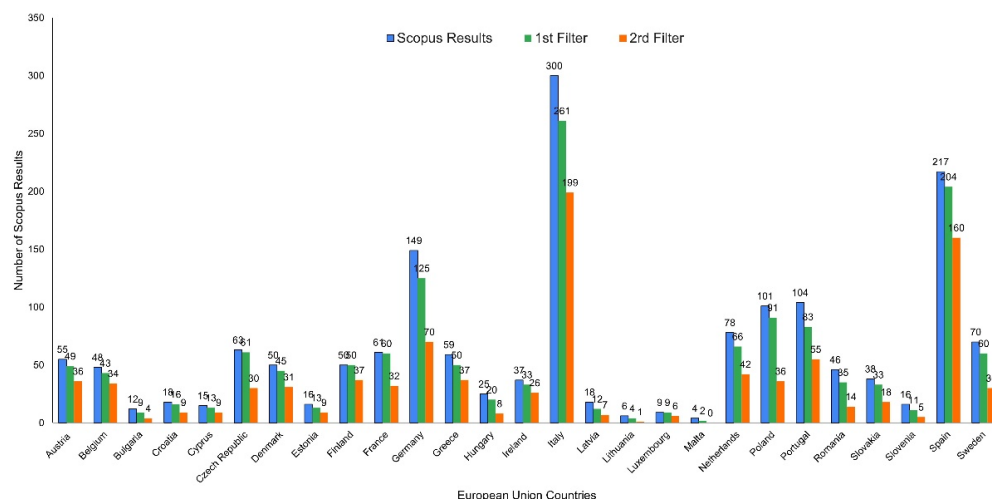


Figure 2. Number of Scopus results per European Union country after applying exclusion criteria.

Of these results, on the one hand, Italy, Spain and Germany were the countries with the most results. On the other hand, countries such as Malta, Lithuania, Luxembourg, Bulgaria, Cyprus, Slovenia and Croatia showed that this subject is still in its early days.

After that, the cities were organized according to their origin countries, and an inductive thematic analysis was performed to find the smart city categories of the initiatives. Finally, quantitative analysis was performed to reflect the number of results per country and the years of publication on the one hand, and on the other hand a hierarchical cluster analysis based on Ward's method was performed to find country clusters to study their relationship between the categories of the initiatives (from the qualitative analysis) and socio-economic characteristics (e.g., population and area of the territory). Figure 3 summarizes both directions of the methodology.

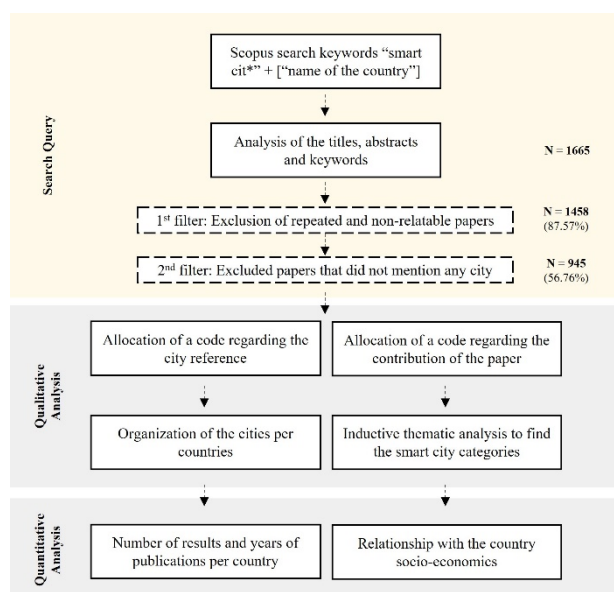


Figure 3. Detailed methodological approach to analyzing the literature.

4. Results

This section presents the results of the literature analysis. Thus, it mirrors the countries' representation according to the number of smart city initiatives. Several country clusters emerged by looking at the existing relationships between their associated results. Furthermore, the clusters were obtained by aggregating them according to (1) the number of literature results, and (2) the category groups (from factorial analysis) of the projects involved. Ultimately these results are compared with the socio-economic aspect and discussed according to the existing literature.

4.1. Countries' Representation According to the Number of Smart City Initiatives

4.1.1. Emergence of the Smart City Initiatives by EU Country

Figure 4 shows this is a recent topic. As stated in the literature, until 2010, the number of smart city studies was low. Only after the emergence of the smart city projects supported by the European Commission was a proliferation of writings and academic publications on the topic noted (Jucevičius, Patašienė, & Patašius, 2014). Furthermore, the first countries to have initiatives under this theme were Germany (2010), the Netherlands (2011), France (2011) and Spain (2011). Nevertheless, every member of the European Union is represented. The last countries to present results were Bulgaria (2017), Luxembourg (2017), Slovakia (2016), Latvia (2016), Hungary (2016), Cyprus (2016), and Croatia (2016).

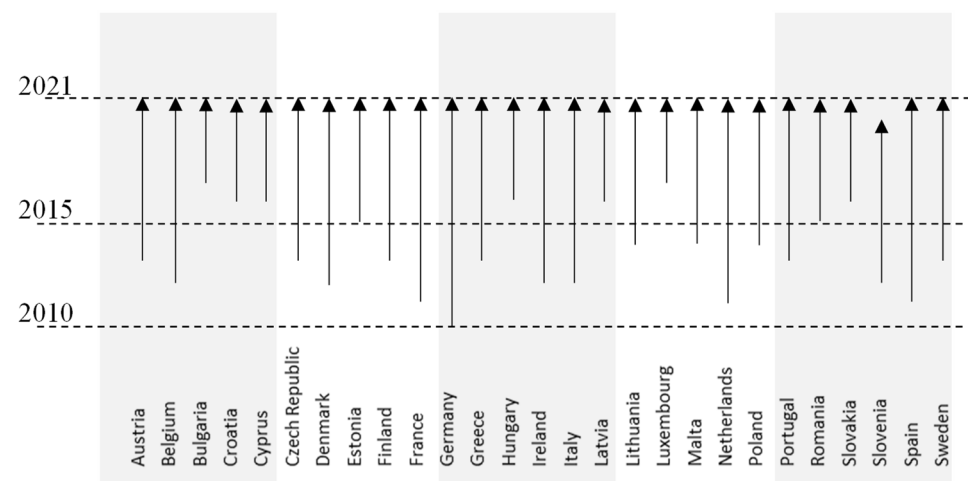


Figure 4. Year of existing studies in the literature by country.

4.1.2. Country Clusters by the Number of Smart City Initiatives

In the analysis of the relationships between countries in terms of the literature results, four different clusters emerged. The first cluster comprises the countries that have less than 25 results and is composed of Lithuania, Malta, Croatia, Hungary, Bulgaria, Luxembourg, Cyprus, Estonia, Latvia, and Slovenia. The second cluster aggregates the countries that have up to 55 results, namely Ireland, Slovakia, Romania, Finland, Greece, Austria, Belgium and Denmark. The third and fourth clusters join the countries with the highest number of results. Moreover, the third cluster is composed by the countries that have up to 130 results, namely Czech Republic, France, Sweden, the Netherlands, Poland, Portugal and Germany. The fourth and last cluster comprises Spain and Italy with more than 130 results. Furthermore, Figure 5 details the cluster analysis and its representation in the map with different colors.

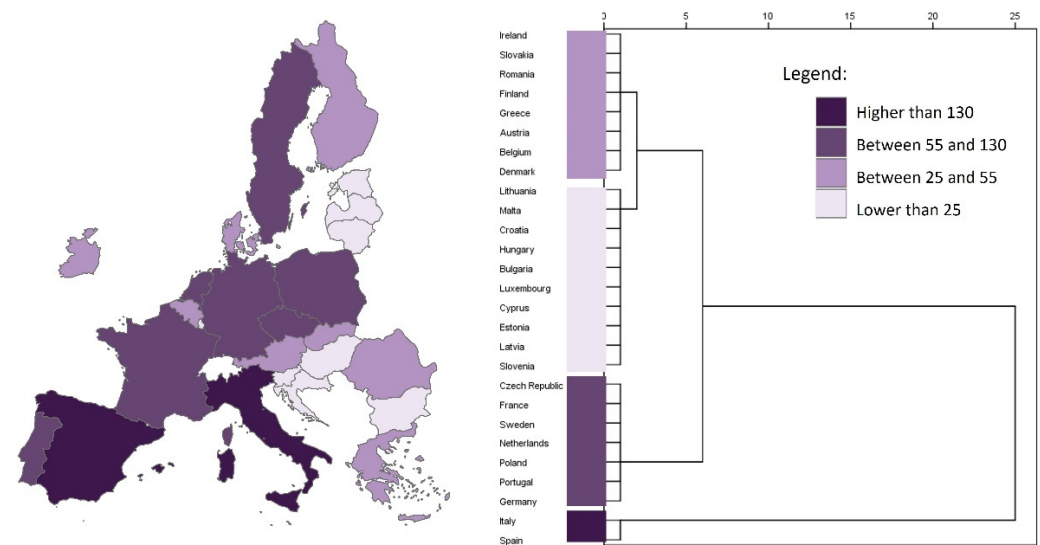


Figure 5. Clusters of the countries by their number of literature results.

4.2. Countries' Representation According to the Smart City Categories

4.2.1. Smart City Categories

From the content analysis of the codes related to each paper's contribution (allocated in the first step), 22 smart city categories can be organized: water and irrigation; environment and air quality; waste; energy and lighting; strategy and governance; urban planning; culture, tourism and heritage; rural and agriculture; sport; smart city foundations; digitization and interoperability; privacy, security and safety; health and well-being; infrastructure and communication networks; buildings and housing; traffic; parking; mobility and transportation; logistics; community, participation and inclusion; education; and economy and industry. Table 1 summarizes a multiple step inductive thematic analysis that produced the smart city categories (Appendix A mirrors the step before).

Table 1. Inductive analysis and originating keywords of smart city categories.

Keywords	Category
Leaks, floods, anomaly detection, infrastructure, wastewater, water quality, irrigation, smart meters, residential consumption	Water and irrigation
Air quality, sound and geo-sensing, green roofs, noise, climate change, green spaces, indoor and outdoor monitoring, crowdsourcing monitoring	Environment and air quality
Circular economy, waste management, fill-level sensing, route optimization, selective waste collection, organic waste	Waste
Smart districts, energy systems, renewable energy, green solar cities, intelligent streetlight management, electric car, smart grid, residential microgrid, geothermal, wind power plants, green energy, biomass, biogas, fast charging	Energy and lighting
Governance framework, development strategy, smart municipality, crisis management systems, public procurement, open strategy, smart city control rooms, policy process standardization, city marketing, smart regions, advanced e-government	Strategy and governance
3D city model, spatial data population distribution, land use, sustainable urban planning, spatial planning, modelling tool, urban computing, virtual reality, geology, urban accessibility	Urban planning
Smart tourism destination, tourism and hospitality, travel behavior, heritage, preservation, sustainable tourism, smart museum, augmented reality, rural tourism	Culture, tourism and heritage

Table 1. *Cont.*

Keywords	Category
Rural areas, rural contexts, small cities, cow sharing, smart town, urban-rural relationships, smart village	Rural and agriculture
Smart stadium, sport and smart communities, sport activity	Sport
Driving elements, challenges, priorities, barriers, benefits, value proposition, ideology, myths and utopias, evaluation system and model, national scale, practices, case studies, characteristics, understandings, findings and lessons, KPIs and index, rankings, trends and opportunities	Smart city foundations
Standards, data interoperability, open data policy, urbanAPI, information modeling, big data analytics, mobile sensor, crowdsensing and crowdsourcing, living labs, integrated dashboard	Digitization and interoperability
Digital rights, surveillance, cybersecurity education management, general data protection regulation, blockchain, risk management, crime prevention, emergency response, cameras and LiDAR sensors, digital rights, urban safety, smart security	Privacy, security and safety
Senior care system, urban health, wellbeing, disease control, hospital information systems (his), e-health, e-prescription system, quality of life, emotion, stress mapping, Covid-19, predicting patients' urgency demand, active mobile phone intervention, health monitoring system	Health and well-being
Wireless sensors, mobile sensors, LoRaWAN, internet of things, 5G networks, communication technologies, LoRa network, Wi-Fi and interactive displays, cyber physical systems, Zigbee wireless communication, narrowband IoT (NB-IoT)	Infrastructure and communication networks
Sustainable urban regeneration, utilities, smart building, buildings renovation, green building, thermal modelling, smart home, municipal building regulation, building information modelling	Buildings and housing
Traffic forecasting and route guidance, traffic management system, road marking, road damage detection, road safety, crowdsensing urban transit, dynamic obstacle detecting, intelligent traffic light, automatic road sign inventory, road safety, intelligent crosswalks	Traffic
Smart parking, off-street parking, parking management, pay-as-you-go, controlling system, applications, mobile payment, social parking, real-time parking prediction system	Parking
Intelligent transportation system, electric bike sharing, carpooling and electro-mobility, smart mobility, light rail, public transport demand, pedestrian movement, green transportation, electric carsharing, multimodal sustainable mobility, shared micromobility, inclusive mobility, soft mobility, autonomous vehicles, mobility-as-a-service (MaaS), crowd mobility, connected cars	Mobility and transportation
Sustainable urban freight transport, logistics, last-mile, intelligent offloading distribution, logistics freight traffic, short-distance freight, autonomous vehicle fleet, city logistics, grocery distribution	Logistics
Participatory governance, collaborative data platforms, citizen participation, human-centric approach, co-creation, smart community, e-governance, democratization, urban experimentation, social policy, inclusion, collaborative decision-making processes, stakeholder involvement	Community, participation and inclusion
Smart campus, hybrid learning, mobile education, public libraries, school as a service, human capital, knowledge and intellectual capital, role of universities, gamification educational strategy, training, employment future skills	Education
Public private partnerships, Industry 4.0, remote working, sharing economy, smart industry, green economy, local entrepreneurs, startups, accelerators, digital nomads, intelligent manufacturing system, ethics, sustainable production, inclusive 3D printing, corporate social responsibility	Economy and industry

4.2.2. Smart City Initiatives by Category

The total of smart city initiatives by category is represented in Figure 6. Thus, energy and lighting; community, participation, and inclusion; and mobility and transportation are the categories with the greatest number of results. On the opposite side, the categories that have less than 20 results are education; health and well-being; waste; logistics; rural and agriculture; parking; and sport.

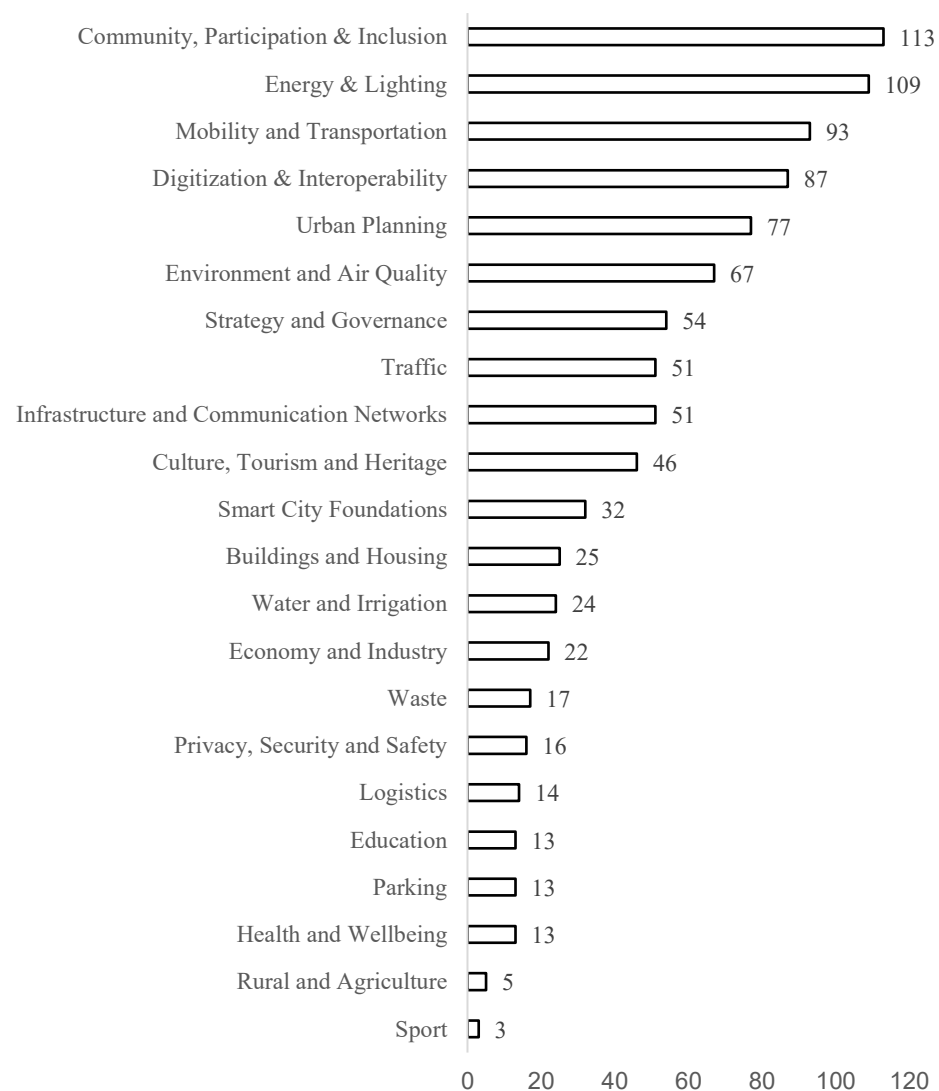


Figure 6. Distribution of the smart city initiative results by category.

4.2.3. Representation of the Smart City Categories by Country

The initiatives sorted by category are detailed in Appendix B. Furthermore, analysis of Appendix B provides information about the cities and countries that have or had projects within each category. This provides useful information for a greater understanding of current initiatives, allowing better organization for researchers and decision makers to know the geographies where a specific problem is being addressed. Thus, the categories that are present in a higher number of countries are mobility and transportation (22 out of 27), environment and air quality (21 out of 27), and community, participation and inclusion (21 out of 27). On the other hand, the cities that have a higher representation of categories are Italy (21 out of 22) and Spain (21 out of 22), which only have no project in the category of sport, followed by Germany (20 out of 22). Furthermore, the information about the smart city categories by country is detailed below in Figure 7. This graphical representation summarizes the information of Appendix C.

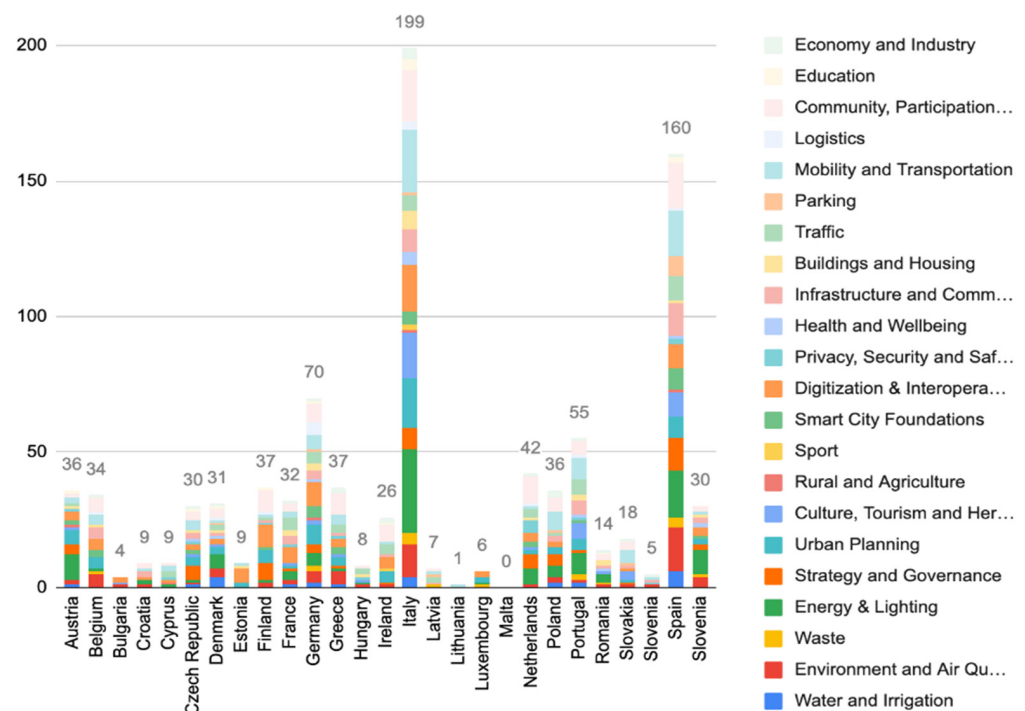


Figure 7. Countries' Smart City initiatives divided by category.

Appendix C and Figure 7 enable the connection of the main initiatives to each of the countries to be identified. It is evident that the categories “energy and lighting” and “community, participation and inclusion” are those with the greatest preponderance of all the initiatives developed; in the first, only three (out of 27) countries have no initiative in this area/category (Ireland, Malta and Lithuania), while in the case of the second there are four countries (Bulgaria, Lithuania, Malta and Luxembourg). Moreover, these are the five countries with the fewest initiatives in the various categories analyzed (with the exception of Ireland, all with less than five connections).

Figure 8 uses Social Network Visualizer (<https://socnetv.org/>, accessed on 14 June 2022) to demonstrate the relationships between the categories and countries, highlighting those that have a greater number of initiatives among the countries. Moreover, the categories with greater representation among the countries are energy and lighting, community, participation and inclusion, and digitization and interoperability. This information can also be consulted in Appendix C.

4.2.4. Country Cluster Analysis (Dimensionality Reduction)

This section presents a cluster analysis that aggregates countries according to the typology of initiatives.

Two distinct approaches were undertaken, one assuming the percentage of projects that each country carried out in each category; and the other, (ii) considering the total number of initiatives, in absolute value, in each category. However, the results of the latter approach are presented and explored in more detail since the territorial patterns are not so clear and evident when considering the relative weight of the initiatives (see the results in Appendix D). Since there is a great variety of initiatives, the importance that each type of initiative assumes in each country also varies greatly.

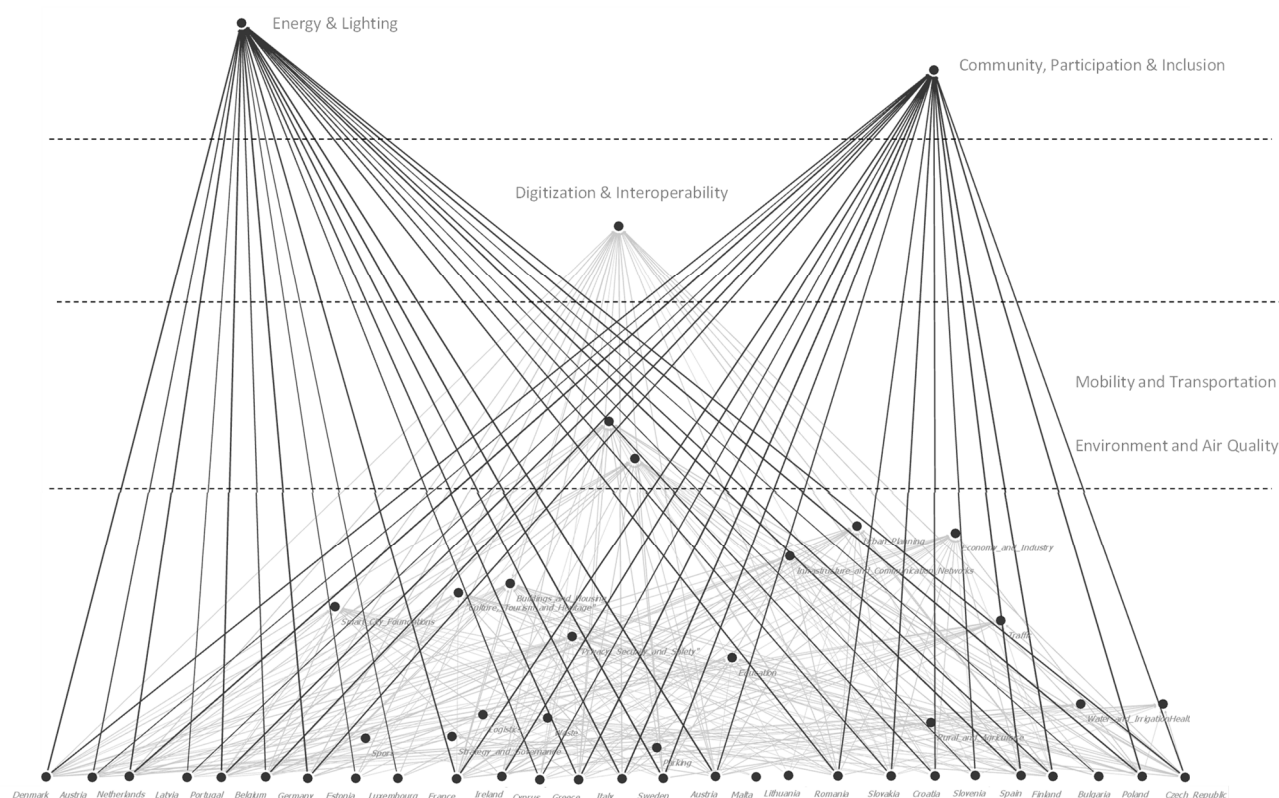


Figure 8. Categories with the widest presence among countries.

Thus, in order to group the categories in large dimensions, a principal component analysis (PCA) was previously carried out. PCA is an unsupervised learning method that transforms the main features of a large set of variables (based on their similarities or correlation) into a smaller set of latent variables (see for more details) [69]. Table 2 represents the loadings (correlation of the initial variables with the new variables) that resulted from the application of the PCA analysis and shows that the twenty-two (22) categories were grouped into four (4) large areas, with a loss of only approximately 15% of the initial information.

Table 2. Loadings of the principal component analysis.

	Component			
	1	2	3	4
Parking	0.892			
Infrastructure and Communication Networks	0.869			
Smart City Foundations	0.778			
Environment and Air Quality	0.757			
Waste	0.669			
Traffic	0.654			
Water and Irrigation	0.651			
Mobility and Transportation	0.626			
Strategy and Governance	0.592			
Sport		0.899		
Health and Wellbeing		0.738		
Education		0.737		
Culture, Tourism and Heritage		0.670		

Table 2. Cont.

	Component			
	1	2	3	4
Urban Planning		0.632		
Energy and Lighting		0.557		
Rural and Agriculture			0.837	
Logistics			0.732	
Buildings and Housing			0.708	
Digitization and Interoperability			0.614	
Economy and Industry			0.541	
Privacy, Security and Safety				0.901
Community, Participation and Inclusion				0.565
Total Variance Explained	64.970	9.633	5.316	4.303

By analyzing the high values of the loadings in Table 2, each of the factors can be characterized as follows:

- The first factor joins initiatives related to the more tangible and material issues of the smart city, such as basic infrastructures (waste, water and air) and transport (parking, communication networks, traffic and mobility). Spain is clearly the leading country in this type of project, followed by Poland, Portugal and Italy (see Figure 9—factor 1);
- Factor 2 involves sectoral initiatives linked to sport, health, education and culture; Italy stands out as the country that invests most in this type of initiative, followed by Ireland and Romania (see Figure 9—factor 2);
- As for the third factor, a concern with the competitiveness of the entire territory is highlighted. Thus, it is possible on the one hand to identify projects related to rural and agriculture, and on the other initiatives in the category of logistics, digitalization, economy and industry. In these categories, four countries can be highlighted, firstly Germany, prominently, and then France, Italy and Poland (see Figure 9—factor 3);
- Finally, and contrary to factor 1, in this factor we have four initiatives of a more intangible nature linked to community participation and issues of security and privacy, in which the Netherlands appears in a leading position, followed by Ireland and Spain (see Figure 9—factor 4).

Using the scores of the four new factors as inputs, a hierarchical cluster analysis (Ward method for aggregation criteria) was applied, allowing the construction of seven different groups of countries, as shown in Figure 10. The significance levels were calculated from the application of the non-parametric Kruskal–Wallis test.

Each cluster emerged by looking at the number of projects involved in the four major categories (factor 1, 2, 3, and 4). Furthermore, by looking at Figure 10, on the left, red and green arrows can be seen that mirror the behavior of that factor for a particular cluster. In addition, on the right there is the color-coded geographic location of each country-cluster.

- Cluster 1 includes four countries (Hungary, France, Austria, and Poland), which are countries that have many initiatives related to agriculture, logistic, housing, digitalization (factor 3) and a few in factor 2; that is, those associated with sports, health, education and culture.
- The eight countries (Ireland, Greece, Finland, Belgium, Bulgaria, Latvia, Cyprus, and Croatia) included in cluster 2 have tended to invest little in factors 1 and 3 (basic infrastructures, transports, logistics, digitalization, economy) when compared with infrastructure-related initiatives that have greater importance.
- Cluster 3 (Estonia, Lithuania, Slovenia, Luxembourg, Malta, Slovakia, Sweden, Denmark, Romania, Czech Republic, and Portugal) is distinguished by low investment in projects related to community participation (factor 4) and rural and agriculture activities (factor 3).

- Clusters 4, 5, 6 and 7 are singular clusters, i.e., formed by a single member state because the values are so distinct that they appear as outliers and thus form a single cluster. In this case, the single-country clusters are Germany, the Netherlands, Spain and Italy. Those are the countries with the greatest number of initiatives in each of the major categories (factor 3, factor 2, factor 4 and factor 1, correspondingly).

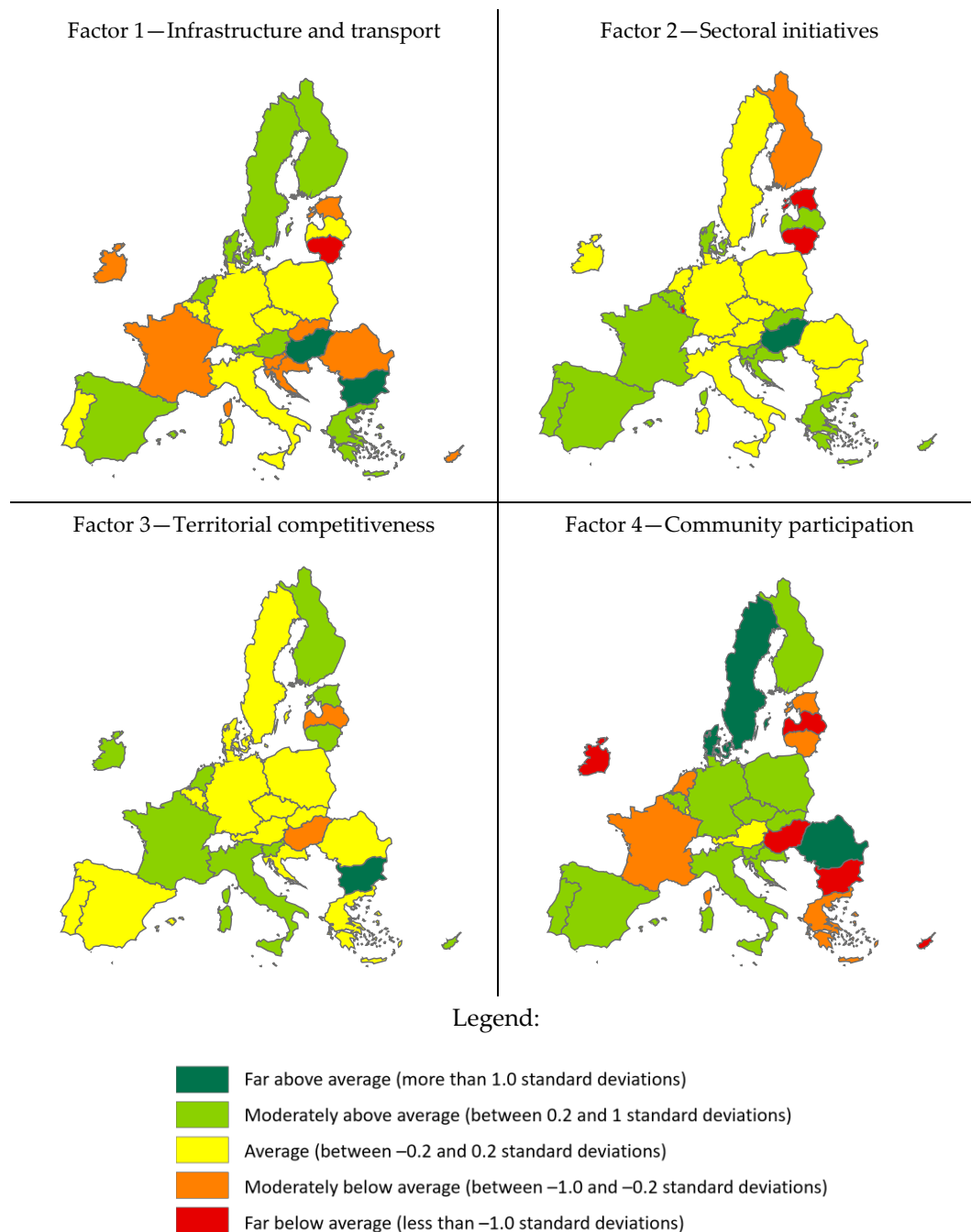


Figure 9. Geographic representation of the scores of the factors.

Additionally, as stated before, instead of the typology of the initiatives, a cluster analysis was also performed considering the relative percentage of the categories in each country, represented in Appendix D (spatial patterns according to the percentage of the initiatives—dimensionality reduction and cluster analysis). However, as demonstrated in Figure A1, the results are homogeneous for a vast majority of the territory, which may not add meaningful insights to this research. The particularity of these results is that they justify

the argument that there is no clear pattern of typology of initiatives when the analysis is purged of the fact of the size of the country. Even so, there is the possibility of identifying which latent dimensions underlie each of the categories. Nevertheless, they deserve a mention since they justified the decision to move forward on the analysis using the clusters by the type of initiatives, hence the option of placing these results in the appendix.

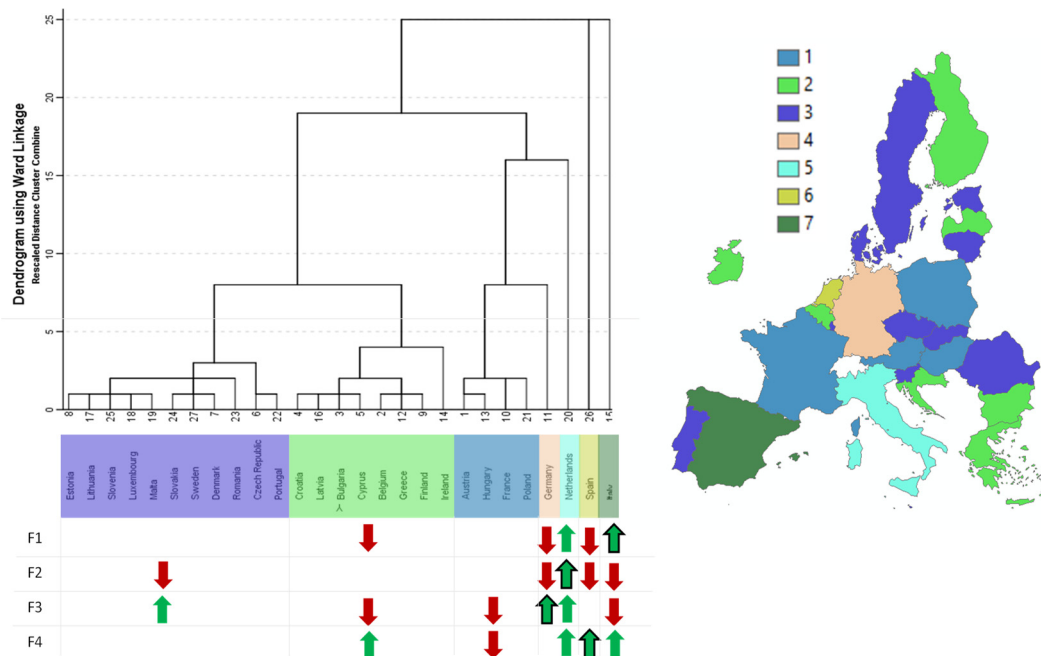


Figure 10. Loadings of the principal component analysis.

4.3. Socio-Economic Relationship

From a Eurostat list of 27 indicators [70] in Appendix E, this section seeks to analyze each of the cluster typologies obtained in the previous section with some socio-economic characteristics. Thus, after applying a principal component analysis, the most relevant variables (with the highest loading value) can be selected in each component. Furthermore, they are organized according to nine carefully selected, independent indicators (see Figure 11).

These independent dimensions are organized into four major categories: (i) the first, structural revenues (A, B and C), represents the economic context of each country, evaluated by the wealth produced (total and per capita) and the public revenues generated as a percentage of the GDP; (ii) the second, conjunctural revenues (D), is reflected by the “European structural and investments funds, in this case between 2014 and 2020”; (iii) the third dimension refers to public investment in general as a percentage of the GDP (F); and finally, (iv) the fourth category corresponds to expenditure at the sectorial level, according to three levels (G: general services, H: social protection and I: education). It can be said that dimensions A, B, C and D are, to some extent, the income generated by the production of the whole country’s economy and external structural supports (inputs); while dimensions F, G, H and I are each member state’s expenditures or investments (outputs). In a balance between the inputs and outputs, an additional dimension is presented that reflects the public budget balance measured in billions of euros (E).

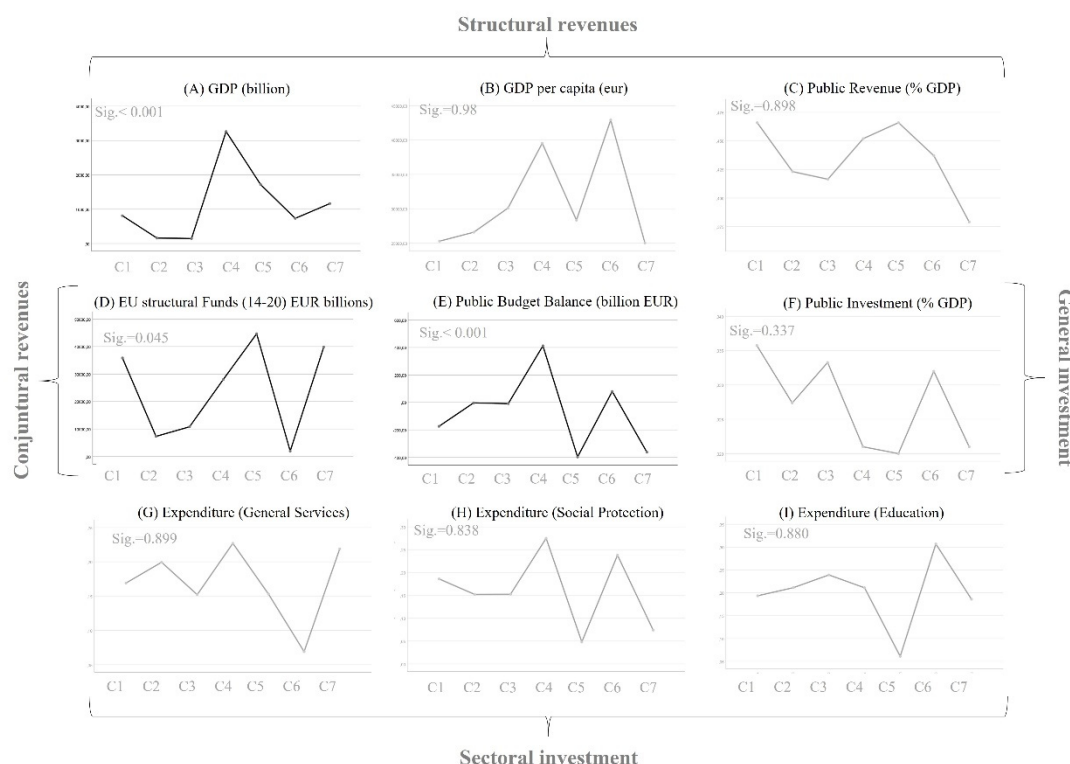


Figure 11. Socio-economic profile of territorial clusters of categories typologies (initiatives).

Each of the graphs in Figure 11 describe the performance of the group of countries belonging to each cluster in the nine dimensions described, and it can also be identified which ones have significant differences, in this case dimensions A, D and E (the line of the graph of these dimensions has a greater color intensity).

Previously, each of the seven clusters shown in Figure 10 aggregates countries that have the same profile of project typologies: cluster 1—Hungary, France, Austria, and Poland; cluster 2—Ireland, Greece, Finland, Belgium, Bulgaria, Latvia, Cyprus, and Croatia; cluster 3—Estonia, Lithuania, Slovenia, Luxembourg, Malta, Slovakia, Sweden, Denmark, Romania, Czech Republic, and Portugal; cluster 4; Germany; cluster 5—the Netherlands; cluster 6—Spain; cluster 7—Italy.

Therefore, as an example of interpretation of Figure 11, in terms of structural revenue, Germany (cluster 4) has a high GDP, high GDP per capita and public revenue; regarding the conjunctural scope, it has a significant contribution of EU structural funds and a low public investment when compared to the percentage of GDP; related to sectoral investments, it has a high value in general services and social protection, and medium in education. Detailed results of the socio-economic characteristics in each of the seven clusters are presented in Appendix E.

5. Discussion

The results show different levels of smart city development between European countries. This corroborates the Portuguese internal context analyzed by Correia, Teixeira and Marques [16]. Moreover, there is a gap not just between cities and regions of the same country, but also from different countries, even if they are under the umbrella of the European Union. Although every European Union member had literature results and is therefore represented in this study, there is a significant difference between the member states. Although this discrepancy can be partially connected with the starting year of the literature results, it does not explain everything. For example, Czech Republic, Italy, Ireland, and Slovenia had their first literature result in 2013 and the total results are very different between them. Furthermore, it can be associated with the fact that there are different

levels of local government engagement and prioritization of investment. Moreover, this demonstrates that although the European Union has been making efforts to develop this topic, it lacks standardization and enforcement in its approach.

Several authors had previously studied the smart city areas/categories [22,51–58,62–68]. However, they failed to obtain a common standard understanding because of their methodological approach. After several years of existence and evolution of the topic, the smart city categories should be defined based on an inductive thematic analysis of the initiatives present in the literature. This way it can be ensured that every category is represented. The tendency is for more categories to emerge in the future. As stated in the literature review section, the scope of smart city categories has been evolving and widening to enable a more detailed understanding. Furthermore, that can also be noted in the results obtained in the cluster analysis. In line with Giffinger [53], who considered six dimensions (smart economy, smart people, smart governance, smart mobility, smart environment, and smart living), the first component that combines parking, infrastructure and communication networks, smart city foundations, environment and air quality, waste, traffic, water and irrigation, mobility and transportation, and strategy and governance covers the fundamental and initial areas of smart cities.

In the second component can be found the categories of sport, health and well-being, education, culture, tourism and heritage, and energy and lighting, which can be seen as an extended vision of component 1. Thus, most of these categories were also named by other studies [59–61], in which smart health, smart security systems, smart building, smart government, smart tourism, smart grid, smart transportation, smart environment, smart home and smart lifestyle were proposed.

The categories represented in the third component (logistics, buildings and housing, digitization and interoperability, and economy and industry) are in line with the dissemination and relationship with Industry 4.0 [71,72]. Furthermore, the same categories were found by Albino, Berardi and Dangelico [55] when linking the former with urban living aspects.

The fourth component (categories of privacy, security and safety, and community, participation, and inclusion) is ultimately connected with Smart City 3.0, the most recent phase of the smart city concept. Here, most of the clusters, meaning all countries, have been making efforts and creating projects under this scope. Smaller countries or those that started later have already focused on citizen engagement (skipping the first stages of the concept).

Although the results at first sight suggested that energy and lighting was the category with the most results, when looking at the number of countries per category it showed that the most representative categories were mobility and transportation (22 out of 27), environment and air quality (21 out of 27), and community, participation and inclusion (21 out of 27). This may be a good sign that countries are following the development of the concept by evolving citizens in early stages of urban planning and are aware of present-day challenges regarding mobility and climate change. Furthermore, this can be found when comparing the factors to countries' socio-economics, as in the examples of Ireland, Greece, Finland, Belgium, Bulgaria, Latvia, Cyprus, and Croatia. Nevertheless, there are countries with similar characteristics, with low GDP and a small contribution of EU structural funds such as Estonia, Lithuania, Slovenia, Luxembourg, Malta, Slovakia, Sweden, Denmark, Romania, Czech Republic, and Portugal; although they have a neutral public budget balance and high public investment, they struggle to move to later stages of the smart city concept and are focused on their infrastructure. However, countries such as Austria and Poland that also present low GDP but have a high contribution of EU structural funds and public investment are already focused on later stages of the concept. Thus, although smart city development is often associated with greater urban centers and countries with higher GDP, there are other significant factors that are crucial to cities' success.

Furthermore, Germany and the Netherlands are the only ones with a positive public budget balance (revenues higher than spendings) and a high GDP per capita, which enables

them to be focused on the competitiveness of the entire territory or pass through the various stages of the concept (with significant projects in every factor).

6. Conclusions

This study leads to the conclusion that a positive public budget balance allows countries to focus on the entire territory. On top of this, countries with significant GDP and EU structural fund contributions were able to evolve at the pace of the smart city concept, with projects in the greatest number of categories. Conversely, countries with low GDP, small contribution from EU structural funds, a neutral public budget balance and high public investment have two different approaches. Some try to close the existing gap and move their efforts to focus on community participation, and others are still investing in infrastructure (the first phase of the concept), which may mean that the existing differences through the member countries of the European Union will continue to exist.

Furthermore, this study demonstrated the heterogeneity of smart city development among European Union member states and the lack of standardized approaches. A strategic direction is needed by the regulator to allow the definition of specific guidelines upon which countries and municipalities should base their action. This strategy should also qualify, organize, and promote the relationship between companies, academia, knowledge centers and municipalities to ensure greater adequacy and sustainability of the projects and associated research. Thus, the discrepancy between territories should be combated with specific policies promoted by the European Commission to guarantee homogeneity between countries and their cities.

This research sets the beginning of a collaborative approach towards countries' involvement in finding synergies while promoting their financial sustainability by allowing others to learn from previous mistakes. Thus, this study should be used by decision makers as reference material to benchmark existing case studies and make contact with other policymakers to exchange knowledge and best practices (considering the type and location of the initiatives). Furthermore, an open dashboard can be created to uniformize each project where relevant characteristics (e.g., problem, solution, level of investment, methodology and people involved) can be associated. In future studies, the same methodological approach can be applied to other regions and continents to study the world state-of-the-art on the topic. Countries' level of investment in innovation, the budget for each of the categories and whether there is a political background relationship with the dispersion of the number of initiatives can also be studied.

Some limitations can also be pointed out in the study. First, the keywords defined for each paper in the qualitative analysis may not exactly reflect the contribution of the paper, since the texts were not read in full. Nevertheless, the authors know that the title and abstract of a paper should state clearly the research contribution. Second, the results obtained may not perfectly portray the reality of the country, since the geography of the initiative could not be found in the abstract. Additionally, others may have not been included. However, this limitation will only serve as proof that there is a lack of documentation of case studies and practical implementations in the literature that can serve as a study of good practices. Third, the assessment of the level of smart city development in a specific country based on the number of Scopus-indexed articles may be disputable. However, since smart cities are an innovation-related hot topic, their case studies are usually found in the literature. If not, the reasons may be the lack of results and conclusion of the project and not the lack of innovative material to be published. Furthermore, research centers and universities are usually connected to these projects.

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Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. Smart City categories and corresponding keywords.

Keywords	Category
Leaks, Floods, Anomaly Detection, Infrastructure, Stormwater, Rain and Melted Water, Wastewater, Water Quality, Irrigation, Smart Meters, Household Metering, Residential Consumption, Geothermal, Supply, Distribution, Pollution	Water And Irrigation
Emissions, Temperature, Air Quality, Sound and Geo-sensing, Green Roofs, Noise, Climate Change, Green Spaces, Indoor and Outdoor monitoring, Ozone, Urban Parks, Crowdsourcing Monitoring, Low Carbon, Remote Sensing, Gardening, Smoke/fire Sensing, Road Transport, Bicycle Monitoring	Environment and Air Quality
Circular Economy, Waste Management, Fill-level Sensing, Route Optimization, Illegal Dumping Recognition System, Waste Sorting, Waste Collection, Selective Waste Collection, Organic Waste	Waste
Smart Districts, Energy Systems, Urban Infrastructure, Renewable Energy, Green Solar Cities, Sustainable Energy, Intelligent Streetlight Management, Thermal Storage Systems, Efficiency, Photovoltaic, Roofs' Solar Potential, Smart Energy, Buildings Performance, Sufficiency, System Optimization, Renewable Heating and Cooling, Electric Car, Smart Grid, Residential Microgrid, Waste Energy Recovery, Heat Storage, Geothermal, Wind Power Plants, Charging Stations, Distribution Network, Smart Lighting, Green Energy, Biomass, Climate Policy, Biogas, Fast Charging Infrastructure, Luminaires LED, Energy Storage, Self-sufficient	Energy & Lighting
Governance Framework, Development Strategy, Smart Municipality, Crisis Management Systems, Cross-Border, Virtual Crowds, Smart Sustainable Cities, Ubiquitous City, Public Procurement, Open Strategy, Smart City Control Rooms, Smart Urban Monitoring, Digital City, Smart City Implementation Strategy, Smart Governance, Smart Institutions, Policy Process Standardization, City Marketing, Official Statistics, Regional Strategy, City Profiling, Smart Regions, Urban Branding, Evaluation Method, European Projects, Sustainable Governance, Advanced e-Government, Green Branding	Strategy and Governance
3D City Model, Urbanism, GIS, Public Services, Urban Policies, Spatial Data Population Distribution, Land Use, Urban Policies, Sustainable Urban Planning, Spatial Planning, Modeling Tool, Sustainable Development, Urban Computing, Urban Sustainability, Digital Twin, Urban Platforms, Planning Instruments, Urban Development Management Tools, Smart Urban Spaces, Virtual Reality, Geology, Soil permeability and Cartography, Mobile Geographic Information, Territorial Management Planning Strategies, Spatial Intelligence, City's Mapping, Urban Accessibility, Smart Urban Spaces	Urban Planning
Smart Tourism Destination, Tourism and Hospitality, Living Lab, Travel Behavior, Heritage, Preservation, Cultural Impact, Sustainable Tourism, Smart Museum, Augmented Reality, Historic City Centers Reconstruction, Sustainable Winter Tourism, Slow Tourism Experience, Digital Interactive Art, Mobile Tourism, ICT for Tourism, Rural Tourism, Smart Tourism, Beach Attendance Prediction, Indicators	Culture, Tourism and Heritage

Table A1. Cont.

Keywords	Category
Rural Areas, Rural Contexts, Tree Inventory System, Small Cities, Cow Sharing, Smart Town, Urban-rural Relationships, Rural Regions, Smart Village, Olive Production Quality	Rural and Agriculture
Smart Stadium, Sport and Smart Communities, Sport Activity	Sport
Driving Elements, Smart City Proposition, Opportunities, Challenges, Priorities, Barriers, Benefits, Value Proposition, Ideology, Myths and Utopias, Evaluation System and Model, National Scale, Practices, Case Studies, Smart Region, Indicators, Characteristics, Understandings, Findings and Lessons, ISO 37120 standard, KPIs and Index, Rankings, Sustainability Assessment, Performance Measurement Systems, Trends and Opportunities	Smart City Foundations
Information Science, Standards, Mobile City Applications, Data Interoperability, Open Data Policy, UrbanAPI, Digital Transformation Strategies, Subsystems Integration, Sensor Aggregation, Information Modeling, Big Data Analytics, Mobile Phone Data, Urban Operating System, Mobile Sensor, Urban Sensing, Digital Society, Urban Digitalization, Digital Transformation, Information Dissemination, Open City Toolkit, Crowdsensing and Crowdsourcing, Urban Dashboards, Living Labs, Data Concentrator, Big Data, Open Data, Crowdsensed Data, Fog Computing Applications, Integrated Dashboard, Open Data Assessment, Platform-as-a-Service Architecture, Interoperability and Open Data	Digitization & Interoperability
Digital Rights, Surveillance, Biometric Border Management, Cybersecurity Education Management, General Data Protection Regulation, Reinforcement, Camera Systems, Blockchain, Security Monitoring, Intrusion and Abnormal Behavior Detection System, Autonomous Vehicles' Privacy and Cybersecurity, Risk Management, Emergency Evacuation Planning, Crime Prevention, Coordinated Management, Emergency Response, Cameras and LiDAR Sensors, Digital Rights, Urban Safety, Smart Security, Public Safety System, Transparency and Control	Privacy, Security and Safety
Senior Care System, Smart Quarantine, Urban Health, Wellbeing, Urban Living, Disease Control, Predicting Diabetes Diseases, Satisfaction Estimation, Ambient Assisted Living (AAL), Elderly People Monitoring, Hospital Information Systems (HIS), Teledermatology Platform, eHealth, E-Prescription System, Quality of Life, Emotion, Stress Mapping, Covid-19, Predicting Patients' Urgency Demand, Active Mobile Phone Intervention, Health Monitoring System	Health and Wellbeing
Wireless Sensors, Mobile Sensors, LoRaWAN, Internet of Things, 5G networks, Communication Technologies, LoRa Network, Wi-Fi and Interactive Displays, Digital Infrastructures, LPWAN Applications, Li-Fi Installation, Wi-Fi Network, Gateway City, Wireless Sensor Network, Cyber Physical Systems, Digital Infrastructures, ZigBee Wireless Communication, Narrowband IoT (NB-IoT), Industrial Internet of Things (IIoT), Architecture and Infrastructure, Wi-Fi hotspot, Bluetooth Sensors Network, Smart Urban Infrastructure, Power Line Communication (PLC)	Infrastructure and Communication Networks
Sustainable and Resilient Buildings, Sustainable Urban Regeneration, Utilities, Smart Building, Buildings Renovation, Green Building, Living Lab, Thermal Comfort, Thermal Modelling, Energy Efficient, Sound Foundations, 3D Buildings, Smart Home, Room Temperature Control Systems, Indoor Conditions Assessment, Occupancy Rate, Municipal Building Regulation, Housing Regeneration, Building Information Modelling (BIM)	Buildings and Housing
Responsive Traffic Signaling System, Traffic Forecasting and Route Guidance, Traffic Management System, Traffic Prediction, Bicycle Traffic, Road Marking, Road Damage Detection, Road Safety, Spatiotemporal Traffic Data, Road Accidents, Crowdsensing Urban Transit, Dynamic Obstacle Detecting, Smart Route Planning, Emergency Vehicle Routing, Road Assessment Conditions, Intelligent Traffic Light, Automatic Road Sign Inventory, Road Safety, Intelligent Crosswalks,	Traffic

Table A1. Cont.

Keywords	Category
Smart Parking, Off-Street Parking, Geospatial Factors, Parking Management, Pay-As-You-Go, Controlling System, Applications, Mobile Payment, Public Parking Spots, Social Parking, Real-Time Parking Prediction System, Park-and-ride Facilities	Parking
Population Distribution, Mobility Dynamics, Walking, Intelligent Transportation System, Electric Bike Sharing, Carpooling and Electro-mobility, Urban Transport, Smart Mobility, Light Rail, Public Transport Demand, Railroad Network, Pedestrian Movement, Transportation Modes, Green Transportation, Automated Driving, Mobility Politics, Integrated Urban Mobility, Electric Carsharing, Multimodal Sustainable Mobility, Shared Micromobility, Multi-modal Mobility, Inclusive Mobility, Carpooling Gamification, Soft Mobility, Autonomous Vehicles, Mobility-as-a-Service (MaaS), Crowd Mobility, Connected Cars	Mobility and Transportation
Sustainable Urban Freight Transport, Logistics, Last-mile, Future Urban Fleets, Intelligent Offloading Distribution, Logistics Freight Traffic, Short-distance Freight, Autonomous Vehicle Fleet, Local Food Delivery, City Logistics, Grocery Distribution and Delivery, Surplus Food Delivery, Logistics Routing Problem, Short Term Load Forecasting	Logistics
Participatory Governance, Collaborative Data Platforms, Citizen Participation, Human Centric Approach, Disabled Citizens, Participatory Sensing, Citizens Engagement, Participatory Innovation Platforms, Open Data, Co-creation, Smart Community, Bottom-up Participation, E-governance, E-participation, Democratization, Urban Experimentation, Social Policy, Virtual Community, Inclusion, Social Sustainability, Crowdsourced Governance System, Citizen Science model, Collaborative Decision-making Processes, Participatory Budget, Socio-technical experimentation, Stakeholder Involvement, Inclusive Smart Society, Local Leadership	Community, Participation & Inclusion
Education, Smart Campus, Hybrid Learning, Mobile Education, Public Libraries, School as a Service, Information Science, Human Capital, Knowledge and Intellectual Capital, Universities Role, Gamification Educational Strategy, Quality Management Skills, Learning and Teaching Environment, E-learning, University Curricula, Training, Employment Future Skills	Education
High-skilled Employment, Public Private Partnerships, Industry 4.0, Remote Working, Green Business Model, Knowledge Proximity, Sharing Economy, Smart Industry, Green Economy, Innovation Districts, Green Entrepreneurship, Economic Development and Welfare, Real Estate Valuation, Intelligent Fabrics, Smart Economy, Local Entrepreneurs, Technology Park, Micro-Enterprises, Startups, Accelerators, Open Innovation, Social Entrepreneurship, Digital Nomads, Intelligent Manufacturing System, Ethics, Sustainable Production, Inclusive 3D printing, Advertising, Corporate Social Responsibility	Economy and Industry

Appendix B

Table A2. Smart City initiatives organized by city and country.

Topic	Cities	Countries
Water and Irrigation	Innsbruck (1), Zdarna (1), Aalborg (1), Copenhagen (2), Isted (1), Region of North Jutland (1), Lille (1), Frankfurt (1), Main (1), Skiathos (1), Bay of Pozzuoli (1), Bresso (1), Calabria Region (1), L'Aquila (1), Małopolska province (1), Sosnowiec (1), Aveiro (1), Cávado (1), Alicante (1), Barcelona (1), Huelva (1), Madrid (1), Valencia (2)	Austria (1), Czech Republic (1), Denmark (4), France (1), Germany (2), Greece (1), Italy (4), Poland (2), Portugal (2), Spain (6)

Table A2. Cont.

Topic	Cities	Countries
Environment and Air Quality	Graz (1), Vienna (1), Antwerp (4), Liege (1), Sofia (1), Dubrovnik (1), Brno (1), Aarhus (2), Copenhagen (1), Helsinki (2), Lyon (1), Nancy (1), Berlin (2), Ruhr Valley (1), Stuttgart (1), Athens (1), Elefsina (1), Igoumenitsa (1), Patras (1), Thessaloniki (1), Szeged (1), Dublin (1), Bologna (1), Campania Region (1), Cosenza (1), Florence (1), L'Aquila (1), Osmannoro (1), Pavia (1), Piedmont (1), Rome (1), Syracuse (1), Terni (1), Tuscany Region (1), Amsterdam (1), Krakow (1), Zabrze (1), Paredes (1), Bucharest (1), Lučenec (1), Krvavec (1), Cartagena (1), Coruña (1), Galicia (1), Huelva (1), Jaén (1), Llíria (1), Madrid (4), Malaga (2), Murcia (1), San Sebastián (1), Santander (1), Vitoria-Gasteiz (1), Malmö (2), Örebro (1), Uppsala (1)	Austria (2), Belgium (5), Bulgaria (1), Croatia (1), Czech Republic (1), Denmark (3), Finland (2), France (2), Germany (4), Greece (5), Hungary (1), Ireland (1), Italy (12), Netherlands (1), Poland (2), Portugal (1), Romania (1), Slovakia (1), Slovenia (1), Spain (16), Sweden (4)
Waste	Flanders Region (1), Hamburg (1), Regensburg (1), Bari (2), Genoa (1), Prato (1), Vidusdaugavas Region (1), Luxembourg (1), Porto (2), Oradea (1), Bilbao (1), Cartagena (1), Malaga (2), Stockholm (1)	Belgium (1), Germany (2), Italy (4), Latvia (1), Luxembourg (1), Portugal (2), Romania (1), Spain (4), Sweden (1)
Energy and Lighting	Graz (4), Linz (1), Salzburg (1), Vienna (2), Villach (1), Leuze (1), Sisak (1), Sveti Križ Začretje (1), Nicosia (1), Jeseník (1), Aarhus (1), Copenhagen (3), Sønderborg (1), Espoo (1), Lorraine Region (1), Lyon (1), Saint-Nazaire (1), Berlin (1), Cologne (1), Dortmund (1), Hamburg (1), Ludwigsburg (1), Trikala (1), Budapest (1), Altavilla Silentina (1), Bagheria (1), Bari (5), Bolzano (3), Campania Region (1), Cesena (1), Cosenza (1), Cuneo (1), Florence (1), Genoa (1), Lazio (1), Milan (3), Naples (1), Padova (1), Palermo (1), Savona (5), Terni (1), Trento (1), Vallerlunga Pratameno (1), Luxembourg (1), Amsterdam (1), Apeldoorn (1), Eindhoven (1), Rotterdam (2), Zaanstad (1), Bydgoszcz (1), Gdańsk (1), Krakow (2), Bragança (1), Coimbra (1), Evora (4), Lisbon (1), Porto (1), Bucharest (1), Iasi (2), Ávila (1), Barcelona (4), Bilbao (1), Girona (1), Madrid (1), Malaga (4), Oviedo (2), Santiago de Compostela (2), Soria (1), Valladolid (7), Eskilstuna (1), Gothenburg (2), Malmö (3), Skellefteå (1), Stockholm (2)	Austria (9), Belgium (1), Croatia (2), Cyprus (1), Czech Republic (1), Denmark (5), Finland (1), France (3), Germany (5), Greece (1), Hungary (1), Italy (31), Luxembourg (1), Netherlands (6), Poland (4), Portugal (8), Romania (3), Spain (17), Sweden (9)
Strategy and Governance	Vienna (4), Brno (1), Karvina (1), Prague (1), Uherske Hradiste (1), Zlín (1), Helsinki (1), Oulu (3), Tampere (1), Vaasa (1), Lyon (1), Hamburg (1), Leipzig (1), Munich (1), Trikala (1), Dublin (1), Basilicata (1), Milan (3), Turin (4), Amsterdam (3), Rotterdam (1), Utrecht (1), Gdańsk (1), Katowice (1), Sandomierz (1), Warsaw (1), Lisbon (1), Banská Bystrica (1), Barcelona (7), Bilbao (1), Madrid (1), Santander (1), Valladolid (2), Stockholm (1), Växjö (1)	Austria (4), Czech Republic (5), Finland (6), France (1), Germany (3), Greece (1), Ireland (1), Italy (8), Netherlands (5), Poland (4), Portugal (1), Slovakia (1), Spain (12), Sweden (2)
Urban Planning	Graz (2), Vienna (3), Antwerp (1), Brussels (1), Wallonia (2), Brno (9), Karlovy Vary (1), Prague (1), Aarhus (2), Sønderborg (1), Tallinn (1), Tartu (1), Helsinki (3), Lohja (1), Tuusula (1), Paris (1), Bonn (2), Herrenberg (1), Leipzig (1), Ludwigsburg (1), Nuremberg (1), Athens (1), Mykonos (1), Thessaloniki (1), Dublin (3), Limerick (1), Bergamo (1), Brescia (2), Cagliari (3), Catania (1), Florence (1), Iglesias (1), Matera (1), Milan (1), Naples (1), Pavia (1), Rome (2), Trento (1), Trieste (1), Turin (1), Luxembourg (2), Amsterdam (2), Plock (1), TriCity (1), Žuromin (1), Algarve (1), Braga (1), Lisbon (1), Porto (1), Trenčín (1), Alicante (1), Elda (1), Girona (1), Madrid (1), Rois (1), Santander (1), Vitoria-Gasteiz (1), Zaragoza (1), Stockholm (9)	Austria (5), Belgium (4), Czech Republic (3), Denmark (3), Estonia (2), Finland (5), France (1), Germany (7), Greece (3), Ireland (4), Italy (18), Luxembourg (2), Netherlands (2), Poland (3), Portugal (4), Slovakia (1), Spain (8), Sweden (2)

Table A2. Cont.

Topic	Cities	Countries
Culture, Tourism and Heritage	Graz (1), Varna (1), Usti nad Labem (1), Aalborg (1), Les Orres (1), Hamburg (1), Karlsruhe (1), Athens (1), Budapest (1), Bologna (1), Cagliari (3), Campania Region (1), Cosenza (1), L'Aquila (3), Madonna di Campiglio (1), Milan (1), Naples (1), Salerno (1), Sulcis Iglesiente—Guspinese (1), Sutri (1), Trento (1), Turin (1), Den Bosch (1), Bragança (1), Lisbon (2), Madeira (1), Porto (2), Brasov (1), Bratislava (1), Komárno (1), Lučenec (1), Ávila (1), Barcelona (1), Donostia-San Sebastián (1), Madrid (1), Malaga (1), Tarragona (1), Valencia (3)	Austria (1), Bulgaria (1), Czech Republic (1), Denmark (1), France (1), Germany (2), Greece (1), Hungary (1), Italy (17), Netherlands (1), Portugal (6), Romania (1), Slovakia (3), Spain (9)
Rural and Agriculture	Schneebergland (1), Nicosia (1), Brandenburg (1), Taranto (1), Granada (1)	Austria (1), Cyprus (1), Germany (1), Italy (1), Spain (1)
Sport	Dublin (1), Cagliari (1), Pisa (1)	Ireland (1), Italy (2)
Smart City Foundations	Vienna (2), Flanders Region (1), Ghent (2), Brno (1), Usti nad Labem (1), Helsinki (1), Berlin (1), Hamburg (2), Main (1), Heraklion (1), Region of Elefsina (1), Trikala (1), Bari (1), Genoa (1), Milan (1), Turin (2), Amsterdam (2), Cascais (1), Barcelona (4), Sant Cugat del Vallès (1), Santander (1), Valladolid (2), Gothenburg (1)	Austria (2), Belgium (3), Czech Republic (2), Finland (1), Germany (4), Greece (3), Italy (5), Netherlands (2), Portugal (1), Spain (8), Sweden (1)
Digitization & Interoperability	Graz (1), Vienna (2), Antwerp (1), Brussels (1), Flanders Region (2), Ruse (1), Sofia (1), Dubrovnik (1), Nicosia (1), Brno (1), Moravia Silesian (1), Aarhus (1), Copenhagen (1), Tallinn (4), Tartu (1), Espoo (1), Hämeenlinna (1), Helsinki (4), Tampere (2), Lyon (1), Nantes (1), Nice (2), Paris (1), Rennes (1), Berlin (2), Freiburg (1), Hamburg (1), Lübeck (1), Munich (1), Munzingen (1), Ruhr Valley (1), Vaihingen (1), Kavala (1), Papagou (1), Trikala (1), Dublin (4), Bologna (2), Cagliari (1), Catania (2), Florence (2), Lecce (1), Merano (1), Messina (1), Milan (3), South Tyrol (1), Turin (2), Venice (1), Luxembourg (2), Amsterdam (1), Eindhoven (2), Krakow (1), Rzeszów (1), Košice (1), Barcelona (1), Béjar (1), Galicia (2), Granada (1), Valladolid (1), Vitoria-Gasteiz (2), Zaragoza (1), Karlshamn (1), Stockholm (1), Uppsala (1)	Austria (3), Belgium (4), Bulgaria (2), Croatia (1), Cyprus (1), Czech Republic (2), Denmark (2), Estonia (5), Finland (8), France (6), Germany (9), Greece (3), Ireland (4), Italy (17), Luxembourg (2), Netherlands (3), Poland (2), Slovakia (1), Spain (9), Sweden (3)
Privacy, Security and Safety	Vienna (1), Nicosia (1), Ostrava (1), Tampere (1), Nice (1), Lesvos (1), Budapest (1), Amsterdam (2), Eindhoven (1), Rotterdam (2), Porto (1), Ljubljana (1), Barcelona (2)	Austria (1), Cyprus (1), Czech Republic (1), Finland (1), France (1), Greece (1), Hungary (1), Netherlands (5), Portugal (1), Slovenia (1), Spain (2)

Table A2. Cont.

Topic	Cities	Countries
Health and Wellbeing	Prague (1), Aarhus (1), Frankfurt (1), Bologna (1), Lecce (1), Messina (1), Sardinian Region (1), Trento (1), Lisbon (1), Brasov (1), Jaén (1), Stockholm (2)	Czech Republic (1), Denmark (1), Germany (1), Italy (5), Portugal (1), Romania (1), Spain (1), Sweden (2)
Infrastructure and Communication Networks	Antwerp (3), Leuven (1), Bol (1), Osijek (1), Brno (2), Aalborg (1), Oulu (1), Grenoble (1), Lille (1), Lyon (1), Dortmund (1), Karlsruhe (1), Mainau-Lake Constance (1), Heraklion (1), Dublin (1), Bologna (1), Florence (1), Padova (2), Palermo (2), Prato (1), Salerno (1), Riga (1), TriCity (1), Warsaw (1), Aveiro (1), Castelo Branco (2), Lagoa (1), Porto (1), Bucharest (1), Bratislava (1), Logatec (1), Coruña (1), Gran Canaria Island (1), Madrid (1), Malaga (1), Pamplona (1), Santander (3), Santiago de Compostela (1), Valencia (2), Valladolid (1), Skellefteå (2)	Belgium (4), Croatia (2), Czech Republic (2), Denmark (1), Finland (1), France (3), Germany (3), Greece (1), Ireland (1), Italy (8), Latvia (1), Poland (2), Portugal (5), Romania (1), Slovakia (1), Slovenia (1), Spain (12), Sweden (2)
Buildings and Housing	Vienna (1), Seraing (1), Havířov (1), Nordhavn (1), Tartu (1), Grenoble (1), Nancy (1), Hannover (1), Munich (1), Vaihingen (1), Miskolc (1), Brescia (1), Gioia Tauro (1), Milan (1), Palermo (1), Pescara (1), Settimo Torinese (1), Turin (1), Amsterdam (1), Lisbon (2), Alba Iulia (1), Galati (1), Betanzos (1), Växjö (1)	Austria (1), Belgium (1), Czech Republic (1), Denmark (1), Estonia (1), France (2), Germany (3), Hungary (1), Italy (7), Netherlands (1), Portugal (2), Romania (2), Spain (1), Sweden (1)
Traffic	Vienna (1), Nicosia (2), Aarhus (1), Odense (1), Oulu (1), Lyon (2), Marseille (1), Nancy (1), Paris (1), Augsburg (1), Cologne (1), Hamburg (2), Patras (1), Thessaloniki (2), Budapest (2), Dublin (4), Catania (1), Florence (2), Milan (2), Modena (1), Turin (1), Jelgava (2), Delft (1), Enschede (2), Białystok (1), Aveiro (1), Braga (1), Porto (4), Barcelona (1), Madrid (2), Malaga (1), Murcia (1), Navarre (1), Santander (2), Zaragoza (1)	Austria (1), Cyprus (2), Denmark (2), Finland (1), France (5), Germany (4), Greece (3), Hungary (2), Ireland (4), Italy (6), Latvia (2), Netherlands (3), Poland (1), Portugal (6), Spain (9)
Parking	Aarhus (1), Mainz (1), Milan (1), Jelgava (1), Warsaw (1), Žilina (1), Barcelona (1), Malaga (2), Santander (2), Seville (1), Zaragoza (1)	Denmark (1), Germany (1), Italy (1), Latvia (1), Poland (1), Slovakia (1), Spain (7)
Mobility and Transportation	Vienna (2), Flanders Region (1), Mons (3), Split (1), Limassol (2), Brno (1), Lovosice (1), Prague (2), Aarhus (1), Tartu (1), Vaasa (1), Lille (1), Paris (1), Berlin (1), Erfurt (1), Munich (2), Ruhr Valley (1), Heraklion (1), Thessaloniki (1), Trikala (1), Volos (1), Dublin (1), Apulia Region (1), Bologna (1), Cagliari (2), Catania (1), L'Aquila (1), Milan (2), Naples (1), Parma (1), Pavia (1), Piedmont (2), Pisa (1), Rome (1), Siena (1), Trento (2), Turin (4), Tuscany Region (1), Riga (1), Kaunas (1), Amsterdam (1), Krakow (1), Warsaw (4), Wrocław (1), Zielona Góra (1), Águeda (3), Aveiro (1), Covilhã (1), Lisbon (1), Porto (1), Viana do Castelo (1), Bratislava (3), Žilina (2), Ljubljana (1), Barcelona (3), Bilbao (1), Castelló de la Plana (1), Galicia (1), Madrid (6), Malaga (2), Pamplona (1), Santander (2), Gothenburg (1)	Austria (2), Belgium (4), Croatia (1), Cyprus (2), Czech Republic (4), Denmark (1), Estonia (1), Finland (1), France (2), Germany (5), Greece (4), Ireland (1), Italy (23), Latvia (1), Lithuania (1), Netherlands (1), Poland (7), Portugal (8), Slovakia (5), Slovenia (1), Spain (17), Sweden (1)
Logistics	Brussels (1), Region of North Jutland (1), Helsinki (1), Baden-Württemberg (1), Cologne (1), Erfurt (2), Heilbronn (1), Basilicata (1), Calabria Region (1), Milan (1), Helmond (1), Covilhã (1), Pamplona (1)	Belgium (1), Denmark (1), Finland (1), Germany (5), Italy (3), Netherlands (1), Portugal (1), Spain (1)

Table A2. Cont.

Topic	Cities	Countries
Community, Participation & Inclusion	Vienna (2), Brussels (1), Ghent (1), Knokke-Heist (1), La Louvière (1), Namur (1), Koprivnica (1), Rijeka (1), Limassol (1), Brno (1), Usti nad Labem (1), Zlín (1), Aarhus (2), Copenhagen (1), Espoo (1), Helsinki (2), Oulu (3), Region of Häme (1), Tampere (1), Lyon (3), Cologne (1), Darmstadt (1), Essen (1), Hamburg (2), Munich (1), Stuttgart (1), Heraklion (1), Island of Kos (1), Kavala (1), Korydallos (1), Samos Island (1), Thessaloniki (1), Trikala (2), Budapest (1), Cork City (1), Dublin (4), Ennis (1), Bologna (1), Cagliari (4), Catania (1), Lombardy Region (1), Milan (3), Montieri (1), Pavia (2), Rome (1), Rovereto (1), Syracuse (1), Turin (3), Riga (1), Amersfoort (1), Amsterdam (4), Eindhoven (3), Schiedam (1), Utrecht (1), Poznań (1), Silesian Province (1), Warsaw (1), Wrocław (2), Evora (1), Lisbon (3), Paredes (1), Cluj (1), Oradea (1), Bratislava (1), Poprad (1), Žilina (1), Alicante (1), Barcelona (3), Bilbao (1), Guadalajara (1), Huesca (1), Madrid (3), Malaga (1), Murcia (1), San Sebastián (1), Santander (2), Valencia (1), Vitoria-Gasteiz (1), Linköping (1), Luleå (1)	Austria (2), Belgium (5), Croatia (2), Cyprus (1), Czech Republic (3), Denmark (3), Finland (8), France (3), Germany (7), Greece (8), Hungary (1), Ireland (6), Italy (19), Latvia (1), Netherlands (10), Poland (5), Portugal (5), Romania (2), Slovakia (3), Spain (17), Sweden (2)
Education	Vienna (1), Prague (1), Aarhus (1), Espoo (1), Düsseldorf (1), Limerick (1), Brescia (1), Genoa (1), Glurns/Glorenza (1), Turin (1), Alba Iulia (1), Barcelona (1), Jaén (1)	Austria (1), Czech Republic (1), Denmark (1), Finland (1), Germany (1), Ireland (1), Italy (4), Romania (1), Spain (2)
Economy and Industry	Flanders Region (1), Prague (1), Aarhus (1), Paris (1), Berlin (1), Heraklion (1), Trikala (1), Dublin (2), Emilia-Romagna Region (1), Liguria (1), Rende (1), Turin (1), Utrecht (1), Białystok (1), Bydgoszcz (1), Czeszochowa (1), Águeda (1), Cluj (1), Žilina (1), Ljubljana (1), Madrid (1)	Belgium (1), Czech Republic (1), Denmark (1), France (1), Germany (1), Greece (2), Ireland (2), Italy (4), Netherlands (1), Poland (3), Portugal (1), Romania (1), Slovakia (1), Slovenia (1), Spain (1)

Appendix C

Table A3. Number of Smart City initiatives divided by country and category.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	Total	Categories
Austria	1	2	0	9	4	5	1	1	0	2	3	1	0	0	1	1	0	2	0	2	1	0	36	15
Belgium	0	5	1	1	0	4	0	0	0	3	4	0	0	4	1	0	0	4	1	5	0	1	34	12
Bulgaria	0	1	0	0	0	0	1	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	4	3
Croatia	0	1	0	2	0	0	0	0	0	0	1	0	0	2	0	0	0	1	0	2	0	0	9	6
Cyprus	0	0	0	1	0	0	0	1	0	0	1	1	0	0	0	2	0	2	0	1	0	0	9	7
Czech Rep.	1	1	0	1	5	3	1	0	0	2	2	1	1	2	1	0	0	4	0	3	1	1	30	16
Denmark	4	3	0	5	0	3	1	0	0	0	2	0	1	1	1	2	1	1	1	3	1	1	31	16
Estonia	0	0	0	0	0	2	0	0	0	0	5	0	0	0	1	0	0	1	0	0	0	0	9	4
Finland	0	2	0	1	6	5	0	0	0	1	8	1	0	1	0	1	0	1	1	8	1	0	37	13
France	1	2	0	3	1	1	1	0	0	0	6	1	0	3	2	5	0	2	0	3	0	1	32	14
Germany	2	4	2	5	3	7	2	1	0	4	9	0	1	3	3	4	1	5	5	7	1	1	70	20
Greece	1	5	0	1	1	3	1	0	0	3	3	1	0	1	0	3	0	4	0	8	0	2	37	14
Hungary	0	1	0	1	0	0	1	0	0	0	0	1	0	0	1	2	0	0	0	1	0	0	8	7
Ireland	0	1	0	0	1	4	0	0	1	0	4	0	0	1	0	4	0	1	0	6	1	2	26	11
Italy	4	12	4	31	8	18	17	1	2	5	17	0	5	8	7	6	1	23	3	19	4	4	199	21
Latvia	0	0	1	0	0	0	0	0	0	0	0	0	0	1	0	2	1	1	0	1	0	0	7	6
Lithuania	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	1	1

Table A3. Cont.

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P	Q	R	S	T	U	V	Total	Categories
Luxembourg	0	0	1	1	0	2	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	6	4
Malta ¹	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Netherlands	0	1	0	6	5	2	1	0	0	2	3	5	0	0	1	3	0	1	1	10	0	1	42	14
Poland	2	2	0	4	4	3	0	0	0	0	2	0	0	2	0	1	1	7	0	5	0	3	36	12
Portugal	2	1	2	8	1	4	6	0	0	1	0	1	1	5	2	6	0	8	1	5	0	1	55	17
Romania	0	1	1	3	0	0	1	0	0	0	0	0	1	1	2	0	0	0	0	2	1	1	14	10
Slovakia	0	1	0	0	1	1	3	0	0	0	1	0	0	1	0	0	1	5	0	3	0	1	18	10
Slovenia	0	1	0	0	0	0	0	0	0	0	0	1	0	1	0	0	0	1	0	0	0	1	5	5
Spain	6	16	4	17	12	8	9	1	0	8	9	2	1	12	1	9	7	17	1	17	2	1	160	21
Sweden	0	4	1	9	2	2	0	0	0	1	3	0	2	2	1	0	0	1	0	2	0	0	30	12
Total	24	67	17	109	54	77	46	5	3	32	87	16	13	51	25	51	13	93	14	113	13	22		
Countries	10	21	9	19	14	18	14	5	2	11	20	11	8	18	14	15	7	22	8	21	9	15		

Legend: (A)—Water and Irrigation; (B)—Environment and Air Quality; (C)—Waste; Energy and Lighting; (D)—Strategy and Governance; (E)—Urban Planning; (F)—Culture, Tourism and Heritage; (G)—Rural and Agriculture; (H)—Sport; (I)—Smart City Foundations; (J)—Digitization & Interoperability; (K)—Privacy, Security and Safety; (L)—Health and Wellbeing; (M)—Infrastructure and Communication Networks; (N)—Buildings and Housing; (O)—Traffic; (P)—Parking; (Q)—Mobility and Transportation; (R)—Logistics; (S)—Community, Participation & Inclusion; (T)—Education; (U)—Economy and Industry. ¹ As mentioned in the Methodology section “If there was not any location in the title, abstract and keywords, the paper’s contribution was considered as of the country. The same happened if it were a generic study of numerous cities in the country. These results were excluded from the final detailed analysis”. Malta’s results did not mentioned any city in particular.

Appendix D

The methodology and analysis are the same of the one described in Section 4.2.4. The difference of the Country Cluster Analysis (dimensionality reduction) performed in this appendix is that instead of the typology of the initiatives, was considered the relative percentage of the categories in each country (spatial patterns according to the percentage of the initiatives). Furthermore, the goal was to find patterns according to the weight of each category compared to the total number of initiatives (and categories) a specific country had. Thus, the categories without projects were excluded in this analysis. The aim was to find if there were similarities between countries when considering only the categories that they contained smart city initiatives.

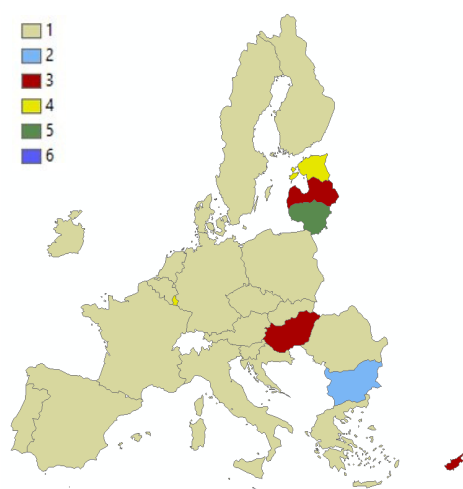
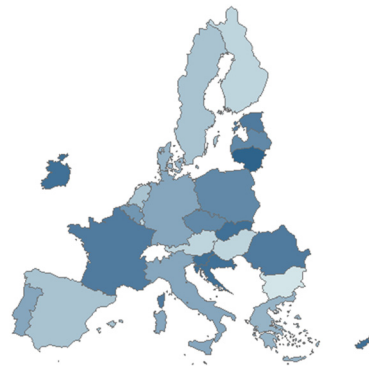


Figure A1. Geographic representation of the countries by category.

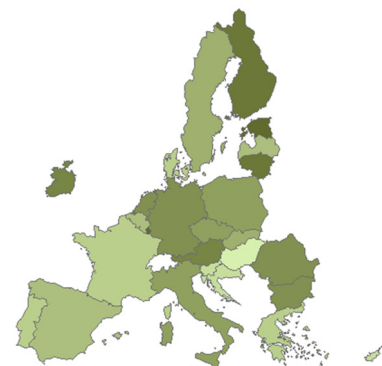
Table A4. Loadings of the principal component analysis (% of initiatives).

	Component			
	1	2	3	4
Economy and Industry(%)	0.850			
Buildings and Housing(%)	0.769			
Mobility and Transportation(%)	0.761			
Strategy and Governance(%)	−0.558			
Culture, Tourism and Heritage(%)	−0.456			
Energy & Lighting(%)				
Urban Planning(%)		0.856		
Digitization & Interoperability(%)		0.652		
Waste(%)		0.616		
Environment and Air Quality(%)		−0.521		
Community, Participation & Inclusion(%)		−0.439		
Water and Irrigation(%)				
Parking(%)			0.978	
Smart City Foundations(%)			0.954	
Traffic(%)				0.690
Health and Wellbeing(%)				−0.671
Infrastructure and Comm(%)				−0.575
Rural and Agriculture(%)				0.549
Privacy, Security and Safety(%)				0.505
Education(%)				−0.503
Logistics(%)				−0.443
Sport(%)				
Total Variance Explained	14.353	13.883	11.874	10.354

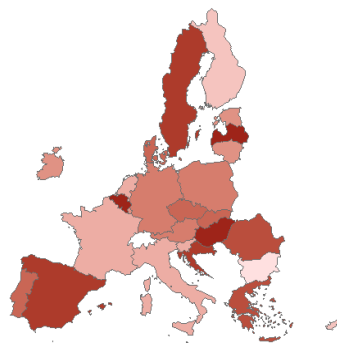
Factor 1—Economy, housing and



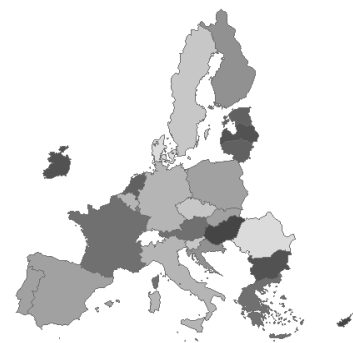
Factor 2—urban planning and digitalization



Factor 3—water and parking



Factor 4—traffic and health

**Figure A2.** Geographic representation of the scores of the factors.

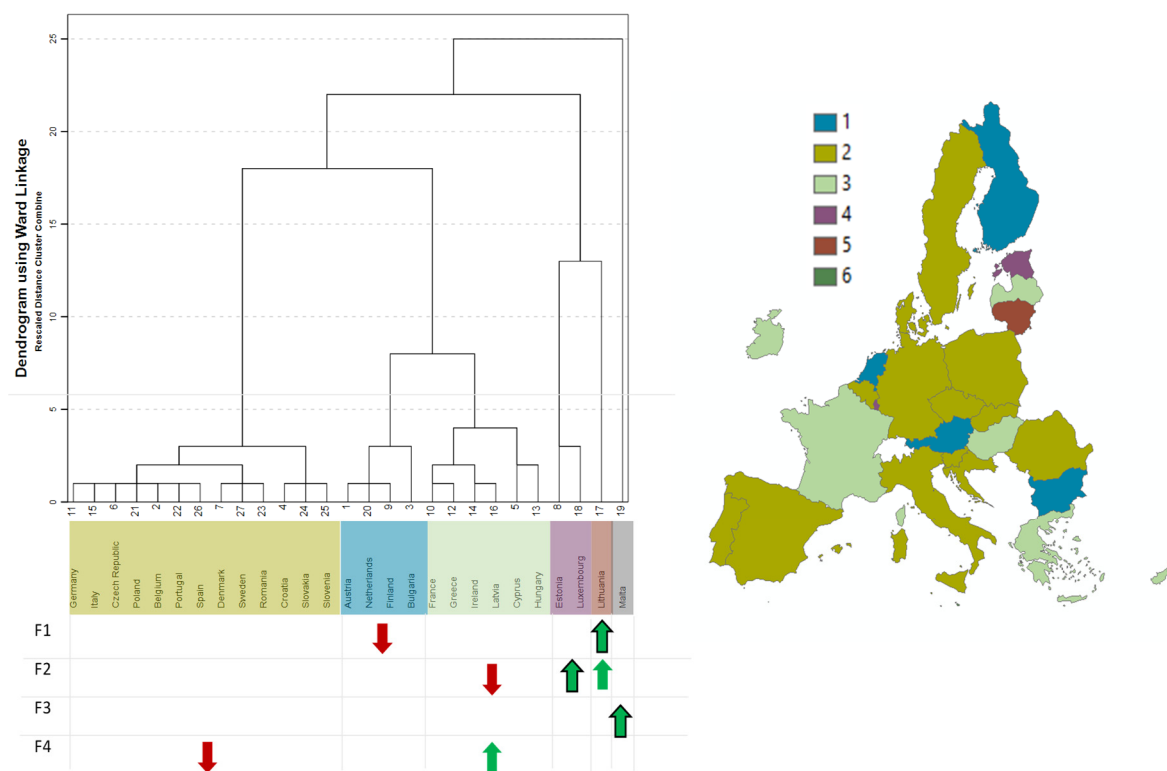


Figure A3. Cluster analysis of the countries by the percentage of the initiatives.

Appendix E

Table A5. Socio-economic characteristics of clusters.

		Descriptions			
		N	Mean	Minimum	Maximum
Number of Municipalities	1	4	10,777.8	2098.00	35,357.00
	2	8	322.0	31.00	589.00
	3	11	1235.1	60.00	6258.00
	4	1	11,054.0	11,054.00	11,054.00
	5	1	7960.0	7960.00	7960.00
	6	1	380.0	380.00	380.00
	7	1	8124.0	8124.00	8124.00
	Total	27	3214.5	31.00	35,357.00
Area (km ²)	1	4	282,356.5	82,409.00	647,795.00
	2	8	96,037.9	5695.00	303,892.00
	3	11	94,445.5	315.00	407,340.00
	4	1	357,376.0	357,376.00	357,376.00
	5	1	295,114.0	295,114.00	295,114.00
	6	1	33,688.0	33,688.00	33,688.00
	7	1	504,712.0	504,712.00	504,712.00
	Total	27	152,871.1	315.00	647,795.00

Table A5. Cont.

		<i>Descriptions</i>			
		N	Mean	Minimum	Maximum
Inhabitants	1	4	30,883.3	8773.00	66,989.00
	2	8	5808.5	855.00	11,352.00
	3	11	6272.1	460.00	19,644.00
	4	1	82,522.0	82,522.00	82,522.00
	5	1	60,589.0	60,589.00	60,589.00
	6	1	17,082.0	17,082.00	17,082.00
	7	1	46,528.0	46,528.00	46,528.00
	Total	27	16,508.0	460.00	82,522.00
GDP (billion EUR)	1	4	811.5	123.50	2287.60
	2	8	160.0	19.20	437.20
	3	11	145.4	11.10	477.90
	4	1	3263.4	3263.40	3263.40
	5	1	1716.9	1716.90	1716.90
	6	1	733.2	733.20	733.20
	7	1	1163.7	1163.70	1163.70
	Total	27	481.5	11.10	3263.40
GDP per capita (EUR)	1	4	25,275.3	12,261.00	42,086.00
	2	8	26,575.4	7101.00	61,900.00
	3	11	30,096.8	9563.00	93,754.00
	4	1	39,545.0	39,545.00	39,545.00
	5	1	28,337.0	28,337.00	28,337.00
	6	1	42,922.0	42,922.00	42,922.00
	7	1	25,010.0	25,010.00	25,010.00
	Total	27	28,910.5	7101.00	93,754.00
Public Budget Balance (billion EUR)	1	4	−174.2	−593.00	−2.60
	2	8	−3.2	−13.00	1.50
	3	11	−8.7	−57.00	8.00
	4	1	412.0	412.00	412.00
	5	1	−397.0	−397.00	−397.00
	6	1	80.0	80.00	80.00
	7	1	−362.0	−362.00	−362.00
	Total	27	−40.2	−593.00	412.00
Public Budget Balance (% GDP)	1	4	0.0	−0.03	−0.01
	2	8	0.0	−0.01	0.02
	3	11	0.0	−0.03	0.04
	4	1	0.0	0.01	0.01
	5	1	0.0	−0.02	−0.02
	6	1	0.0	0.01	0.01
	7	1	0.0	−0.03	−0.03
	Total	27	0.0	−0.03	0.04
Debt (billion EUR)	1	4	709.7	90.50	2218.40
	2	8	303.0	10.80	1373.00
	3	11	71.2	2.10	242.60
	4	1	2092.6	2092.60	2092.60
	5	1	2263.1	2263.10	2263.10
	6	1	416.1	416.10	416.10
	7	1	1144.3	1144.30	1144.30
	Total	27	443.0	2.10	2263.10

Table A5. Cont.

		<i>Descriptions</i>			
		N	Mean	Minimum	Maximum
Debt (% GDP)	1	4	0.7	0.51	0.97
	2	8	0.8	0.25	1.79
	3	11	0.5	0.09	1.26
	4	1	0.6	0.64	0.64
	5	1	1.3	1.32	1.32
	6	1	0.6	0.57	0.57
	7	1	1.0	0.98	0.98
	Total	27	0.7	0.09	1.79
Public Investment (EUR billion)	1	4	28.3	5.10	79.60
	2	8	4.1	0.50	9.80
	3	11	5.0	0.20	21.20
	4	1	68.9	68.90	68.90
	5	1	34.3	34.30	34.30
	6	1	23.6	23.60	23.60
	7	1	24.0	24.00	24.00
	Total	27	13.0	0.20	79.60
Public Investment (EUR per capita)	1	4	857.5	450.00	1275.00
	2	8	703.4	124.00	1523.00
	3	11	1076.4	270.00	3758.00
	4	1	834.0	834.00	834.00
	5	1	566.0	566.00	566.00
	6	1	1380.0	1380.00	1380.00
	7	1	516.0	516.00	516.00
	Total	27	896.0	124.00	3758.00
Public Investment (% GDP)	1	4	0.0	0.03	0.04
	2	8	0.0	0.02	0.04
	3	11	0.0	0.02	0.06
	4	1	0.0	0.02	0.02
	5	1	0.0	0.02	0.02
	6	1	0.0	0.03	0.03
	7	1	0.0	0.02	0.02
	Total	27	0.0	0.02	0.06
Public Revenue (EUR billion)	1	4	412.6	55.00	1232.60
	2	8	70.6	7.70	224.50
	3	11	65.0	4.50	240.60
	4	1	1474.6	1474.60	1474.60
	5	1	799.9	799.90	799.90
	6	1	320.0	320.00	320.00
	7	1	441.1	441.10	441.10
	Total	27	221.0	4.50	1474.60
Public Revenue (EUR per capita)	1	4	12,305.8	4850.00	20,358.00
	2	8	10,931.6	2567.00	21,592.00
	3	11	13,397.6	2913.00	41,599.00
	4	1	17,869.0	17,869.00	17,869.00
	5	1	13,202.0	13,202.00	13,202.00
	6	1	18,735.0	18,735.00	18,735.00
	7	1	9480.0	9480.00	9480.00
	Total	27	12,716.1	2567.00	41,599.00

Table A5. Cont.

		<i>Descriptions</i>			
		N	Mean	Minimum	Maximum
Public Revenue (% GDP)	1	4	0.5	0.40	0.54
	2	8	0.4	0.26	0.53
	3	11	0.4	0.31	0.53
	4	1	0.5	0.45	0.45
	5	1	0.5	0.47	0.47
	6	1	0.4	0.44	0.44
	7	1	0.4	0.38	0.38
	Total	27	0.4	0.26	0.54
Public Tax Revenue (EUR Billion)	1	4	297.7	98.00	681.00
	2	8	42.9	4.90	134.70
	3	11	45.7	3.00	196.10
	4	1	773.3	773.30	773.30
	5	1	502.6	502.60	502.60
	6	1	180.2	180.20	180.20
	7	1	259.4	259.40	259.40
	Total	27	139.0	3.00	773.30
Public Tax Revenue (EUR per capita)	1	4	6846.0	2580.00	11,424.00
	2	8	6759.8	1511.00	12,650.00
	3	11	8982.8	1563.00	25,771.00
	4	1	9371.0	9371.00	9371.00
	5	1	8296.0	8296.00	8296.00
	6	1	10,551.0	10,551.00	10,551.00
	7	1	5574.0	5574.00	5574.00
	Total	27	7928.3	1511.00	25,771.00
Public Tax Revenue (% GDP)	1	4	0.3	0.21	0.30
	2	8	0.3	0.19	0.31
	3	11	0.3	0.16	0.46
	4	1	0.2	0.24	0.24
	5	1	0.3	0.29	0.29
	6	1	0.2	0.25	0.25
	7	1	0.2	0.22	0.22
	Total	27	0.3	0.16	0.46
Public Tax Revenue (% Public Revenue)	1	4	0.6	0.53	0.57
	2	8	0.6	0.57	0.73
	3	11	0.6	0.46	0.88
	4	1	0.5	0.52	0.52
	5	1	0.6	0.63	0.63
	6	1	0.6	0.56	0.56
	7	1	0.6	0.59	0.59
	Total	27	0.6	0.46	0.88
European Structural and Investment Funds (2014–2020 EUR billions)	1	4	35,830.8	4923.00	86,112.00
	2	8	7300.6	917.00	21,382.00
	3	11	10,797.6	140.00	30,883.00
	4	1	27,935.0	27,935.00	27,935.00
	5	1	44,656.0	44,656.00	44,656.00
	6	1	1947.0	1947.00	1947.00
	7	1	39,835.0	39,835.00	39,835.00
	Total	27	16,106.5	140.00	86,112.00

Table A5. Cont.

		<i>Descriptions</i>			
		N	Mean	Minimum	Maximum
European Structural and Investment Funds (2014–2020 EUR per capita)	1	4	1447.3	407.00	2553.00
	2	8	1443.8	242.00	2889.00
	3	11	1820.6	237.00	3362.00
	4	1	339.0	339.00	339.00
	5	1	737.0	737.00	737.00
	6	1	114.0	114.00	114.00
	7	1	856.0	856.00	856.00
	Total	27	1459.7	114.00	3362.00
Expenditure (Education)	1	4	0.2	0.15	0.28
	2	8	0.2	0.00	0.41
	3	11	0.2	0.00	0.40
	4	1	0.2	0.21	0.21
	5	1	0.1	0.06	0.06
	6	1	0.3	0.31	0.31
	7	1	0.2	0.19	0.19
	Total	27	0.2	0.00	0.41
Expenditure (Social Protection)	1	4	0.2	0.12	0.23
	2	8	0.2	0.00	0.33
	3	11	0.2	0.05	0.56
	4	1	0.3	0.28	0.28
	5	1	0.0	0.05	0.05
	6	1	0.2	0.24	0.24
	7	1	0.1	0.07	0.07
	Total	27	0.2	0.00	0.56
Expenditure (General Services)	1	4	0.2	0.10	0.25
	2	8	0.2	0.05	0.41
	3	11	0.2	0.04	0.37
	4	1	0.2	0.23	0.23
	5	1	0.2	0.15	0.15
	6	1	0.1	0.07	0.07
	7	1	0.2	0.22	0.22
	Total	27	0.2	0.04	0.41
Expenditure (Health)	1	4	0.1	0.01	0.25
	2	8	0.1	0.00	0.26
	3	11	0.1	0.00	0.27
	4	1	0.0	0.02	0.02
	5	1	0.5	0.48	0.48
	6	1	0.0	0.03	0.03
	7	1	0.3	0.27	0.27
	Total	27	0.1	0.00	0.48
Expenditure (Economic Affairs)	1	4	0.2	0.12	0.20
	2	8	0.1	0.00	0.21
	3	11	0.1	0.04	0.18
	4	1	0.1	0.11	0.11
	5	1	0.1	0.13	0.13
	6	1	0.1	0.13	0.13
	7	1	0.1	0.10	0.10
	Total	27	0.1	0.00	0.21

Table A5. Cont.

		Descriptions			
		N	Mean	Minimum	Maximum
Expenditure (Others)	1	4	0.2	0.08	0.27
	2	8	0.2	0.05	0.59
	3	11	0.2	0.04	0.46
	4	1	0.2	0.15	0.15
	5	1	0.1	0.13	0.13
	6	1	0.2	0.22	0.22
	7	1	0.1	0.15	0.15
	Total	27	0.2058	0.04	0.59

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