

Science Mapping and Country Clustering Regarding Challenges of Public Governance to Ensure Societal Well-Being

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Abstract: *This study maps the challenges public governance faces in its mission to ensure a high level of societal well-being in European countries due to complex and multidimensional analysis, both on scientific and economic levels: bibliometric analysis, vector quantisation mapping, and clustering analysis of countries. The proposed research advocates considering relevant descriptors of the two phenomena, namely the six dimensions of public governance and the composite quality of life index, to analyse their interdependence by 2020, the year for which official statistics reveal data. Our research proposes a classification of the European Union Member States from the perspective of the progress made at the governmental decision-making level for the multidimensional approach to quality of life to identify the models of good practice. The methodological support was offered by cluster analysis and a vector quantisation method, namely K-means. KNIME software has allowed us to connect to various data sources visually. Clustering of European countries has revealed several disparities thus, Denmark and Finland (which are countries with a high level of quality of life) are examples of good practices, while countries such as Romania and Bulgaria are facing difficulties in significantly improving their quality of life due to the deficiencies of the governing act. Finally, the research highlights the channels through which public governance can substantially contribute to societal well-being, keeping in mind the relatively low importance of welfare given to formal aspects of democratic representation compared to the extent of quality governance.*

Keywords: *public governance, citizen welfare, vector quantisation, bibliometric analysis, data mapping, EU Member States.*

How to cite: Lobonț, O.-R., Trip, A., Țăran, A.-M., Mihiț, L.-D., Moldovan, N. C. (2023). Science mapping and country clustering regarding challenges of public governance to ensure societal well-being. *BRAIN. Broad Research in Artificial Intelligence and Neuroscience*, 14(2), 257-284. <https://doi.org/10.18662/brain/14.2/454>

1. Introduction

In an ever-changing period where new reasons are emerging everywhere for which the level of welfare of society can be determined to follow a negative evolution, challenges on the following topics appear health (Devlin et al., 2016; Leach et al., 2010; Luchez et al., 2021; Stroetmann, 2013), pollution (Moore et al., 2011), green growth and smart city (Bowen & Hepburn, 2014; Gargiulo & Tremitterra, 2015; Khan et al., 2020), education (Peeters et al., 2018), financial system (Ropke, 2017) and exploitation of natural resources (Engwicht & Grabek, 2018; Haikola & Anshelm, 2019); it is becoming increasingly clear that governance interventions are needed to combat the decline in welfare levels. Together with subordinate public institutions, the government plays the most crucial role in ensuring the well-being of the citizens, having an obligation to take measures that prevent the decrease of the welfare level in society and create safe and prosperous societies. On the other hand, governance must provide policies that contain the most effective and appropriate choice in developing and providing solutions to mitigate the negative variation in well-being. However, today's society is categorised as that of knowledge, resulting from which authority and supremacy are no longer concentrated only around governance. The organisations involved in these activities and the citizens involved and informed significantly affect combating society's declining prosperity and vary according to their opinions. Thus, effective coordination and constant cooperation between public and private sector institutions are essential (Moore et al., 2011). At the same time, Leach et al. (2010) state that it is necessary to have good governance, take decisions and measures quickly, efficiently, and rationally, and ensure the increase of the level of well-being felt by society. Over time, at the level of EU MS (Member States), social challenges and significant consequences on economic welfare have emerged. In front of these facts, Cristea et al. (2022) highlighted the need to implement specific and distinctive strategies and policies at the EU level.

The paper illustrates how macro-level changes in institutional structures and public policies influence well-being, considering the neo-institutional theory for the transformation and evolution of institutions and the heterogeneity of actors and practices in public governance. Even though it is essential to maintain and increase well-being, there are constant problems fulfilling this commitment for some countries. Most of the measures and mechanisms by which societal well-being growth can be ensured depend on the public administration's managerial and management capacity. Disregarding specific social or professional categories leads to

measures that favour one category over another, thus varying the level of welfare of society according to various criteria such as ethnicity, sex, age, geographical area, or field of activity (Dincă & Luceș, 2018; Matichescu et al., 2017;).

The general objective of the paper is to assess the impact of public governance on social welfare and graphically represent the links between these dimensions at the level of EU-27 Member States. The target is to highlight the discrepancies between these countries using dendrogram and K-means clustering algorithms.

Our research addresses a topical issue based on the difficulties of public governance in maintaining and improving societal well-being, so the context of the study can be presented from a different perspective. There is much variation concerning social and economic development within and across EU countries. Given the current socio-economic context (economic bubbles, financial crises, pandemic and social isolation, social change, international policy perspective, (lack of) confidence in elections, geopolitical risks leading to governance weaknesses and institutional challenge design), the topic is very timely and beneficial for practice and current research, both in public finance (in terms of public policies priorities, institutional capacities, new research methodologies) as well as the economic and social (generational accounting models to set measures to be taken by generations not to diminish the prospects of future generations) or even political (strengthening democratic values, moral arguments against the welfare state) or cultural and religious (immigration, culture, ageing).

The following significant contribution mainly reflects the novelty and contributions of this paper. First, it improves the existing literature by providing a new visual methodological approach perspective on public governance's challenges to ensure societal well-being, performing vector quantisation, hierarchical clustering, and graphical representation. Second, the research will highlight which governance dimensions directly impact the quality of life and the difference between nations or groups of nations or country specificities. Several types of theory have been considered to underline the nexus of good governance - well-being. While most of the studies argue or assume that causal forces run from the quality of governance to levels or changes in well-being, there is the possibility of causal arrows also running in the other direction. Also, how well-being research findings can be used to set well-being-maximization goals for public policy needs careful examination, as the translation from research to policy is not always straightforward.

Noticing the importance of the subject, the paper is divided into six sections. After the introduction, section 2 provides concise information regarding the most relevant studies on public governance and societal welfare; section 3 presents the methodology and the data set applied in the analysis. Section 4 reports the empirical results and their interpretations. Section 5 includes substantial discussions, and Section 6 offers conclusions and recommendations for the EU-27 Member States.

2. Literature review

The process of evaluation of governance addresses the degree of commitment and action of public authorities in formulating and implementing standard-setting, policy and institutional frameworks and making available infrastructures and institutional mechanisms to increase the citizen's level of well-being. We note that the issue becomes complex, engaging both microeconomic aspects of individual behaviour and macroeconomic stability and development issues.

Contextualising research is primarily influenced by the necessity of practical, realistic and enhanced interventions to provide human well-being. Leach et al. (2010) examined how governance changes in an age of complexity in times of instability created by epidemiological risk. Furthermore, the research conducted by Leach et al. (2010) illustrates how the challenges of current public governance in addressing epidemics and so-called emerging infectious diseases are directly related to the administration's concern for equity, social justice, and society's well-being so that poor groups are not neglected—and marginalised. The authors conclude that the government's approaches must effectively embrace robustness and resilience strategies to combat epidemics' effects. It is essential to include diversity, flexibility and highlighting alternative ways to achieve a sustainable development policy in these practices. Moore et al. (2011) studied the need for political involvement in the difficulties faced by the marine ecosystem as a result of its pollution and the impact it has on the health of the population living closer to the coast. To address these issues, the authors resorted to various methods. Still, the most relevant and indispensable is implementing integrated global action by national governments, as the local government lacks the necessary resources and the ability to coordinate with other local governments. Therefore, to produce significant results, the collective involvement of several national, regional and global management and administration institutions is needed to create a sustainable environment suitable for future generations. Moreover, assessing the quality of government and well-being is an important fact. Lobonç et al. (2019)

constructed a composite index of the quality of government and citizens' well-being, and its hierarchy emphasised that the Scandinavian countries present the highest scores. The performance in these countries reflected the systematic control from citizens towards the government and reduced corruption. Citizens' confidence in government is reflected in their willingness to pay higher taxes than anywhere else in the European Union, but also significant governmental support through public investments and large social protection expenditures. Moreover, it has been recognised by the literature that corruption can affect both positively and negatively the level of innovation of countries, with direct implications for societal well-being. In this light, Pirtea et al. (2019) addressed this issue regarding the corruption influences and concluded that governmental corruption has a negative impact and affects innovation perspectives.

To assess the capacity to effectively and efficiently provide high-quality services to citizens, Gargiulo and Tremiterra (2015) studied the city of Florence, the importance of the implementation by local governance of many measures to implement new technologies aimed at improving the quality of life, the well-being of urban society, promoting an efficient urban system, sustainable, and competitive. All this materialises Smart City's idea, which is strongly emerging at the European level. Therefore, this paper captures how the relationship between Smart City and territorial competitiveness contributes to establishing metropolitan governance and increases the level of well-being felt by society due to implementing these measures relevant to today's European society. Leväsluoto et al. (2019) are experimenting with innovative public service techniques to increase the population's well-being. Experimental development has been suggested to address slowdown problems and inefficiency in current innovation activities. It also applies to the public sector, which raises specific issues due to traditional bureaucracy and strong professionalism. Thus, clarifying the concept of experimentation and improving the collaboration between local administrations and government policies are among the most important lessons learned.

Since the literature on public governance and the well-being of citizens is vast and complex, but also due to the needs of society to receive, in exchange for their contributions to the public budget, quality services to raise their welfare - we propose to find out the state of knowledge in this field and to make a complex analysis that could be a starting point for future research on public governance concerning the well-being of citizens. For a comprehensive scientific mapping of the existing literature and in-depth investigation of the current state of knowledge in the field, our study

followed the method proposed and used by Lobont et al. (2020), namely bibliometric analysis.

Therefore, to document and be able to refer to those with the most appropriate contributions in this field, we resorted to the bibliometric research tool. Through VOSviewer software, we have managed to organise all the articles made in our area of research. Thus, we have been driven to identify and group by the most used keywords, the most influential authors, and collaborations between certain countries.

Next, we present, step by step, the process by which the articles used to create the bibliometric networks were extracted. Thus, employing the database “Web of Science Core Collection”, we consider the following three concepts: “Governance”, “Challenge”, “Wellbeing”, and for the type of included documents, we considered: “Article”, “Proceeding Papers”, “Book Chapters”, “Review Articles”, “Editorial Materials” and “Early Access”. Finally, the analysis period between the years 2000-2022 was considered, but the first year in which articles published on the topic began to appear was 2005. Therefore, Web of Science provides 291 results, and these were downloaded in a “.txt” file that we entered in the VOSviewer software for analysis (Van Eck & Waltman, 2019), according to the following steps:

- a. Web of Science – Clarivate (Analytic database):
 - The subject of the research: “Governance”, “Challenge”, and “Wellbeing”;
 - Period: 2005-2022;
 - Documents type: “Article”, “Proceeding Papers”, “Book Chapters”; “Review Articles”, “Editorial Materials”, and “Early Access”.
- b. VOSviewer Instruments:
 - Recorded content for VOSviewer: Full text and cited references.
- c. The analysis was based on:
 - keywords;
 - citations/countries;
 - citations/authors.

Keyword analysis allows us to count and expose the most common ones. Usually, we report according to their frequency in the selected documents. The primary purpose is to extract the keywords most used by the authors who approach the field of public governance and the welfare of society.

In addition to the three keywords considered in the initial search of the subject of the analysis (Governance, Challenge, and Wellbeing), the network given by VOSviewer also presents other keywords (Figure 1) that

appear mainly in the articles: “climate change” (with 38 appearances), “management” (with 37 appearances), “policy” (with 31 appearances), “ecosystem services” (with 29 appearances), “sustainability” (with 23 appearances), “health” and “resilience” (with 22 appearances).

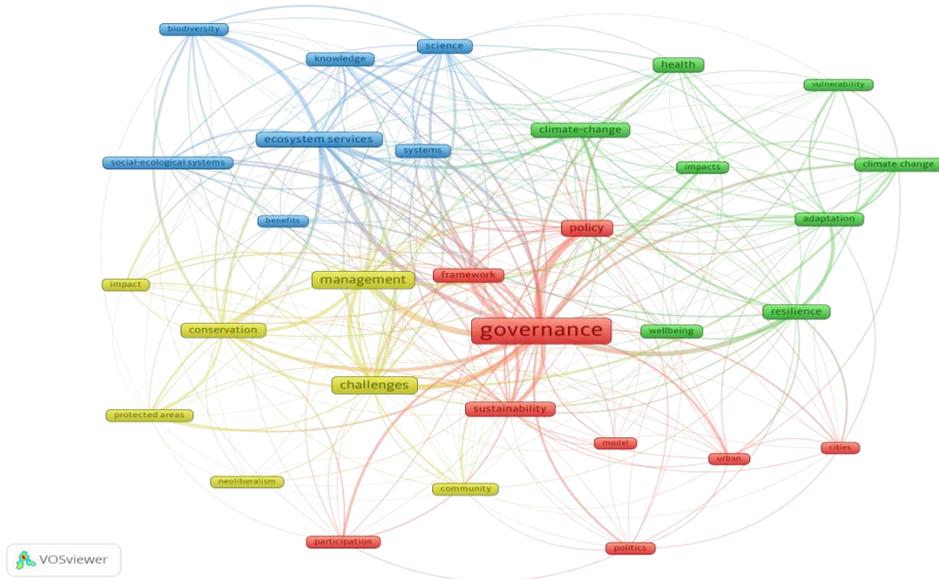


Figure 1. Keywords network. Source: Own process in VOSviewer (Van Eck & Waltman, 2019)

Figure 1 evidence the most important keywords and the links between them; the higher the nodes and the keyword, the higher the frequency of the keywords; when the distance between the nodes is greater, the connection between them is weaker. At the same time, the thicker the lines, the more frequent the coincidence. A group of keywords or a series of related keywords is indicated in the same colour. Figure 1 points out the most frequently occurring keywords (applying a threshold of 10 occurrences). The largest group is the red group, which focuses on words such as “governance”, “sustainability”, “policy”, or “model”. The next group is the green one, where keywords such as “resilience”, “wellbeing”, or “health” dominate. The third group focuses on words such as “science”, “systems”, or “ecosystem services”. The last and smallest, the yellow group, consists of the terms “management”, “challenges”, and “community”. The entire groups are detailed and can be observed in Table 1.

Table 1. Keyword groups.

Group 1 (Red)	Group 2 (Green)	Group 3 (Blue)	Group 4 (Yellow)
Cities	Adaptation	Benefits	Challenges
Framework	Climate change	Biodiversity	Community
Governance	Climate change	Ecosystem services	Conservation
Model	Health	Knowledge	Impact
Participation	Impacts	Science	Management
Policy	Resilience	Social-ecological systems	Neoliberalism
Politics	Vulnerability	Systems	Protected areas
Sustainability	Wellbeing		
Urban			

Source: author's processing in VOSviewer

Therefore, group 1 is related to sustainable development over time, focusing on administrative and structural aspects and policy models that can bring and increase societal well-being. In contrast, group 3 is focused on the theoretical, technical, and professional parts. It follows how services and systems adapt to the needs of societies, considering ecological components. Group 2 contains factors with vulnerabilities in achieving the objective of including society's well-being. Thus, health is vital in people's lives, and resilience and climate change affect it negatively. Finally, group 4 summarises how society feels the impact of management specific to conservative, neoliberal or ecological policies.

The analysis of the “scientific co-authorship” in terms of the number of documents, citations and countries focuses on the research area of the network of the principal authors and countries. This first network of citations concentrates on the three concepts of analysis (governance, challenges, and well-being), considering only the authors who published at least two articles indexed in the Web of Science Core Collection database. Figure 2 highlights the network of authors, grouped into 12 groups.

VOSviewer offers the following results for the most-cited authors: all authors have two documents (excepting Yigitcanlar T. with 3 documents). Most authors are below 200 citations (including those in the red group, which turns out to be the one with the strongest links), with the only authors above 200 being the authors of group 6 (cyan) and group 12 (light blue). Details on the number of documents and citations are included in Table 2.

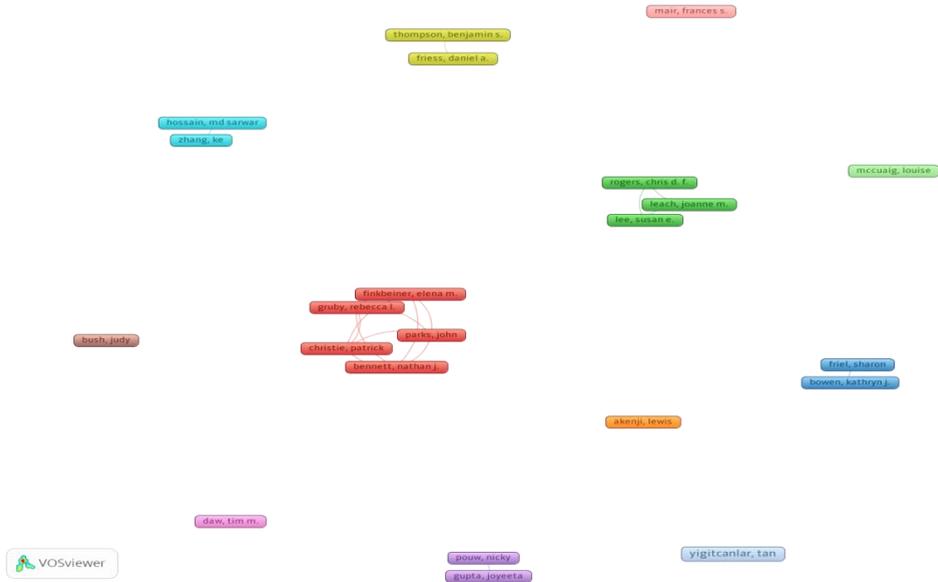


Figure 2. Network of co-authors, based on the number of documents per author. Source: author's processing in VOSviewer.

Table 2. Groups of papers and citations by the author.

Group	Authors	Doc./Cit.	Binding Strenght
Group 1 (red)	Bennet N.	2/147	7
	Christie P.	2/147	7
	Gruby R.	2/147	7
	Parks J.	2/147	7
	Finkbeiner E.	2/72	4
Group 2 (green)	Leach J.	2/35	4
	Lee S.	2/35	4
	Rogers C.	2/35	4
Group 3 (yellow)	Friess D.	2/62	2
	Thompson B.	2/62	2
Group 4 (dark blue)	Bowen K.	2/20	1
	Friel S.	2/29	1
Group 5 (purple)	Gupta J.	2/30	1
	Pouw N.	2/24	1
Grup 6 (cyan)	Hossain MD.	2/229	1
	Zhang K.	2/225	1
Group 7 (orange)	Akenji L.	2/177	0
Group 8 (brown)	Bush J.	2/22	0
Group 9 (magenta)	Daw T.	253	0
Group 10 (pink)	Mair F.	2/59	0
Group 11 (lime)	Mccuaig L.	2/28	0
Group 12 (light blue)	Yigitcanlar T.	3/225	0

Source: author's processing in VOSviewer.

The first group (red) contains 5 authors. At the same time, this group can be considered the main one from the citation perspective. In this case, in group 1 all authors have an equal impact since they all have the same number of published documents (2) and the same number of citations (147), except Finkbeiner E. with 72 citations. From the perspective of citations, the next cluster in terms of impact are those from group 6, which registers a number of 229 citations (Hossain MD.), respectively 225 (Zhang K.). Then

we have group 7 with 177 citations (Akenji L.). Group 2 also stands out as important because the authors each have an equal number of citations (35) and documents (2) and a link strength of 4. Finally, we have group 12, in which Yigitcanlar T. stands out both by the number of citations (225) and the position of being the only author with 3 published documents, and the rest of the authors with a number of citations below 100 and a link strength below 3.

In the last part of the bibliometric analysis, we approached the study of scientific co-authorship of countries based on a sample of 291 documents. The map (Figure 3) highlights the links and collaborations between member authors of different countries. Therefore, the map reveals the degree of communication between the countries and those with the most influential roles in governance and citizens' well-being. Figure 3 contains groups of different colours with significant links between them. England, USA, Australia, Canada, Netherlands, and Germany are the most influential countries in our analysis, the ones that have the most significant nodes. We can see that the links between the most important countries are also the strongest. At the same time, if we look at the thickness of the lines, we can see close links between the countries in the red group and those in the green and blue, and most of these essential relations include countries in our sphere of analysis and research (England, Germany, Netherlands, and Sweden).

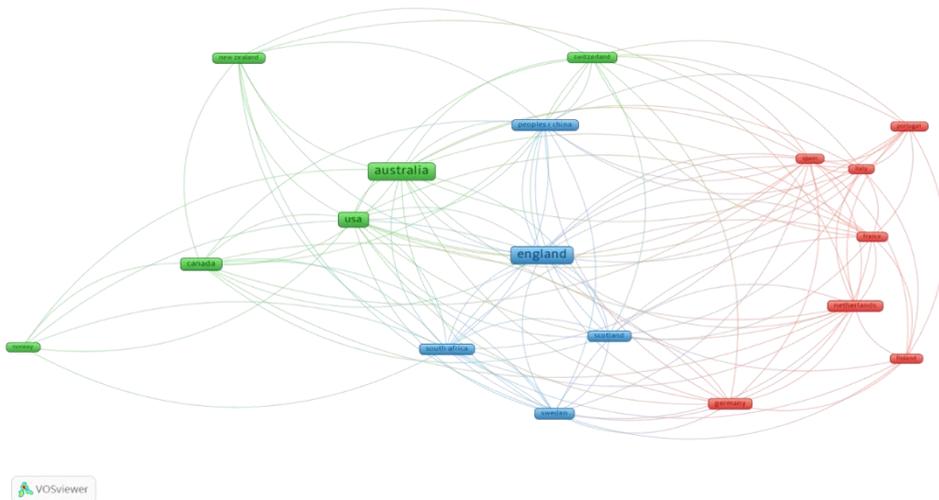


Figure 3. Scientific co-authorship network, based on the countries where the documents were published.

Source: author's processing in VOSviewer.

Table 3. Article groups by countries.

Group	Authors	Doc./Cit.	Binding Strength
Group 1 (red)	Finland	9/361	17
	France	9/263	22
	Germany	20/659	28
	Italy	9/213	19
	Netherlands	20/402	27
	Portugal	9/87	17
	Spain	10/104	24
Group 2 (green)	Australia	76/1313	79
	Canada	33/929	45
	New Zealand	15/253	23
	Norway	11/180	16
	Switzerland	12/239	27
	USA	50/1049	74
Group 3 (blue)	England	76/1928	94
	Peoples R China	19/396	35
	Scotland	22/440	30
	South Africa	17/264	34
	Sweden	17/681	35

Source: author's processing in VOSviewer.

According to Table 3, the most significant influence in the area of governance analysis and its impact on the well-being of citizens was in England (76 documents), Australia (76 documents), USA (50 documents), where the most documents were published. The highest number of citations was found in countries such as England (1928 citations), Australia (1313 citations), the USA (1049 citations), Canada (929 citations) and Sweden (681). But even so, in each group, except group 2, the majority are European countries. At the same time, group 1 is composed entirely of EU member states, making the studies carried out in the European Union area more relevant. Moreover, we find countries such as England, the Netherlands, Sweden and Germany, which according to the present analysis, have obtained a significant number of documents and citations, indicating that these countries address in a broad sense the issue of governance efficiency and its influence on the welfare of society.

3. Materials and Methods

At the same time, it is increasingly important to provide the best living conditions for all the citizens of a country, regardless of the region and subregions of origin respectively the diversity of the types of problems they face and must be solved. This depends mainly on the quality of the act of public governance, respectively on its measures to increase citizens' quality of life.

Thus, the well-being of society is mainly about the quality of life, or rather, the way the community feels about the quality of government decisions and how it deals with new or existing problems in everyday life, such as pollution, traffic, health system quality, criminal security, and purchasing power. Considering citizen's quality of life as a necessary feature for assessing the level of well-being and the effectiveness of governance as an essential aspect for measuring the performance of public governance, several methodologies specific to empirical analysis have been used, as follows:

- (i) Analytical approach involving data mapping;
- (ii) Vector quantisation, using KNIME software and K-means algorithm to obtain a clustering for the available data set;
- (iii) Hierarchical clustering to segment the EU-27 Member States into clusters based on the similarities between the six dimensions of governance and the quality-of-life index.

Therefore, in choosing the data set, the primary evidence in the literature was considered, which led us to include in the data set the dimensions of governance and the global index of quality of life, as follows:

- Societal wellbeing index: "Quality of Life Index" (Qlty_life) (the unit of measurement is not clearly defined, the indicator is calculated according to the following empirical formula: $\text{index.main} = \text{Math.max}[0, 100 + \text{purchasingPowerInclRentIndex} / 2.5 - (\text{housePriceToIncomeRatio} * 1.0) - \text{costOfLivingIndex} / 10 + \text{safetyIndex} / 2.0 + \text{healthIndex} / 2.5 - \text{trafficTimeIndex} / 2.0 - \text{pollutionIndex} * 2.0 / 3.0 + \text{climateIndex} / 3.0]$).

- Administration/Governance indicators: "Voice and Accountability (Voice_account)"; "Political Stability and Absence of Violence/Terrorism (Polit_stab_abs_v)"; "Government Effectiveness (Gov_eff)"; "Regulatory Quality (Reg_qlty)"; "Rule of Law (Rule_law)"; "Control of Corruption (Corrupt_ctrl)". All values are the units of standard normal distribution, with an average of 0 and a standard deviation of 1, taking values from -2.5 to 2.5.

Data for the administration were taken from the WGI - World Governance Indicators database and societal wellbeing in the Numbeo

database. The variables involved in our analysis are statistically detailed in Table 4:

Table 4. Descriptive statistics, EU-24, 2020.

Variable	N	Mean	Standard Deviation	Min	Max
Qlty_life	24	160.183	19.306	128.160	192.670
Polit_stab_abs_v	24	0.690	0.241	0.130	1.030
Corrupt_ctrl	24	1.037	0.774	-0.270	2.270
Gov_eff	24	1.024	0.607	-0.220	1.950
Reg_qlty	24	1.102	0.484	0.380	1.850
Rule_law	24	1.084	0.610	-0.090	2.080
Voice_account	24	1.068	0.373	0.260	1.620

Source: author's processing in Stata 17.

The main dimensions of governance are illustrated in Figure 4, an EU-24 perspective. The results show the following: the highest values for most indicators are recorded for the countries which are situated in the north, centre and north-west of the European Union, countries such as Denmark, Sweden, Finland, Austria, the Netherlands, Estonia, Germany and then the UK, Ireland, Belgium, France, and even Portugal. Atypical is that the UK and France are still in the weakest category despite the record high values in most indicators, we can see for Polit_stab_abs_v (Figure 4a). Even for Germany, the score is below average. At the other end of the spectrum, countries such as Romania, Bulgaria, Poland, Italy, Greece, and Hungary, countries in the southern, south-eastern, and eastern parts of the European Union, have the lowest values for governance indicators.

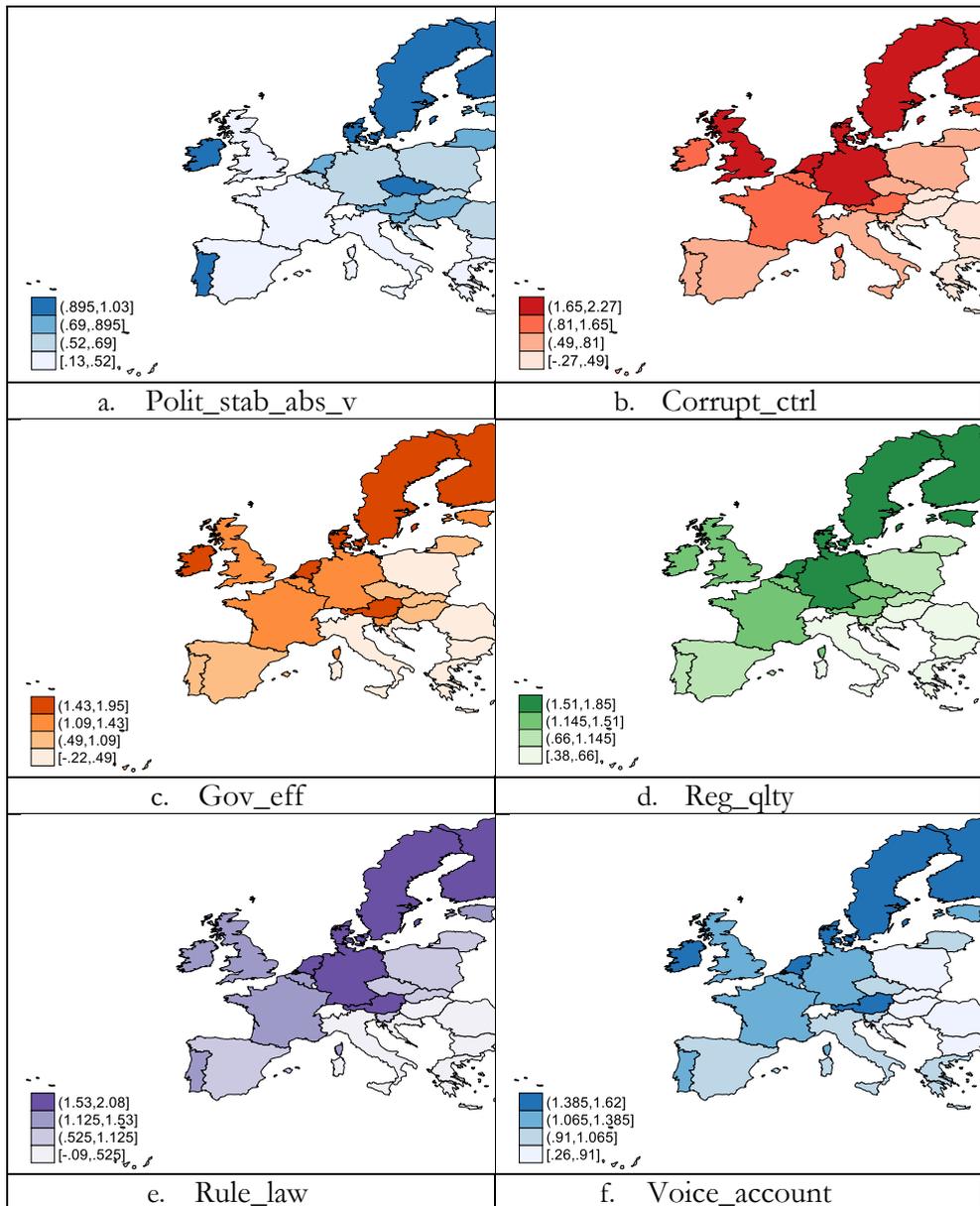


Figure 4. Administration/Governance in EU-24, 2020: (a) Political Stability and Absence of Violence/Terrorism; (b) Corruption Control; (c) Government Effectiveness; (d) Regulatory Quality; (e) Rule of Law; (f) Voice and Accountability. Source: author's processing in Stata 17.

In correlation with the Quality of Life global index (Figure 5), we notice that in 2020 the highest values were recorded in the same regions of the European Union by countries such as Germany, Austria, Denmark, the Netherlands, Finland, and Estonia. On the other hand, the lowest values are in the same areas where common values for governance were recorded, in countries such as Romania, Hungary, Bulgaria, Greece, Italy, and Poland.

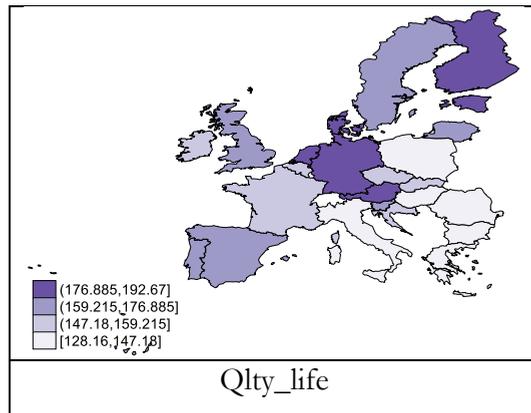


Figure 5. Societal wellbeing in EU-24, 2020: Quality of Life Index. Source: author's processing in Stata 17.

The technique by which data set analysis is possible is called data mining. New structures and previously unknown relationships can be identified and extracted with them. Following the data extraction process, obtained information can be considered an added value for creating national or global strategies and at all stages of the decision-making process.

The main topic of data mining is cluster analysis and represents a significant area of research (Zou, 2019). This type of analysis, called cluster analysis, is a quantitative form of grouping data into categories depending on their specific similarities and differences, based on this statistical data processing method. Creates data groups using several algorithms and grouping methods, compressing all of them into one (Frades & Matthiesen, 2010). Also, the algorithm K-means can balance the elements within a group and their diversity to agglomerate as many similar features within a group but keep the groups as far apart as possible. The K-means algorithm can be applied by employing the KNIME software. This platform allows data extraction, integration, reporting and analysis while having various machine learning components.

The component stages of our analysis start with identifying problems, setting goals, and collecting data, then processing and analysing

them using data mining functions, clustering them using the K-means - KNIME algorithm, evaluating the quality of clustering and interpreting the results:

- I. Problem Identification;
- II. Setting Goals;
- III. Collecting Data;
- IV. Using Data Mining Functions;
- V. Clustering Using K-mean Algorithm – KNIME Software;
- VI. Euclidean distance;
- VII. Concluding Results.

The data set was processed only for 2020 to obtain a fair comparison in creating clusters for the EU-24 Member States. K-means algorithm is a vector quantisation method, which is the basis of the methodology we used in the KNIME software.

The data clustering stages which employ the K-Means algorithm are:

1. Select how many clusters to be included.
2. Finding the centroid (midpoint) value in compliance with the number of selected clusters.

$$M_x = \min + \{[(x-1) * (\max - \min)] / t\} + [(\max - \min) / (2 * t)] \quad (1)$$

where:

M_x = midpoint of class “x”

min = the continuous data category with the lowest value

max = the discrete data category with the highest value

t = total number of discrete classes.

3. Distributing every data to the nearest centre of the cluster.

$$L_c = [(\sqrt{(O_x - T_x)^2}) / [(O_y - T_y)^2]] \quad (2)$$

where:

L_c = distance from cluster centroid to data

O = data records

T = data midpoint

4. Determining the new cluster midpoint.

$$M_x = (D_x + \dots + D_t) / \Sigma D \quad (3)$$

where:

M_x = midpoint of class “x”

D_1 = value of $x = 1$

D_t = data record value to t

ΣD = total number of data records.

At the same time, measuring the distance from the centre of the group to a specific data value represents another procedure performed by

the k-means algorithm. Thus, the Euclidean distance, whose formula is applied and calculated, looks as follows:

$$Ed(x, y) = (X1x-X1y)^2 + (X2x-X2y)^2 + \dots + (Xkx-Xky) \quad (4)$$

where:

Ed (x, y) = the distance from “x” to midpoint “y”

Xki = the data to “x” on attribute data to “k”

Xkj = the centre point to “y” at attribute to “k”.

One of the main advantages of KNIME software is the variety of programming languages and its machine learning abilities. The component nodes of a workspace (shown in Figure 6) that aims to obtain a KNIME clustering are grouped as follows:

Orange: for taking input data - Excel Reader;

Green: the clustering algorithms – K-Means and Hierarchical Clustering;

Blue: customisation and displaying output data – Color Manager, Interactive Table (local), Scatter Plot (local), Shape Manager.

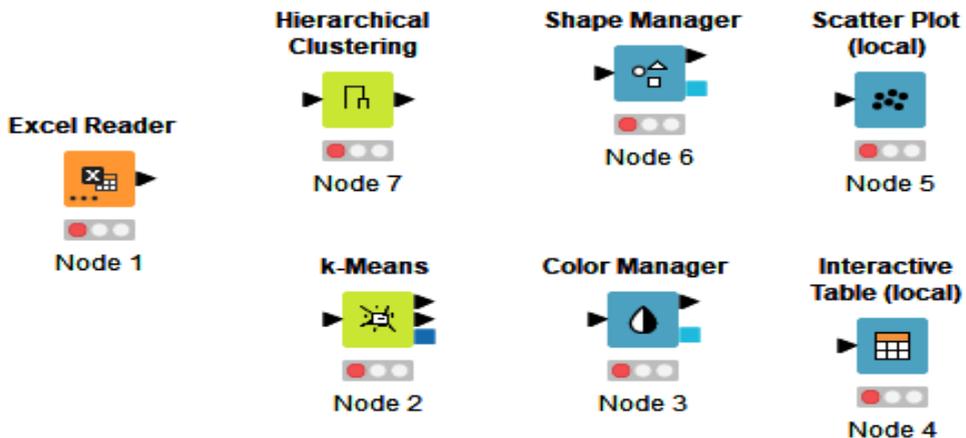


Figure 6. Nodes used in KNIME workspace. Node 1 – Excel Reader; Node 2 – K-Means; Node 3 – Color Manager; Node 4 – Interactive Table (local); Node 5 – Scatter Plot (local); Node 6 – Shape Manager; Node 7 – Hierarchical Clustering. Source: author’s processed data in KNIME software.

To configure the clustering, it will be necessary to establish the connections between the nodes in the form of a workflow after was established the network of nodes that will perform the ranking and clustering of EU-24 Member States based on selected indicators. Therefore, the analysed period is limited to 2020, considering both types of hierarchies. Thus, the dendrogram is necessary to be obtained to allow an intuitive

hierarchy, and then the K-means clustering also, which enables the segmentation of data into sets of “k” groups, offering the possibility to observe each country in its group with similar countries, non-overlapping with another one from another group.

4. Results

To begin, the cluster analysis created groups containing the EU-24 Member States in the context of governance and welfare indicators. At the same time, it was possible to group, visualise and associate the countries with each other based on the values of the indicators due to the vector quantisation method. Based on Euclidean distance and single connections, hierarchical clustering in KNIME was applied, and the dendrogram (shown in Figure 7) was obtained.

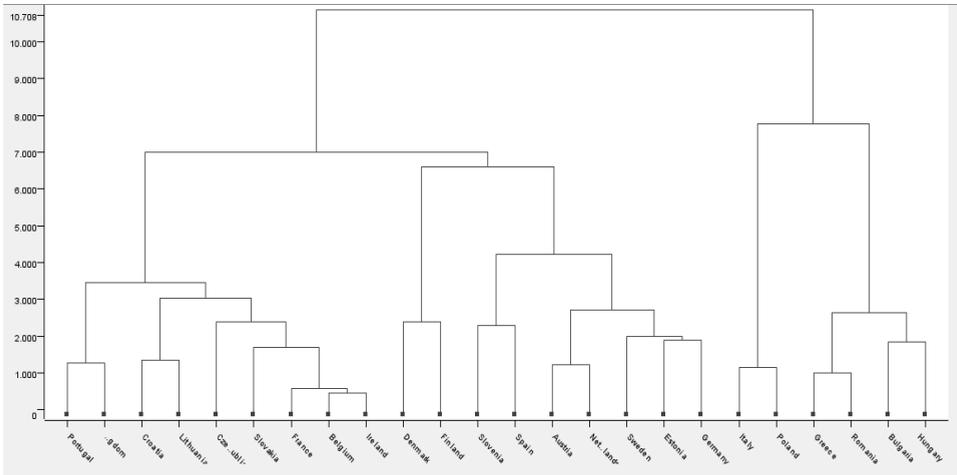


Figure 7. Dendrogram of clusters. Source: author’s processed data in KNIME software.

The dendrogram evidences the distance between the formed groups and the analysed countries, using a scale that starts from the value of 0 and reaches up to about 10.7. It can be seen how, as we move towards the maximum value of the scale used in the dendrogram, the distance between the clusters is greater. At the same time, the considerable distance between the groups shows a significant discrepancy that they have with each other. The primary purpose of this section is to group the countries in the analysis to evaluate each of the independent variables (the six dimensions of Governance) and the dependent variable (Quality of life), all to examine the quality of life for each specific group and country.

Compared to the method of analysis and grouping in the form of a dendrogram, where the groups are formed intuitively, the figure below can be observed as another way to group these countries for visualisation. Thus, the KNIME software made it possible to make a tabular representation of these countries and categories according to the same data considered when creating the dendrogram. Thus, in Figure 8, we can visualise the nodes chosen to obtain the dendrogram from Figure 7 and the tabular analysis presented in Figure 9.

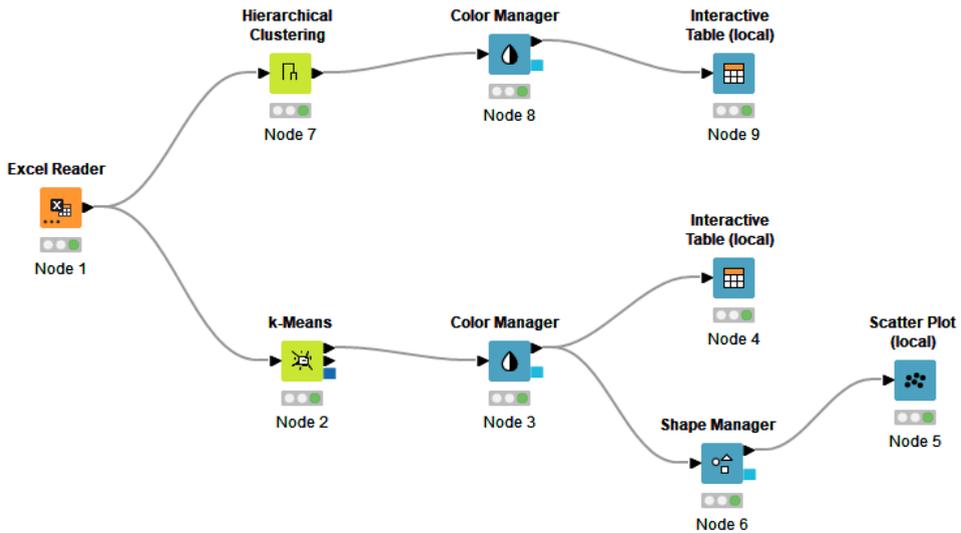


Figure 8. KNIME elements. Source: author’s processed data in KNIME software.

Each element, called nodes, is necessary to reach the expected result. In obtaining the relevant results, the decisive nodes are node 2, “K-Means”, and node 7 “, Hierarchical Clustering”. Thus, the upper node (hierarchical clustering) path was used to obtain the dendrogram in Figure 7, starting from the data set taken from node 1 and continuing through node 7. The lower path (K-means) was used for the tabular representation of this information, according to Figure 9, which also originates in node 1 and whose route is continued through node 2. Due to its interactivity feature, the table allowed us to sort the data by several categories, among which we chose the alphabetical sort of these countries, as shown in Figure 9.

▲ Row ID	D Political...	D Control of	D Govern...	D Regulat...	D Rule of ...	D Voice a...	D Quality ...	S Cluster
Austria	0.85	1.51	1.66	1.4	1.81	1.4	182.5	cluster_2
Belgium	0.59	1.48	1.12	1.35	1.37	1.28	153.47	cluster_1
Bulgaria	0.47	-0.27	-0.07	0.52	-0.09	0.26	129.8	cluster_0
Croatia	0.61	0.2	0.44	0.43	0.29	0.58	159.01	cluster_1
Czech Republic	0.92	0.59	0.96	1.24	1.06	0.98	156.24	cluster_1
Denmark	0.94	2.27	1.89	1.79	1.86	1.52	192.67	cluster_2
Estonia	0.71	1.61	1.34	1.54	1.38	1.17	177.82	cluster_2
Finland	0.94	2.2	1.95	1.85	2.08	1.62	190.22	cluster_2
France	0.31	1.15	1.25	1.2	1.33	1.07	153.95	cluster_1
Germany	0.67	1.86	1.36	1.58	1.56	1.38	179.78	cluster_2
Greece	0.13	0.06	0.44	0.55	0.32	0.97	133.07	cluster_0
Hungary	0.86	0.1	0.58	0.48	0.51	0.39	128.16	cluster_0
Ireland	0.98	1.57	1.48	1.47	1.5	1.39	153.53	cluster_1
Italy	0.44	0.54	0.4	0.5	0.24	1.06	140.76	cluster_0
Lithuania	0.87	0.81	1.06	1.09	0.99	1.01	159.42	cluster_1
Netherlands	0.85	2.03	1.85	1.75	1.76	1.53	183.67	cluster_2
Poland	0.57	0.65	0.38	0.89	0.54	0.62	141.83	cluster_0
Portugal	1.03	0.75	1.02	0.83	1.18	1.26	162.91	cluster_1
Romania	0.59	-0.03	-0.22	0.38	0.37	0.58	132.44	cluster_0
Slovakia	0.64	0.44	0.54	0.78	0.68	0.88	152.53	cluster_1
Slovenia	0.71	0.81	1.17	0.92	1.07	0.94	172.15	cluster_2
Spain	0.4	0.74	0.89	0.77	0.9	1.01	169.82	cluster_2
Sweden	1.02	2.13	1.72	1.68	1.81	1.5	175.95	cluster_2
United Kingdom	0.47	1.69	1.38	1.48	1.5	1.25	162.71	cluster_1

Figure 9. The distribution of countries into clusters is based on Governance dimensions and the Quality of Life Index. Source: author’s processed data in KNIME software.

To perform the analysis and tabular representation, it was necessary to create the database with indicators and introduce an ID row to identify each variable and correlate its value with its country; the reference year is 2020. Then we chose the necessary nodes, established the connections, and configured them. In the beginning, the node that records the values from the excel file was adjusted, and the K-means algorithm was introduced to create and apply the distribution on clusters. Furthermore, only 3 groups of countries (clusters) were formed. To establish the colour of each cluster, a new node was introduced, which was then linked to the last node that allows us to view the processed data in the form of an interactive table.

Consequently, the data in the table are distributed as follows: the “Row ID” column contains the names of the states in the model, and the “D” type columns refer to the analysed indicators and their values (the indicators being ordered as follows: Political Stability and Absence of Violence, Corruption Control, Government Effectiveness, Regulatory Quality, Rule of Law, Voice and Accountability, and Quality of Life), and the “S” type column indicates in which group of countries (cluster) each country was distributed. At the same time, for the easy identification of the categories, a square of the colour corresponding to the cluster in which the country next to it falls is presented before the first column.

The groups obtained from the distribution are consistent and reasonably balanced; the countries that are part of them have similar values in all recorded values. Evaluating the groups received, the results highlight

that the Regulatory Quality indicator takes values between 128.16 - 141.83 for group 0 (red), then we have group 1 (yellow), which reaches values between 152.53 - 162.91 and finally, we have group 2 (green) which records values in the range 169.82 - 192.67.

Continuing with the indicators of public governance, Political Stability and Absence of Violence register the lowest values in groups 0 (red) and 1 (yellow), respectively 0.13 and 0.31. The maximum value is found in groups 2 (green) and 1 (yellow), which contain values of 1.02 and 1.03. For Corruption Control, the minimum values are recorded by Romania and Bulgaria (-0.03 and -0.27), while the maximum is obtained by Finland and Denmark (2.20 and 2.27). The effectiveness of the Government also records minimum values for Bulgaria and Romania (-0.07 and -0.22), and the maximum values are again obtained by Finland and Denmark (1.95 and 1.89). The Regulatory Quality indicator shows minimum values for Romania and Croatia (0.38 and 0.43), while Finland and Denmark remain at the top (1.85 and 1.79). The rule of law is the lowest for Italy and Bulgaria (0.24 and -0.09), while Denmark and Finland's maximum is also given (1.86 and 2.08). The last indicator, Voice and Responsibility, counts the lowest values for Bulgaria and Hungary (0.26 and 0.39) and the highest for Finland and the Netherlands (1.63 and 1.62).

5. Limits and Discussion

This paper's research objective was to map the channels through which public governance can significantly contribute to societal well-being and manages to illustrate graphical representations and geographical reports of European countries. The data were selected for 2020, limited by the Quality of Life Index to only 24 EU Member States. Thus, Cyprus, Luxembourg, Latvia, and Malta were excluded, but the United Kingdom was included in the model due to its membership until 31 January 2020.

The flow of selected data, processed in the KNIME analytic platform, guides the analysis on the path of intuitive formation of 3 clusters of countries, as Table 5 shows:

Table 5. Country distribution in groups, based on Figure 9, EU-24.

Cluster 0 (red)	Cluster 1 (yellow)	Cluster 2 (green)
Bulgaria	Belgium	Austria
Greece	Croatia	Denmark
Hungary	Czech Republic	Estonia
Italy	France	Finland
Poland	Ireland	Germany
Romania	Lithuania	Netherland
	Portugal	Slovenia
	Slovakia	Spain
	United Kingdom	Sweden

Source: author's processing in KNIME.

Given the clustering of countries, peoples and especially geographical positioning, we conclude that the Germanic nations (Anglo-Saxon, Nordic), more precisely those located in the centre, north and northwest of the European Union, have the highest values for most indices analysed (group 2 - green), while at the opposite end are the Latin and Slavic countries, more precisely those states located in the eastern, south-eastern and southern part of the European Union (group 0 - red).

We can notice that the western and southwestern part is balanced and is located, in most cases, in the middle category (group 1 - yellow). Therefore, a country is likelier to have low values in the eastern, south-eastern and southern parts of Europe. In contrast, countries in the northern and central parts tend to have higher values for both analysed dimensions (public governance and societal well-being).

It should also be noted that the time when a country joined the European Union is also a factor that we can consider. Therefore, we have countries with high values for governance and well-being; these countries are also considered veterans (Denmark, Germany, Netherlands, Austria, Sweden, Finland) and low-value countries that are recent members (Romania, Bulgaria, Poland, Hungary, and Slovakia). But even so, there are exceptions, such as Greece and Italy, which are long-standing states in the European Union but register low values. Our results complement the research of Cernakova and Hudec (2012), who performed a cluster analysis by considering only one of the variables analysed within this paper and using 75 European cities instead of countries. Still, the results also attested high values for Nordic and central European cities compared to south and eastern ones in the analysed clusters.

6. Conclusions

Our research analyses the links between public governance and social welfare, graphically exposing the discrepancies between the EU-24 Member States, considering the indicators of both dimensions studied. Therefore, the results obtained in the current research reinforce the conclusions of other studies, which state that public governance has a significant impact and produces considerable effects on social welfare, as reported by Carcaba et al. (2017).

The methodological approach involved bibliometric analysis in obtaining the most important keywords, co-authorship and the most influential countries in which the articles from our research area were mainly published. Scientific mapping has revealed that, in addition to the keywords considered in the initial search for the subject of the analysis (government, challenges and well-being), the network provided by VOSviewer has other associated keywords, namely “management”, “health”, “climate change”, “sustainability” and “resilience”, representing the main orientations of the contemporary society in the context of ensuring the well-being. Therefore, the focus of public governance must be on prioritising sustainable development, focusing on the challenges of achieving it without damaging the natural ecosystem, namely climate change. The government has also proven to depend on management, with the decision-making mechanism influencing people's well-being. Moreover, the scientific co-author highlighted the countries where the most studies on our topic have been published: England, Australia, the USA, Netherlands, and Germany; a considerable number of governance and welfare studies from the EU.

Cluster analysis was also applied, performing the method of relative distances, to create a dendrogram that groups the EU Member States according to their similarity, depending on the six dimensions of governance and the Quality of Life Index. At the same time, the K-means algorithm was also used to achieve a preferential grouping of the EU Member States into three different clusters, involving the same indices as in the hierarchical clustering, namely dendrogram. The availability and relevance of the data generated a first limitation of the research, reducing the group of EU-27 countries to EU-24. Cyprus, Luxembourg, Latvia, and Malta were excluded, and the United Kingdom was included in the model due to its membership until 31 January 2020. An analytical approach involving data mapping exposed the discrepancies between the EU-24 Member States, also mapping them. Thus, we observed, through intuitively visual representation, that the countries in certain areas (such as northern and central) have very high

values, while countries positioned in other regions (such as south and east) have a low score.

Furthermore, hierarchical clustering was applied, whose purpose was to divide the EU-24 Member States into clusters based on the similarities between the six dimensions of governance and the quality of life index. The results displayed a graphical representation in a dendrogram revealing the links and the discrepancies between the analysed countries. Therefore, the most similar countries/groups are always prioritised, with high similarities between countries in the groups at the bottom of the hierarchy (Denmark and Finland), while larger groups at the top of the hierarchy will include more states. Still, their similarity is much lower (Romania and Portugal).

In performing vector quantisation, the K-means algorithm was applied in KNIME software. The results highlight another type of hierarchy obtained whose objective was to divide the EU-24 Member States into three clusters (groups of similar countries). Thus, cluster 2 (green) includes the most advanced countries in terms of welfare and governance (Denmark and Finland). Then, the results indicate cluster 1 (yellow), which contains countries with moderate values that should pursue an improvement (France, UK, and Portugal). Finally, we have cluster 0 (red), which exposes the most defective countries. It is necessary to adopt measures to increase the standard of living and administration quality (Romania, Poland, and Greece).

Therefore, measures to improve public governance may include: adopting more straightforward methodologies, focusing on improving the skills of staff and services provided, meritocracy, and decision-making transparency. On the other hand, specific measures to enhance well-being are limited to a regulated system through which the citizen is protected in terms of sustainable development.

The study's preliminary results suggest the need to improve and strengthen the public governance of the states in some regions of the European Union to approach strategies aimed at improving the welfare of citizens and reducing the considerable discrepancies between the EU member states. Thus, it is much more essential for countries with higher values to maintain current levels and continue to improve them. In contrast, countries with shallow scores are more important to improve them by adopting more efficient strategies constantly, decisions, norms, and regulations modelled on countries that have demonstrated the quality of public governance.

The study's main limitations are represented by the unavailability of data for all EU Member States and the inclusion of a limited number of indicators expressing the two phenomena of the research. Therefore, future

studies may include all EU-27 Member States, considering several indicators descriptive of the analysed dimensions or others considered more qualitative or representative.

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