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X-STATIS: A Multivariate Approach to Characterize the Evolution of E-Participation, from a Global Perspective

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Abstract: This paper aims to categorize countries by their e-participation index, according to political, capacity, and governmental environment factors; examine how they are projected based on these factors; and analyze whether this projection corresponds to the current state of e-participation development. It is the first study to provide an overview of the e-participation level using multivariate analysis techniques for three-way data analysis, specifically, the X-STATIS methodology and cluster analysis. These techniques enable the simultaneous representation of countries, factors, conditions, trajectories, and groupings, taking into account national conditions in the evolution of e-participation from 2008 to 2016. The results show that when the conditions of each country interact with the level of e-participation development, and depending on the economic development, 7% of countries are lagging behind in e-participation evolution, given their institutional and political capacity. This delay is particularly relevant in countries that enjoy a higher level of socioeconomic status. Meanwhile, 38% are above the level they would correspond to.

Keywords: X-STATIS; multivariate statistics; e-participation; e-government; classification, clustering; human capital index; gross domestic product per capita

MSC: 62-00

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1. Introduction

A fundamental element for the development of any representative democracy is citizen participation, defined as any activity carried out by citizens, individually or collectively, aimed at directly or indirectly influencing public policies in order to make them more suitable to general interests [1]. In this sense, the United Nations defines e-participation as the process of citizen participation through Information and Communication Technologies (ICTs) in policy design, decision-making, and service, so that it is participatory, inclusive, and deliberative (UN, [2]). This definition implies an improvement in the quality of public policies and in the relationship between citizens and the central government [3].

Fortunately, the use of the Internet has allowed us to overcome many of the technical barriers that hindered a fluid relationship between citizens and the Public Administration, allowing the dissemination of information and the reduction of printing and distribution costs [4], as well as the possibility of interaction between administration and user, enabling citizens to not be mere recipients but to participate, propose, and freely inform themselves about the functioning of the administration [5].

Initially, electronic transparency was configured as a useful mechanism to increase citizens' confidence in governments and improve the assessments of political management [6]. Subsequently, e-government, defined as a new form of government that uses ICT to manage planning activities and information administration related to public administration dependencies [7], began to be conceived as a way in which information technologies could be used to simplify and improve transactions between government and other agents [8], changing both the provision of public services and the broader field of interactions between citizens and the government [9]. In this way, e-government would erase the barriers of time and space for citizens in their dealings with the Public Administration, perceived as an entity at their service [10]. At the same time, it would allow citizens to take part in democratic institutions and political processes [8,11], portraying governments as accessible, transparent, responsible, effective, and participatory [6].

Empirically, various authors have analyzed the degree of development of e-government [12–15], focusing on the relevance of disclosed financial and budgetary information [16,17] and on the explanatory factors of such practices [11,18–22]. More recently, these analyses have been extended to the disclosure of information on sustainability and its determinants [23,24]. However, these studies have a common limitation: they ignore the role that e-government can play in the citizen participation processes [25]. Recently, studies such as Alathur et al. [26] have focused on analyzing developed models that achieve greater citizen participation. Krishnan et al. [27] show that ICT infrastructure has a positive impact on government willingness.

In this context, e-participation contributes to the increase and progress of communications between the citizens and governing politicians [28] and therefore, in democratic processes [29].

Regarding the determinants of the development of e-participation, the evidence is more limited. The works of García-Sánchez et al. [5], Åström et al. [30], and Jho and Song [31] point to politicians, the democratic or non-democratic state of the country, and the interaction of politics with technological development as determinants. In this sense, for Jaeger [32], significant technological development is insufficient if it is not accompanied by institutional democracy. In this regard, Lee et al. [33] state that policy change is strongly linked to the development of e-government, while a country's e-participatory development is connected to internal factors such as political norms and citizen pressures.

Consequently, this work integrates previous studies with a new perspective that allows advancing in the understanding of the current state of e-participation and the state in which online citizen participation should evolve according to the conditions of each country, using the United Nations e-participation index (EPI) for this purpose, an important data source on e-participation progress around the globe (UN, [2]). It presents a different and novel approach, as it shows at what level the e-participation indices of countries should be. The current state and evolution between 2008–2016 are analyzed, identifying clusters of countries based on their degree of development. Specifically, the situation is analyzing using multivariate analysis through a three-way technique known as X-STATIS or Triadic Partial Analysis.

In summary, the main objective of this article is to categorize countries according to their e-participation index based on political, capacity, and governmental environment factors; and to determine how they are projected globally according to these factors.

The paper is structured as follows. Section 2 establishes the main determinants of e-participation development according to previous literature. Section 3 describes the data and the methodologies used. Section 4 contains the results of the study. Section 5 provides a discussion of the work. Finally, Section 6 presents the main conclusions.

2. Literature Review

Previous studies have attempted to identify the explanatory factors for the level of development of different levels of e-government maturity. Recently, the focus has shifted to the birth [3] and current state of e-participation [28,29] evidencing the need for an inter-

action between national economic development and democracy as the main determining factors. However, these documents have not considered that public sector reform trajectories are also largely determined by the characteristics of the political-administrative regime [34] and demands arising from the capacities of its citizens.

In this sense, an exploratory theoretical framework is defined to identify the factors that can show the reality of the different stages of e-participation development. Specifically, this framework links the organizational environment and internal and political characteristics to the development of e-participation (Figure 1).

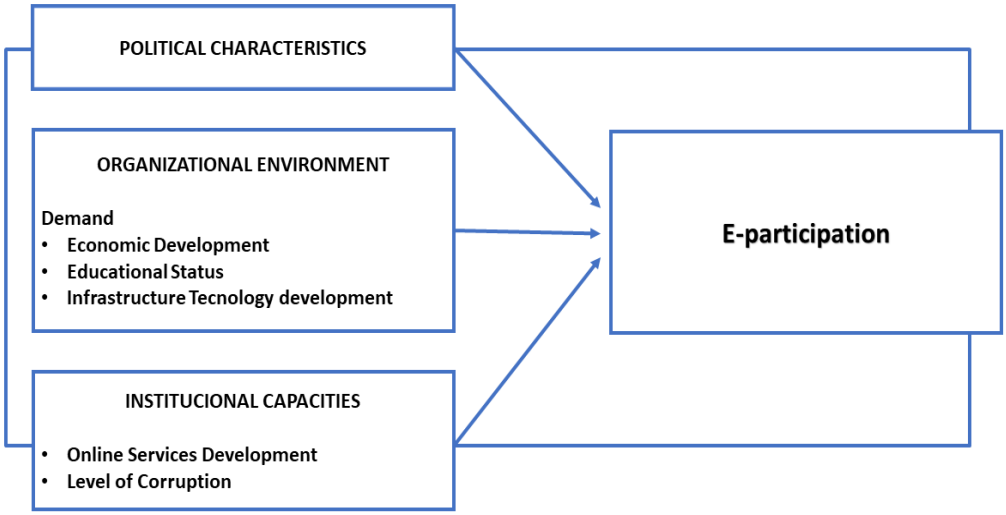


Figure 1. E-participation framework.

It should be considered that the effectiveness of e-government in general, and e-participation in particular, requires certain drivers linked to the economic, technological, demographic, and educational development of countries, as well as to the institutional and political strength that promotes their development.

2.1. Political Characteristics

Political leaders are the ultimate decision-makers, determining institutional organization, administrative activity funding, and rules governing the use of administrations [23]. Thus, García-Sánchez et al. [5] point out that the main decision-makers for the implementation of e-participation are politicians, although they are generally reluctant to embrace its existence. The work of Åström et al. [30] states that e-participation has greater development in democratic countries, although considerable progress has been observed in non-democratic countries in recent years due to economic globalization. However, recently, Jho and Song [31] identified that e-participation is higher when there is an interaction between political conditions and technological development in countries. However, Grönlund [35] points out that measuring e-participation criteria can give a false impression of progress and may not reflect the reality of governments.

2.2. Organizational Environment

The organizational environment encompasses the demand for e-participation by citizens [36]. Traditionally, socioeconomic variables have been used as substitutes for organizational factors, since a higher economic and educational level leads to more significant public sector reforms [37]. In this sense, a well-educated population will require a greater volume of information from public administrations [38]. Although in the early stages of e-government adoption, no significant influence of education was found, cited in Tolbert et al., 2008 [39], subsequent studies have confirmed its importance in the level of e-government maturity [15,16,36].

In relation to wealth or economic development, the development of e-government in general depends on the economic performance of the country [11], to the point that it can even be considered a necessary condition [18]. According to Lee and Whitford [40], countries with unstable economies are unable to hire adequate personnel and maintain quality government infrastructure, processes, and practices, so these deficiencies become obstacles to the development of e-participation.

As a result, previous literature that has considered economic wealth [8,13,15,36,41] has found a positive association between it and the use of e-government. On the other hand, the adoption of e-government, especially the development of e-participation, requires significant investments in technical and administrative infrastructures. Therefore, a certain level of technological development is needed to update websites using advanced software and technologies [18].

2.3. Political Characteristics

According to Allen et al. [42], the necessary transformation in public governance can be hindered by an administrative culture poorly adapted to the digital world. Prior to the development of e-government, countries should develop online administrative platforms that foster citizen interaction with the administration and build technical and administrative infrastructure to enable its development [25]. Along these lines, Pina et al. [43] high emphasize the strong roots of administrative culture. For example, Nordic and Anglo-Saxon countries are primarily considered client-oriented, so they will better respond to citizens' needs through e-government; conversely, continental European countries, traditionally more oriented towards compliance, with legality as their main source of legitimacy, will be slower to incorporate the new styles of public government. However, these countries will have a higher development of electronic administration than those countries not involved in public management improvement.

On the other hand, corruption indicators reflect the role of anti-corruption legislation, organizational change and integrity, and administrative corruption, determining the widespread damage of these practices and the loss of trust they cause in public administration (TI, [44]), following patterns that reflect certain social and cultural characteristics of interactions between citizens and institutions [45]. Thus, countries with higher levels of corruption will have opaque administration styles, hindering the development of e-participation.

In summary, political factors are widely represented in the characteristics of each country's political-administrative regime [34]. Institutional capacities determine, on the one hand, their level of technological development and commitment to e- administration and, on the other hand, the style of public administration represented by their level of corruption control [46].

3. Materials and Methods

3.1. Population and Data

To successfully address the objectives of this work, we take into consideration the United Nations' e-participation indicators (UN, [47]) related to the E-Government surveys (UN 2008, 2010, 2012, 2014, 2016); in addition to the socioeconomic indicators from the World Bank (WB, [48]), political risk [49], and transparency (TI, [44]).

Seven indicators were analyzed, which are described in detail in Appendix A. To identify political factors, the Political Constraint Index (*POLCONIII*) [50] was used. Regarding the organizational environment, three variables were used: Gross domestic product per capita (GDP) to identify the level of wealth or economic development of the country, the Human Capital Index (HCI) to represent the level of education of citizens, and the Telecommunication Infrastructure Index (TII) to describe the technological development of countries. Institutional capabilities were represented by the Online Service Index (OSI) indicators and the Corruption Perception Index (CPI) indicator of transparency.

The information corresponds to the period 2008–2016. The final sample consisted of 101 countries.

3.2. Methodology

This paper applies the X-Statis and Clustering techniques to observe the relationships between the indicators. X-STATIS, also known as Partial Triadic Analysis (PTA), has been used to observe the evolution of individual indicators by year and country. On the other hand, cluster analysis has allowed for grouping individuals according to similar characteristics. Together, these methods have enabled the observation of the behavior of individuals (countries) and variables (indicators) in a reduced dimensional space and the identification of clusters of countries. These techniques have been successfully applied in different areas [51–54].

3.2.1. X-STATIS

The X-Statis [55] was proposed by Jaffrenou [56]. Initially, it was called Triadic Analysis by Thioulouse and Chessel [57], and later, Partial Triadic Analysis by Kroonenberg [58]. Essentially, it is an exploratory tool for three-way data analysis and contemplates three essential phases: the interstructure, the compromise analysis, and the intrastructure [59] (see Figure 2).

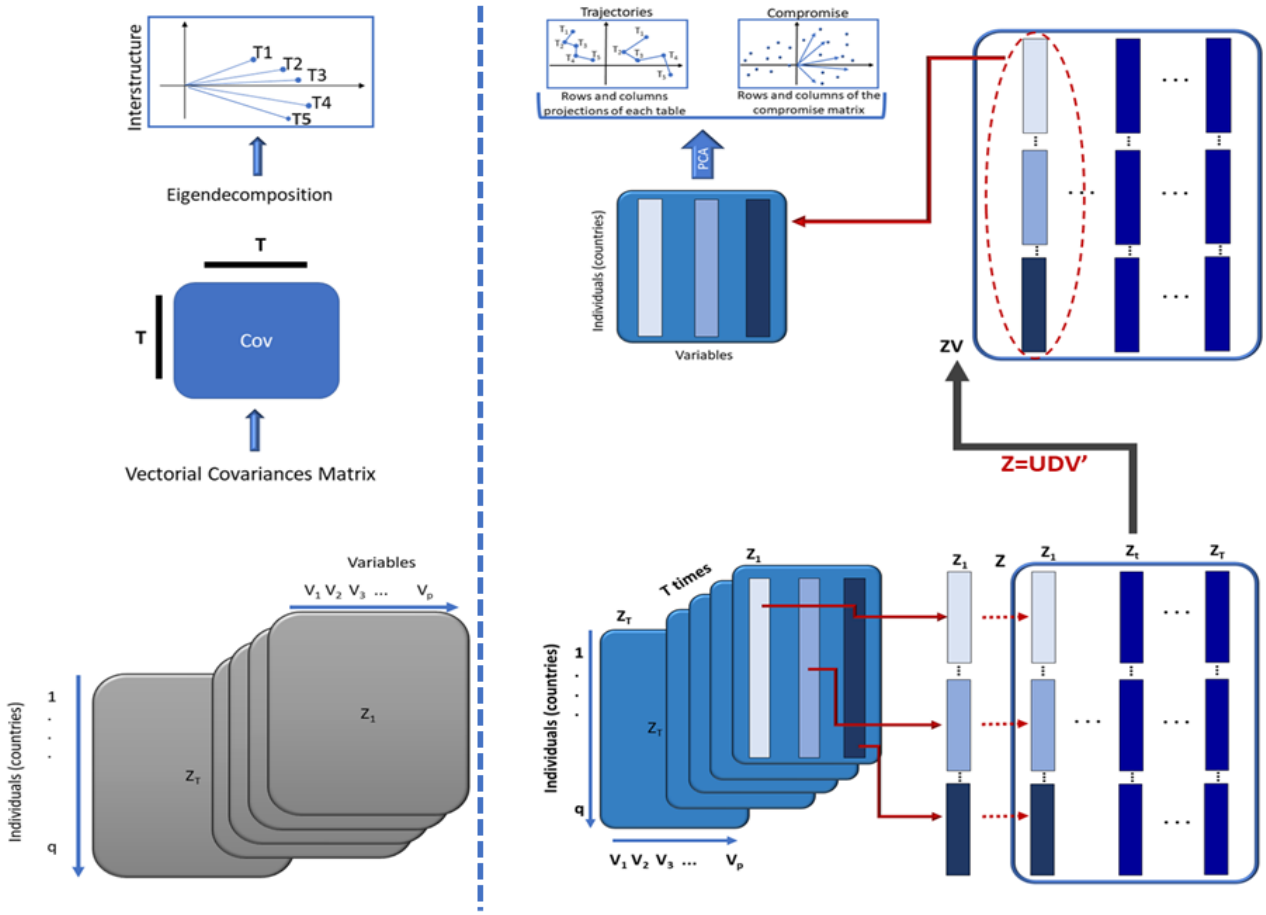


Figure 2. Scheme of the X-STATIS or PTA Method. Reprinted/adapted with permission from Ref. [52]. 2017, Springer.

In the interstructure, each table is projected onto the factorial plane and represented by a vector, to establish the ordering of tables, which summarizes the overall structure and relationships between tables. Based on the covariance, the configuration matrix allows for an overall graphical comparison of tables and shows proximities between configurations of

the same observations. Next, the compromise is constructed, consisting of a mean matrix of maximum inertia (compromise matrix) that represents the vectorial correlations between the sub-matrices, indicating the strength of the links between different submatrices from the different years [60]. The intrastructure (trajectories) summarizes the variability of the series of tables around the common structure defined by the compromise. The rows and columns of all the tables in the series are projected onto the factor map of principal component analysis (PCA) of the compromise, as additional elements. Points can then be connected by lines to highlight their trajectories [61].

The ADE-4 software was used for data analysis using the X-STATIS multivariate technique [62].

Analytically, the process begins with a three-dimensional matrix containing the same H individuals and L variables under K conditions.

Let $\boldsymbol{Z_h}$ and $\boldsymbol{Z_l}$ be two tables with the same n rows and p columns.

For each matrix, the triplets $(\boldsymbol{Z_h M_I M_J})$ and $(\boldsymbol{Z_l M_I M_J})$ are obtained, where $\boldsymbol{M_I}$ is the diagonal matrix containing the weights for the rows, and $\boldsymbol{M_J}$ is the diagonal matrix containing the weights for the columns.

Next, a scalar product of matrices, also called vector covariance—denoted COVV—between the tables is calculated [60]:

$$\mathrm{Covv}(\boldsymbol{Z_h}, \boldsymbol{Z_l}) = \mathrm{trace}(\boldsymbol{Z_h^T M_I Z_l M_J})$$

The diagonalization of this matrix provides eigenvectors.

Alternatively, a vectorial correlation matrix can be used which rescales the covariance vector:

$$\mathrm{RV}(\boldsymbol{Z_h}, \boldsymbol{Z_l}) = \frac{\mathrm{Covv}(\boldsymbol{Z_h}, \boldsymbol{Z_l})}{\sqrt{(\mathrm{Covv}(\boldsymbol{Z_h}, \boldsymbol{Z_h})\mathrm{Covv}(\boldsymbol{Z_l Z_l}))}}$$

To plot the interstructure, vectors starting at the origin and ending at the points given by the rows of $\boldsymbol{V_2 D_2}$ are used, where $\boldsymbol{V_2}$ is the first two eigenvectors of the covariance matrix of the vector and $\boldsymbol{D_2}$ is the diagonal matrix with the two associated eigenvalues.

The compromise $\boldsymbol{Z_c}$ is a linear combination of $\boldsymbol{Z_h}$ weighted by γ_h, the coordinates of the first eigenvector of the inter-structure, which are assumed to be all positive, since the vector covariance matrix is symmetric and all of its elements are positive, thus:

$$\boldsymbol{Z_c} = \sum_{\boldsymbol{h}} \gamma_\mathrm{h} \boldsymbol{Z_h}$$

With the compromise analysis, two-dimensional representations can be obtained to interpret its structure.

This process for calculating the compromise matrix is equivalent to performing a singular value decomposition of the matrix $\mathbf{Z} = \mathbf{UDV^T}$ obtained by placing the columns as vectors and concatenating the columns of each of the matrices in the sequence. Then, the first column of $\boldsymbol{ZV}$ will be taken as the compromise and displayed as a matrix.

The intrastructure is obtained by projecting the rows and columns of each table in the compromise analysis. Let $\boldsymbol{V_r}$ be the first r matrix of eigenvectors from the compromise analysis. The coordinates of the rows of the table $\boldsymbol{Z_h}$ are the rows of $\boldsymbol{Z_h M_j V_r}$, and the columns are the rows of $\mathbf{Z_h^T M_I U_r}$, where $\boldsymbol{U_r}$ contains the first eigenvectors of $\mathbf{Z_c M_J Z_c^T M_I}$.

3.2.2. Cluster Analysis

The cluster analysis covers a wide variety of techniques, whose purpose is to profile the conglomerates present in the data, according to the behavior of the individuals in the variables [63]. There are several methods of clustering, in this work, the Ward Method [64] was used, which tends to provide clearly defined groups [65].

4. Results

X-STATIS starts with a comparison of the structures of the years using the representation of the interstructure, to interpret the similarities and differences between the years.

In the graphic profile (see Figure 3), acute angles are observed between the vectors, which are interpreted as strong relationships that occur gradually over the years. This representation shows similar structures between years, with 94.14% of the information, ensuring a good representation of the reality described by the matrices of each year. The year most similar to the represented configuration is the one closest to the horizontal axis, in this case, the year 2012, which means it is the year most similar year, on average, to all other years. At the same time, we can see how the years are grouped: on the one hand, 2008 and 2010 are very close to each other in the first quadrant, and far from the years 2014 and 2016, in the fourth quadrant.

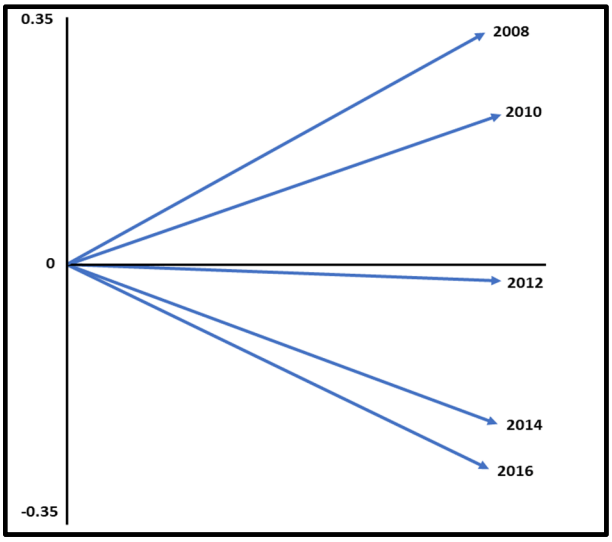


Figure 3. X−Statis Interestructure plot.

All the matrices obtain similar weights in the construction of the compromise (Weights) and a good representation in that subspace (Cos^2) as shown in Table 1.

Table 1. Weight and Representation of each matrix on Compromise.

Axis	Weights	Cos^2
2008	4.394×10^{-1}	0.839
2010	4.535×10^{-1}	0.897
2012	4.534×10^{-1}	0.895
2014	4.505×10^{-1}	0.888
2016	4.391×10^{-1}	0.847

Once the similarities and differences of the different matrices with the "average year" are known, the so-called compromise matrix is calculated, which encompasses the countries and the most stable values they take in the indicators. It is observed that four groups of countries are formed, according to the level of e-participation: countries with low levels of e-participation (red), countries with a medium level of e-participation (purple), countries with a high level of e-participation (green), and countries with a very high level of e-participation (blue) (see Figure 4).

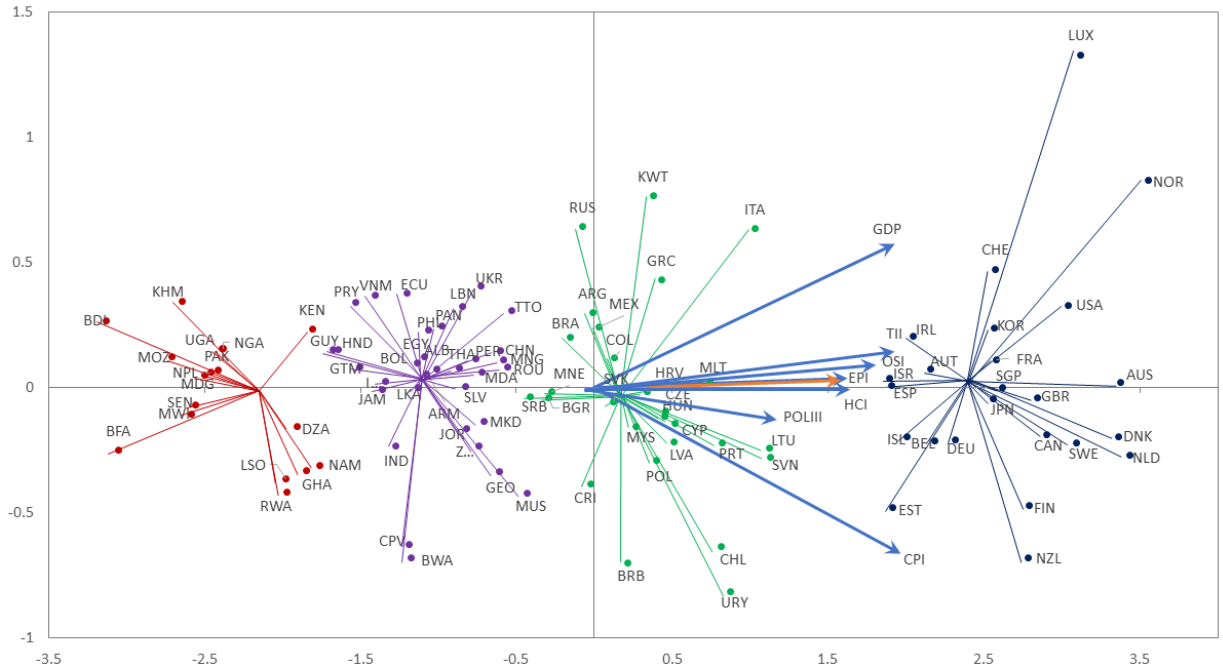


Figure 4. X-Statis Compromise subspace: position of indicators.

All variables are positively related. The indicator of government capabilities, CPI, is closely related to the indicator of government environment, TII. The indicators of government environment, HCI and TII, are closely related to the indicator of government capabilities, OSI. On the other hand, the indicator of government environment, GDP, is positively related to the indicator of government capabilities, CPI.

In addition, the relationships between countries and variables are also observed. For instance, we see that countries such as Australia, France, Great Britain, Denmark, United States, Norway, Luxembourg, Canada, and New Zealand, among others, mark the end of the horizontal gradient, indicating that they have very high levels of e-participation, and this is due to showing high values in the factors of government environment (HCI, GDP and TII), government capabilities (OSI, CPI) and political factors (POLIII). On the other hand, we have Madagascar, Mozambique, Senegal, Uganda, Pakistan, and Nepal, among others, that mark the opposite end, indicating that they have the lowest levels of e-participation, and in the same way, this is due to showing very low values in the factors of government environment, government capacities, and politicians.

The cluster classification of countries based on e-participation is presented in Table 2 (see Table 2). The intermediate countries are classified into two groups, those with medium and high levels of e-participation. These countries are characterized by having average values in all their factors, but with greater influence from the government capabilities indicator, CPI. On the other hand, there is the group with a high level of e-participation, which is basically more influenced by their level in the government indicator, CPI. In addition, countries with a very high level of e-participation (blue color), are identified by their high level in all variables under study.

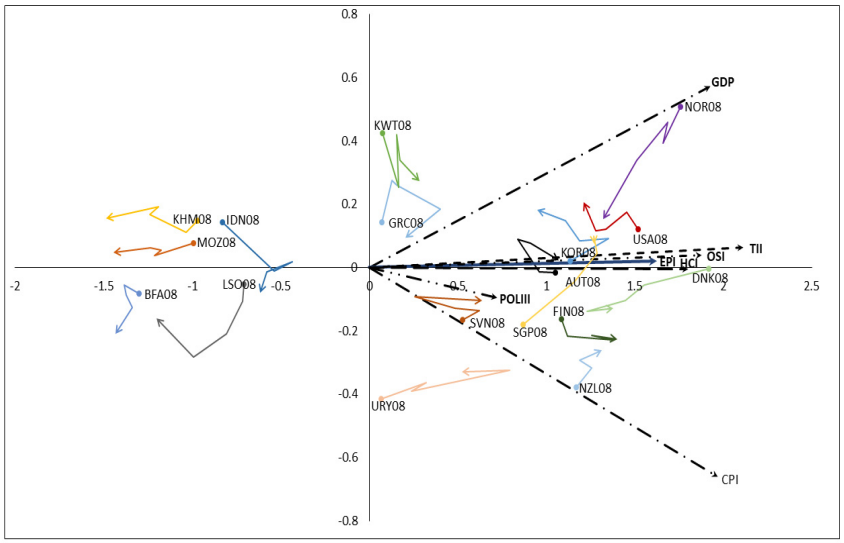
Upon analyzing each quadrant, it is observed that countries located in the first quadrant are characterized by having medium-high values in GDP, TII, and OSI, while those in the fourth quadrant have medium-high values in HCI, POLIII, and CPI. On the other hand, countries located in the second quadrant have low values in relation to the indicators CPI, POLIII and HCI, while those in the third quadrant are characterized by having low values in the indicators GDP, TII and OSI.

Table 2. Countries with level e-participation index 2016 and classified compromise with the ward method.

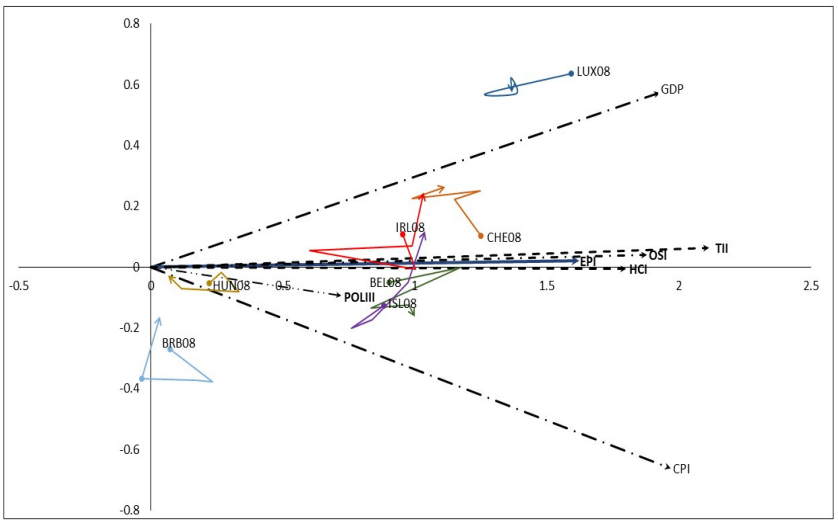
CLUSTER COMPROMISE	E-PARTICIPATION INDEX LEVEL–2016			
	LOW (Less than 0.25)	**MEDIUM (Between 0.25 and 0.50)**	**HIGH (Between 0.50 and 0.75)**	**VERY HIGH (More than 0.75)**
1: LOW	Algeria, Burkina Faso, Burundi, Cambodia, Lesotho, Madagascar, Malawi, Mozambique, Namibia, Nigeria, Pakistan, Uganda. (12)	Ghana, Rwanda, Senegal. (3)	Kenya, Nepal. (2)	
2: MEDIUM		Botswana, Cape Verde, Egypt, Guyana, Honduras, Indonesia, Jamaica, Jordan, Lebanon, Panama, Trinidad and Tobago. (11)	Albania, Armenia, Bolivia, Ecuador, El Salvador, Georgia, Guatemala, Macedonia. Mauritius, Mongolia, Paraguay, Peru, Philippines, the Republic of Moldova, Romania, South Africa, Sri Lanka, Thailand, Vietnam. (19)	China, India, Ukraine. (3)
3: HIGH		Barbados, Hungary. (2)	Argentina, Brazil, Bulgaria, Costa Rica, Cyprus, Czech Republic, Greece, Kuwait, Latvia, Malaysia, Portugal, Slovakia, Slovenia, Uruguay. (14)	Chile, Colombia, Croatia, Italy, Lithuania, Malta, Mexico, Poland, Montenegro, Russian Federation, Serbia. (11)
4: VERY HIGH			Belgium, Iceland, Ireland, Luxembourg, Switzerland. (5)	Australia, Austria, Canada, Denmark, Estonia, Finland, France, Germany, Israel, Japan, Netherlands, New Zealand, Norway, Singapore, Spain, Sweden, South Korea, United Kingdom, United States. (19)

When observing the clusters formed according to their level of e-participation (see Table 2), 55% of the countries are classified at a level consistent with their national conditions. 38% are classified at a higher level, and these countries are characterized by high levels of social and democratic development, which is an indication that they may not have made sufficient investments in e-participation. On the other hand, 7% of the countries are classified at a lower level according to their national characteristics, and this group includes countries with non-democratic governments.

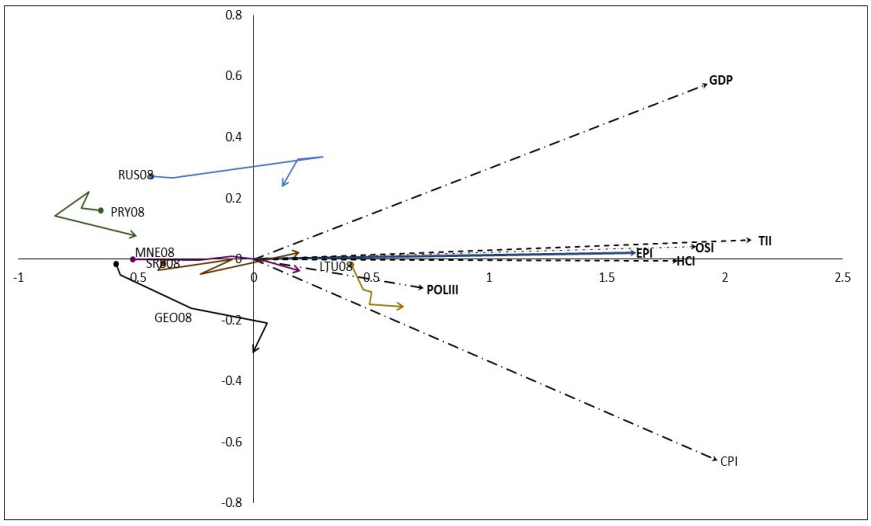
The X-STATIS method generates trajectories of countries during the study period. These trajectories are represented in Figure 5a–c. Some countries have been plotted according to the group to which they belong based on their e-participation index, followed by those that are below their level, and lastly, those that are above their level.



(**a**)



(**b**)



(**c**)

Figure 5. The trajectory of the countries by e-participation index: (**a**) according to their national situation; (**b**) below; (**c**) (Bowl).

Figure 4 displays the trajectories, for the group of countries whose e-participation indicator is at the corresponding level (Figure 5a), showing a decrease in all of their indicators. On the other hand, the countries whose e-participation indicator is below the level that corresponds to their national conditions (Figure 5b), exhibit trajectories with little variation during the study period in all of their indicators. Finally, the group of countries with an e-participation index above the level that corresponds to their national conditions (Figure 5c), shows trajectories that tend to increase during the study period.

A detailed analysis of Table 2 along with the trajectories, for all the countries, indicates that the countries located in the blue-shaded cells have a lower level of e-participation development than would be expected given their political, institutional, and socioeconomic conditions. Conversely, the countries located in the pink-shaded cells correspond to countries that have a higher level of e-participation development than predicted by the considered conditions.

5. Discussion

In 2008, a study of e-participation conducted by the United Nations revealed the existence of three groups of countries with low, medium and high levels of development. Currently, the level of e-participation development has shown an evolution in these categories, with a group of countries emerging with a more advanced level of e-participation development, creating the categorized "very high" group.

In our study, we have found that the majority of countries with high and very high levels of e-participation are grouped in the first and fourth quadrant, demonstrating high levels of political factors, governmental environment, and institutional capacities. Meanwhile, in the second and third quadrant, we find countries with low levels of e-participation, countries whose factors show values from medium to low, and are generally countries with non-democratic or hybrid governments.

Contrary to what might be expected, the availability of fewer economic resources does not imply significant barriers to the implementation of electronic administration, which is opposite to previous empirical evidence [38,66]. Thus, in cluster 2, countries with a low-medium level of socioeconomic development are located, but due to the effect of institutional and organizational characteristics, they present a level of e-participation development similar to that of countries with more favorable economic environments.

The results obtained allow us to affirm that the organizational environment associated with the ICT infrastructure and human capital has a positive impact on the government's willingness to implement e-participation, as evidenced by authors such as García-Sánchez et al. [5], Åström et al. [30], Jho and Song [31], and Krishnan et al. [27].

As Gulati et al. [67] point out, various strategies underlie the development of e-government, depending on a nation's political structure. Thus, we see that there are countries with less advanced levels of democracy that are using e-government to preserve their status. For example, Russia and China maintain high levels of e-participation, but as Cooley [68] indicates, they do not achieve electronic democracy, the highest level of e-government, which inherently promotes e-participation.

Finally, we argue that the development of e-participation needs to be complemented by institutional democracy.

6. Conclusions

We have evidenced that the organizational environment and the political and organizational characteristics play a relevant role in the process of evaluating the improvement of government effectiveness, which in turn depends on the economic development of the countries. The factors that have allowed for a better understanding of e-participation initiatives are the indicators of the governmental environment factor, as on one hand the telecommunication infrastructure index and the human capital index are the ones that are most correlated with the e-participation variable.

Considering political, institutional and organizational factors, this research highlights the evolution of e-participation, with 45% of countries being at a level that does not correspond to their expected level. Specifically, 7% of countries have a lower level of e-participation development than they should, mainly countries that should have a very high level but have a medium-high level instead. Meanwhile, 38% show greater progress than expected, being at a higher level than what would correspond to their national characteristics.

Thus, our results indicate that countries currently positioned at the high level according to the United Nations score showed a delay in the development of e-participation compared to others countries with similar political, organizational, and institutional characteristics. This delay was evident in 2008, when they were situated at medium and low levels. Therefore, in terms of trajectory, the variations have not been very significant for the most economically developed countries. However, among the less developed countries, there is a group of countries for which significant changes have been evidenced, moving from low to medium levels of e-participation and from medium to high levels; in other words, showing an optimal position compared to what was expected.

The influence of political risk in the development of e-participation is observed, indicating that the values of these indices are not necessarily a reflection of citizen participation in public policies of their countries and similarly do not reflect the level of e-democracy of the country.

We support the view of previous studies on the importance of these factors in the evaluation of e-participation levels, just as the absence of these factors constitutes significant impediments to implementing effective electronic administration. This research makes two contributions. Firstly, it integrates information that combines data from three sources (countries, indicators, and years) to provide a global view of e-participation through X-STATIS. In this sense, our work reveals the similarities and differences between countries regarding e-participation during the study period. The conclusions obtained validate the selection of the studied indicators since they correlate strongly, regardless of the year of study. Given the complexity of electronic participation processes, these results are only achievable with multivariate statistical techniques with a cube structure, as in our case. The second contribution is related to the focus of the study, aimed at determining the evolution of e-participation in each country, which represents an opportunity for governments to evaluate their efforts in electronic participation and validate these processes to address future challenges. In conclusion, we defend the idea that the factors studied to provide a better understanding of the level of e-participation of countries over time.

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Appendix A

Table A1. Description of indicators.

Indicator Code	Description
Dependent Variable	
e-participation index (EPI).	It is a complementary index to the United Nations E-government Survey. It focuses on the use of online services to facilitate the provision of information by governments to citizens ("electronic information exchange"), interaction with stakeholders ("electronic consultation"), and participation in decision-making ("electronic decision making") (UN, [47]).
Political Factors	
Political Constraint Index (POLIII).	Estimates the feasibility of policy change (the extent to which a change in the preferences of any actor can lead to a change in government policy) [49,50].
Organizacional Environment	
Human Capital Index (**HCI**).	It shows the aggregate level of education of a country, it is made up of two indicators: the adult literacy rate and the combined gross rate of primary, secondary and tertiary enrollment.
Gross domestic product per capita (**GDP**).	GDP per capita (WB, [48]).
Telecommunication Infrastructure Index (**TII**).	Evidence of the economic and ICT development of a country (UN, [47]).
Institutional Capacities	
Online Service Index (**OSI**).	Demonstrates the scope and quality of online services (UN, [47]).
Corruption Perception Index (**CPI**).	It is elaborated with the perception of its levels of corruption, coming from businesses, political analysts and the public. (TI, [44]).

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