

Research Article

# Digitalisation landscape in the European Union: Statistical insights for a Digital Transformation

## Panorama de la digitalización en la Unión Europea: Perspectivas estadísticas para una Transformación Digital

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**Abstract:** The widespread adoption of digital technologies is transforming societies, bringing with it both opportunities and challenges. This article examines the level of digitalisation in different European Union (EU) countries, with the aim of providing insights and lessons for advancing digital transformation. The research methodology uses a quantitative approach, with Eurostat as the primary data source. Principal component and cluster analyses were conducted to identify the key factors shaping digital transformation in the EU-27 countries. The results show the existence of three key factors that can help to understand digital transformation in the EU, namely “digital empowerment”, “digitalisation of enterprises” and “broadband access”, and four clusters with heterogeneous performances along these dimensions, classified as “digital access leaders”, “digital transformation champions”, “digital empowerment laggards” and “empowerment driven disparities”. By recognising interdependencies and understanding each country’s digital performance, policymakers can develop targeted strategies to close the gap and ensure that the benefits of digitalisation are accessible to all. An integrated approach focusing on digital empowerment, enterprise digitalisation and broadband access can promote inclusive and sustainable digital development, contributing to economic growth and improved quality of life.

**Keywords:** digital transformation; European Union; digitalisation; digital divide; factor analysis; cluster analysis.

**Resumen:** La adopción generalizada de las tecnologías digitales está transformando las sociedades, trayendo consigo tanto oportunidades como retos. Este artículo examina y analiza el nivel de digitalización en diferentes países de la Unión Europea (UE), con el objetivo de aportar ideas y lecciones para avanzar en la transformación digital. La metodología de investigación utiliza un enfoque cuantitativo, con Eurostat como fuente primaria de datos. Se realizaron análisis de componentes principales y de conglomerados para identificar los factores clave que configuran la transformación digital en los países de la UE-27. Los resultados muestran la existencia de tres factores clave que pueden ayudar a comprender la transformación digital en la UE, la “capacitación digital”, la “digitalización de las empresas” y el “acceso de banda ancha”, y cuatro grupos con resultados heterogéneos en estas dimensiones, clasificados como “líderes del acceso digital”, “campeones de la transformación digital”, “rezagados de la capacitación digital” y “disparidades impulsadas por la capacitación”. Al reconocer las interdependencias y comprender el rendimiento digital de cada país, los responsables políticos pueden desarrollar estrategias específicas para cerrar la brecha y garantizar que los beneficios de la digitalización sean accesibles para todos.

Un enfoque integrado centrado en el empoderamiento digital, la digitalización de las empresas y el acceso a la banda ancha puede promover un desarrollo digital inclusivo y sostenible que contribuya al crecimiento económico y a la mejora de la calidad de vida.

**Palabras clave:** transformación digital; Unión Europea; digitalización; brecha digital; análisis factorial; análisis de conglomerados.

## 1. Introduction

The widespread adoption of digital technology has become a ubiquitous phenomenon in today's society, with significant social and economic implications. It encompasses various advances and changes in technology that have completely transformed the way people live, work and interact. The rapid growth of digitalisation has been fuelled by improvements in computing power, the widespread availability of high-speed internet, the proliferation of smartphones and other digital devices, and more recently by the Covid-19 pandemic. As a result, the ability to effectively navigate and use digital tools and technologies has become critical for individuals, businesses and governments alike.

Nevertheless, it is essential to acknowledge that digitalisation is not a uniform phenomenon as its impact differs between individuals, communities and nations. The concept of the digital divide highlights the differences in access to and use of digital technologies, resulting in inequalities in digital literacy, skills and opportunities. Bridging this divide and promoting inclusive digital policies and infrastructure are critical to ensuring equal access to digital opportunities and minimising potential inequalities. Recognising the transformative power of digitalisation, the European Union (EU) has actively developed public policies to harness its potential and address its challenges.

The aim of this study is to examine and analyse the different levels of digitalisation in different countries within the European Union. By comparing the digitalisation efforts of these countries, we aim to gain valuable insights and lessons that can help drive digital transformation across the EU. To achieve this goal, the research methodology relies on a quantitative approach, using Eurostat as the primary data source. The data was analysed using principal component and cluster analyses to identify the key factors shaping digital transformation in the EU-27 countries and their digital transformation landscape.

The article is divided into five sections. The first provides a theoretical introduction to the topic, outlining the significance of digitalisation, the impact of Covid-19, the digital divide and the importance of public policies. This is followed by an explanation of the methodological strategy and a presentation of the results. The paper concludes with a summary of the main findings and implications for public policy.

## 2. The Importance of Digitalisation in Contemporary Societies

### 2.1. *The transformative impact of Covid-19 on Digitalisation*

Digitalisation has become a ubiquitous term in contemporary society, encompassing a wide range of technological advances and transformations with significant sociological and economic implications. The rapid rise of digitalisation has ushered in a new era characterised by unprecedented connectivity and technological advances. In recent years, digitalisation has become a driving force that permeates all aspects of society, revolutionising the way we live, work and interact (Katz, 2017; Karajz, 2021). This paradigm shift has been fuelled by advances in computing power, the widespread availability of high-speed internet connectivity, and the ubiquity of smartphones and other digital devices. As a result, the ability to effectively navigate

and use digital tools and technologies has become critical for individuals, businesses, and governments alike (Buhr, 2017).

This importance has taken on a new dimension with the social and economic changes brought about by the Covid-19 pandemic. The pandemic has exposed a range of difficulties faced by global communities, including collapsed health systems, widespread job loss, increased poverty and hunger, with the hardest hit being on households dependent on daily income and the self-employed in low- and middle-income countries (Kamran et al., 2002). In response to this external shock, drastic measures were taken to contain the spread of the virus. One of the most significant changes was the shift towards remote working and virtual collaboration. With the closure of many offices and workplaces due to the pandemic, businesses, especially small and new companies, were under pressure to adapt quickly in order to survive (Scheidgen et al., 2021). This led to a surge in the use of videoconferencing tools, virtual collaboration platforms and other technologies that facilitate remote working. As a result, organisations have become more flexible and agile, with many considering remote working as an integral part of their operations.

Despite the grim consequences of the pandemic, it has also provided various entrepreneurial opportunities (Shepherd, 2020; Krlev et al., 2018). Covid-19 has accelerated the digital transformation process by several years, highlighting the importance of artificial intelligence and intensifying the need for technological advancement (Okón-Horodyńska, 2021). This crisis has created a unique environment for researchers to explore threshold innovations and their impact on different industries, assess the extent of creative and sustainable transformation during a crisis, examine clear indications of these transformations, and potentially predict the future directions of the industry (Okón-Horodyńska, 2021).

As the global economy has expanded, technological advances have facilitated the development of global value chains and multi-site operations, creating employment opportunities in previously marginalised economies. Technology has also enabled network effects, driving productivity, expansion and value creation in industries (Bria et al., 2015). The dominance of digital firms among the world's leading companies underscores the central role of digitalisation in driving economic growth (Gruber, 2017).

The Covid-19 outbreak has highlighted the importance of digital technologies and accelerated their global adoption, fundamentally changing both work and personal lifestyles. This has facilitated the sharing of knowledge, concepts and resources to develop effective solutions to the immediate and long-term effects of the pandemic. The unintended nature of this transformation has led to the emergence of a potential fifth era in societies, referred to as the era of "forced digital innovation" (Nagy & Somosi, 2022, p. 6).

The recent health crisis has driven many organisations to rapidly adopt technology, resulting in a significant increase in demand for digital solutions and services as organisations seek to streamline operations and adapt to the new normal. The increased reliance on digital communications, teleworking and business process automation has highlighted the need for reliable platforms that offer flexibility and scalability (Telefonica Foundation, 2021).

The idea that recovery will come from the adoption of digital technologies is gaining popularity. It is believed that the convergence of different technologies will usher in a new era of digitalisation, blurring the boundaries between the physical, digital and biological domains. The European Commission has recognised this trend and actively promotes policies to facilitate this transition (Telefonica Foundation, 2021). However, the digital transition also involves several peculiarities. Firstly, there is not always agreement on what is understood by digitalisation, transition or digital transformation. And, in particular, this process also ends up creating or exacerbating inequalities that need to be reflected upon.

## 2.2. Defining Digitalisation and bridging the digital divide

Digitalisation refers to the process of incorporating digital technologies into various aspects of human life (Sarren & Haarstad, 2021). It involves the conversion of analogue information into a digital format, enabling its storage, manipulation and transmission using electronic devices and networks (Kohlgrüber & Schröde, 2019). Digitalisation is characterised by the rapid development and deployment of digital technologies, the increasing connectivity and interdependence of people and systems through digital networks, and the generation and use of vast amounts of data (Buhr, 2017).

From a sociological perspective, digitalisation has profoundly reshaped social interactions, relationships and identities. For example, the rise of social media platforms has revolutionised the way people communicate and connect with each other. The blurring of boundaries in time and space has enabled individuals to connect and collaborate globally, changing the dynamics of social interactions (Nagy & Somosi, 2022; Sarren & Haarstad, 2021; Ignatow, 2020). Economically, digitalisation has had a transformative impact on industries, labour markets and economic systems. Traditional business models have been disrupted and new digital platforms and ecosystems have emerged (Carayannis & Jancelewicz, 2021). Businesses have used digital technologies to streamline operations, improve efficiency, and increase productivity through automation and data-driven decision making (Dhondt et al., 2021; Buhr, 2017). The growth of the sharing economy, facilitated by digital platforms, has introduced new forms of employment and peer-to-peer transactions.

However, it is important to note that digitalisation is not uniform as its impact varies between individuals, communities and countries. With the increasing adoption of remote working and online service delivery, driven by broadband connectivity (Global Digital Transformation Survey Report, 2021), individuals and regions with limited digital literacy or skills face significant challenges in adapting to these changes. The importance of investing in digital skills and education, as highlighted in the OECD's 2021 report on digitalisation in a post-COVID world, is evident in improving employability, productivity and well-being amidst the rapidly changing digital landscape (OECD, 2021). Nevertheless, digital infrastructure remains inaccessible to all individuals, a concern recognised by G20 countries (G20, 2017).

The term 'digital divide' refers to differences in access to and use of internet-based digital services, including information and communication technologies (Cullen, 2001). It describes the differences between individuals, communities and countries in their ability to access, use and benefit from digital technologies (Lythreatis et al., 2022). Several factors contribute to the digital divide, including regional, demographic, urban-rural, socioeconomic, gender and age differences, and business-related characteristics (Novak et al., 2018). These gaps and divides highlight the need to consider implicit reference groups when examining disparities, such as non-metropolitan versus metropolitan regions, SMEs versus large firms, and developed versus emerging economies (OECD, 2019).

According to the OECD (2021), digital divides manifest in different dimensions. They can be conceptualised in terms of three layers: the network or connectivity layer, which includes access to and use of communication services; the application and data interface layer, which includes access to and transfer of data across borders and running applications on networks; and the end-user layer, which examines the diffusion and use of digital technologies by different firms and individuals, taking into account their different needs and capabilities.

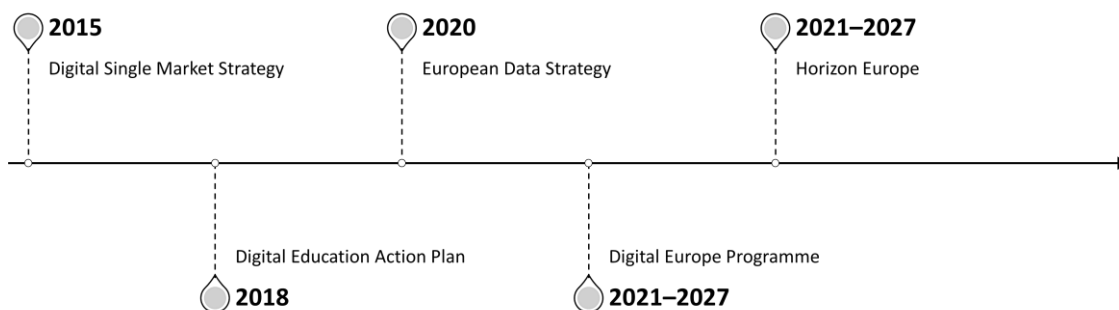
While digitalisation has the potential to bring many benefits to society, it is imperative to ensure equal access to these benefits. Inclusive digital policies and infrastructure are essential to bridge the digital divide and promote equal access to digital opportunities (Cullen, 2001; Novak et al., 2018). Initiatives targeting vulnerable populations, such as the elderly, the homeless and people with disabilities, aim to provide access to technology and develop specialised tools and software to improve the accessibility and usability of technology (Lythreatis et al., 2022). In this

sense, the development of policies and frameworks that promote inclusive digitalisation is essential to ensure equal access to digital opportunities and minimise potential inequalities.

### 2.3. Public Policies on Digitalisation in the European Union

The EU has recognised the transformative power of digitalisation and is actively developing public policies to harness its potential and address the challenges it poses. The EU's digital agenda is guided by several key policy frameworks, including the Digital Single Market Strategy, the Digital Education Action Plan, the European Data Strategy, the Digital Europe Programme and Horizon Europe. These policies and programmes form a comprehensive framework addressing different aspects of digitalisation in the EU, which aims to position itself at the forefront of the global digital revolution. Figure 1 shows the chronological organisation of these programmes and policy agendas by publication date.

**Figure 1.** Chronology of EU Policies on Digitalisation.



Source: Author's elaboration.

The Digital Single Market Strategy, launched in May 2015, is a milestone in the EU's efforts to create a single digital market and recognises the importance of digitalisation in driving economic growth, innovation and competitiveness in the European Union. This strategy emphasises three key dimensions (EU, 2015). The first one involves harmonising regulations across EU member states, which involves creating a consistent legal framework that allows businesses and consumers to operate and engage in digital activities across borders more easily. The second one concerns the promotion of innovation and growth in the digital economy, aiming to support the development and deployment of emerging technologies such as artificial intelligence, cloud computing and the Internet of Things. Finally, the Digital Single Market Strategy also focuses on ensuring that all citizens have equal access to digital services and opportunities and seeks to close the digital divide by improving digital skills and literacy among the population.

The Digital Education Action Plan (EU, 2018), adopted in January 2018, represents the European Union's commitment to improving the digital skills and competences of its citizens. The plan recognises the importance of digital technologies in shaping the future of education and aims to equip individuals with the necessary skills to thrive in the digital age. One of the main objectives of this action plan is to integrate digital technologies into education and training systems, emphasising the need to harness the potential of digital tools and resources to enhance the teaching and learning experience. It also recognises the importance of digital skills for all citizens, regardless of age or background, thus promoting digital inclusion by providing equal access to digital educational opportunities.

The European Data Strategy (EU, 2020), published in February 2020, represents a comprehensive approach to harnessing the power of data in the European Union. The strategy recognises that data has become a valuable asset in the digital age and aims to unlock its potential for innovation, economic growth and societal benefits. At its core, the European Data Strategy focuses on promoting data sharing and fostering cross-border data flows within the EU. By facilitating data sharing, the strategy aims to foster collaboration, stimulate innovation and create new business opportunities. This approach is particularly relevant in sectors such as health, transport, energy and agriculture, where valuable insights can be gained from data integration and analysis.

Horizon Europe (EU, 2023), the EU's research and innovation programme for 2021-2027, represents a major investment in promoting scientific excellence and driving technological progress. The programme recognises the transformative potential of digital technologies and allocates significant funding to research and innovation in this area. One of its main objectives is to support research and development in key digital technologies. This includes areas such as artificial intelligence (AI), cybersecurity and advanced digital infrastructures.

The Digital Europe Programme (EU, 2021), established as part of the EU's long-term budget for 2021-2027, represents the EU's commitment to driving the digital transformation of its economy and society. The programme aims to support and accelerate the uptake of digital technologies across different sectors through targeted funding and investment. One of the main objectives of the Digital Europe programme is to promote excellence and innovation in key digital areas, focusing on the development and deployment of advanced technologies such as supercomputing, AI and cybersecurity. This programme also places a strong emphasis on digital skills and competences. It recognises the importance of equipping European citizens with the necessary digital skills to thrive in the digital economy. In addition, the Digital Europe Programme also supports the development and deployment of digital public services and streamlines and improves public administration processes through digital technologies, making them more efficient, accessible and citizen-centred.

These initiatives demonstrate the EU's commitment in harnessing the power of digitalisation and technology to drive economic growth, foster innovation, address societal challenges and improve the well-being of its citizens. The importance of these policies lie in their ability to foster a competitive, secure and sustainable digital ecosystem that drives economic progress, improves public services and enhances the quality of life of European citizens. However, it is important to consider that while these policies and programmes are designed to benefit the EU, not all Member States are at the same level in terms of digital progress. Different countries have different levels of infrastructure, digital skills and technological capabilities, and it is important that these policies and programmes recognise and address the differences between Member States in terms of digital readiness.

### **3. Methodology**

#### *3.1. Goals and Strategy for Data Collection*

The development of this article is based on several assumptions that form the basis of the research carried out. First, it is assumed that digitalisation plays a crucial role in the economic and social development of countries, contributing to increased productivity, innovation and competitiveness. Second, it is assumed that there are significant differences in the level of digital readiness between countries within the European Union, due to differences in factors such as infrastructure, skills and policy frameworks. Third, it is assumed that examining and comparing the digitalisation efforts of different countries can provide valuable insights and lessons that can be applied to drive digital transformation across the EU. These reasonable assumptions guided the research methodology, data analysis and interpretation of findings, while also setting the stage for evidence-based discussions and recommendations.

In general, the purpose of this study is to examine and analyse the different levels of digitalisation in different countries within the European Union, to identify the more important latent dimensions and to group the EU-27 countries into similar groups in terms of digitalisation performance. By examining and comparing the digitalisation efforts of different countries, it contributes to a deeper understanding of the digital landscape within the European Union and to provide insights for policy makers, researchers and practitioners in designing effective strategies for digital transformation.

This study uses a quantitative approach to analyse the digital performance of the EU-27 countries. The research is based on secondary statistical data, mainly from the Eurostat database, in particular the section "Science, Technology, Digital Society". This comprehensive dataset provides a range of indicators that offer valuable insights into the digital aspects of different countries. The analysis focuses on information for the year 2021, which is used as the most recent data available to ensure accuracy and relevance.

A total of 33 indicators were collected. Given the similarity between some of the variables, a correlation analysis was carried out to verify the existence of highly correlated variables. It was decided to include only one of the variables when there was very high correlation. The variables used in the study are listed below:

- Share of individuals having at least basic digital skills (%).
- Privacy and protection of personal data (%).
- Employed ICT specialists (%).
- Enterprises that provided training to develop/upgrade ICT skills of their personnel by size class of enterprise (%).
- Level of internet access – households (%).
- Individuals using mobile devices to access the internet on the move (%).
- Overall fixed broadband take-up (%).
- Fast broadband coverage – NGA (%).
- Fibre to the Premises Coverage (%).
- Cable modem DOCSIS 3.0 (%).
- G Coverage (%).
- Enterprises with high digital intensity index (%).
- Enterprises use at least one of the AI technologies (%).
- E-government activities of individuals via websites (%).
- Internet use: obtaining information from public authorities' websites (%).
- Internet purchases by individuals (%).
- E-commerce sales of enterprises by size class of enterprise (%).
- Meetings via the internet by size class of enterprise (%).

By using the Eurostat database, this study ensures consistency and comparability of the indicators collected for the assessment of digitalisation across the EU-27 countries. The quantitative methodology allows objective measurements and comparisons, providing a comprehensive overview of the digital landscape within the European Union.

### 3.2. Data analysis

The data analysis process in this study involved the use of SPSS software to examine the digitalisation indicators for the EU-27 countries. In order to gain insights into the underlying patterns and dimensions of digital performance, principal component factor analysis was used as a first technique. This allowed the identification of key factors, latent variables that capture the variation in the observed indicators (Hair et al., 2006). Factor analysis helped to reduce the complexity of the dataset and provided a clearer understanding of the relationships between the digitalisation indicators (Pestana & Gageiro, 2008).

Following the factor analysis, cluster analysis was used to group countries according to their digital performance. This technique facilitated the identification of distinct clusters or segments

of countries with similar characteristics in terms of digital readiness (Pestana & Gageiro, 2008). The cluster analysis aimed to identify patterns and similarities between countries, providing a framework for understanding the heterogeneity of digitalisation within the EU-27.

It is important to note that these data analysis techniques have their own assumptions and limitations (Hair et al., 2006). Factor analysis assumes that the observed variables are linearly related to the underlying factors and that there is no multicollinearity between the variables. Cluster analysis, on the other hand, assumes that the clusters are spherical, equal in size and have similar variances. To increase the reliability and validity of the findings, robust data pre-processing and quality control measures were implemented. These included data cleaning, missing value handling and ensuring the consistency and accuracy of the data used for analysis. In addition, appropriate statistical tests and significance thresholds were used to assess the significance of the results.

## 4. Results

### 4.1. Key Factors Shaping Digital Transformation in the EU-27 Countries

One of the goals of this study was to see how the indicators collected could be grouped into main explanatory factors. Principal component factor analysis is a statistical technique used to simplify and extract the most important dimensions within a data set, as mentioned above. Its aim is to elucidate the underlying correlations between variables through statistical procedures that condense the data by reducing the number of variables (Pestana & Gageiro, 2008). This method assumes that certain unobservable variables, called latent variables or common factors, encapsulate the relationships between the original variables (Moroco, 2003). Identifying and analysing these latent variables reduces the complexity of the data and allows for a more concise understanding of the relationships between the variables.

One of the first steps in applying this technique is to validate the quality of the correlations between variables. The Kaiser-Meyer-Olkin (KMO) test and the Bartlett's test were used to assess this quality. In this case, the KMO is 0.803 (cf. Appendix), which indicates that the factor analysis is adequate (Pestana & Gageiro, 2008). Bartlett's test of sphericity tests the null hypothesis that the matrix of correlations is the identity matrix and must be statistically significant, that is, the significance must be less than 0.05 ( $p < 0.00$ ) (Pestana & Gageiro, 2008). In this case, the  $H_0$  of Bartlett's sphericity test was rejected, thus validating the use of factor analysis.

Maintaining a balance between explanatory power and parsimony is crucial. Increasing the number of extracted components decreases parsimony but increases the total variance explained by the components. Conversely, reducing the number of components increases parsimony but results in a smaller amount of variance explained by the components (Hair et al., 2006). In this analysis, the Kaiser criterion was applied, which requires a minimum of 60% accumulated variance. Following this criterion, three components were extracted, explaining a total variance of 74.463% of the original set of 16 variables (see Table 3).

- *Digital Empowerment*: The first component explains 35,1% of the total variance of the data. Digital empowerment is a factor that focuses on improving individuals' digital skills, internet access and use of technology for different purposes. It considers variables such as the share of individuals with basic digital skills, privacy and data protection, employment of ICT professionals, household internet access, mobile internet use, e-government activities, obtaining information from government websites and individual internet purchases. This component recognises the importance of equipping individuals with digital skills, ensuring data protection, having a skilled ICT workforce, providing widespread internet connectivity, embracing mobile technology, promoting accessible e-government services and enabling online transactions. By addressing these issues, Digital Empowerment highlights the promotion of the participation and success of individuals in the digital age.



- *Enterprise Digitalisation*: The second component explains 26,9% of the total variance and focuses on the digital transformation of companies. This factor includes variables such as enterprises providing ICT training based on size, use of cable modem DOCSIS 3.0, enterprises with high digital intensity, adoption of AI technologies, and internet-based meetings based on enterprise size. The name 'Enterprise Digitalisation' emphasises the adoption of digital technologies, ICT skills training and the integration of advanced technologies in enterprises. This component provides valuable insights into the extent and impact of digitalisation efforts within enterprises.
- *Broadband Accessibility*: is a component that explains 12,4% of the variance in the data. It includes variables such as total fixed broadband penetration, fibre to the premises and G coverage. This component represents the focus on the availability and accessibility of broadband services. This component provides insights into fixed broadband take-up, fibre coverage and advanced mobile network coverage. By examining these variables, it helps to assess the accessibility and availability of broadband services, thus providing a better understanding of digital connectivity within a given area or region.

These components collectively provide valuable insights into the factors driving digital transformation in the EU-27 countries. The subsequent section will further explore these key factors and present a comprehensive analysis of the digital transformation efforts across the EU-27, unveiling the landscape of digitalisation within the region.

#### 4.2. Digital Transformation Landscape of EU-27 Countries

Once the components to be retained were identified, cluster analysis was used to identify differences in performance across the EU-27 countries in terms of digital empowerment, business digitalisation and broadband access. There are three basic criteria to consider when applying cluster analysis: what is the measure of similarity of the data, how to form the clusters and how many groups to form.

Euclidean distance was chosen as the measure of similarity. The closer the Euclidean distance is to zero, the more similar the objects being compared are (Hair et al., 2006). The clustering procedure was a hierarchical analysis in which cases are grouped based on proximity. For clustering procedures, a specific method should be chosen. In this study, the Ward method was used. This method produces clusters of approximate size by minimising internal variation (Malhotra, 2006; Kubrusly, 2001). The method used to select the number of clusters was to look at the dendrogram, using the nearest neighbour as the clustering method and the Euclidean square distance as the interval measure. The dendrogram is a graphical representation in which similar objects are grouped according to the variables studied. From the dendrogram analysis, four clusters of EU-27 countries with homogeneous characteristics were defined in relation to the latent dimensions previously extracted.

Cluster 1 includes 8 cases (Belgium, Denmark, Germany, Ireland, Malta, the Netherlands, Finland and Sweden), cluster 2 includes 4 countries (Bulgaria, Poland, Portugal and Romania), cluster 3 includes 6 cases (Czech Republic, Greece, Croatia, Italy, Cyprus and Austria) and finally the last cluster includes 9 countries (Estonia, Spain, France, Latvia, Lithuania, Luxembourg, Hungary, Slovenia and Slovakia).

Regarding the performance of these clusters in the three factors under analysis (figure 2), the following results can be highlighted:

Cluster 1 was named "Digital Access Leaders" because it comprises countries that excel in broadband accessibility, with widespread internet connectivity and advanced mobile network coverage. However, their performance in digital empowerment and enterprise digitalisation is below average. While they have built a strong foundation in terms of digital infrastructure, there

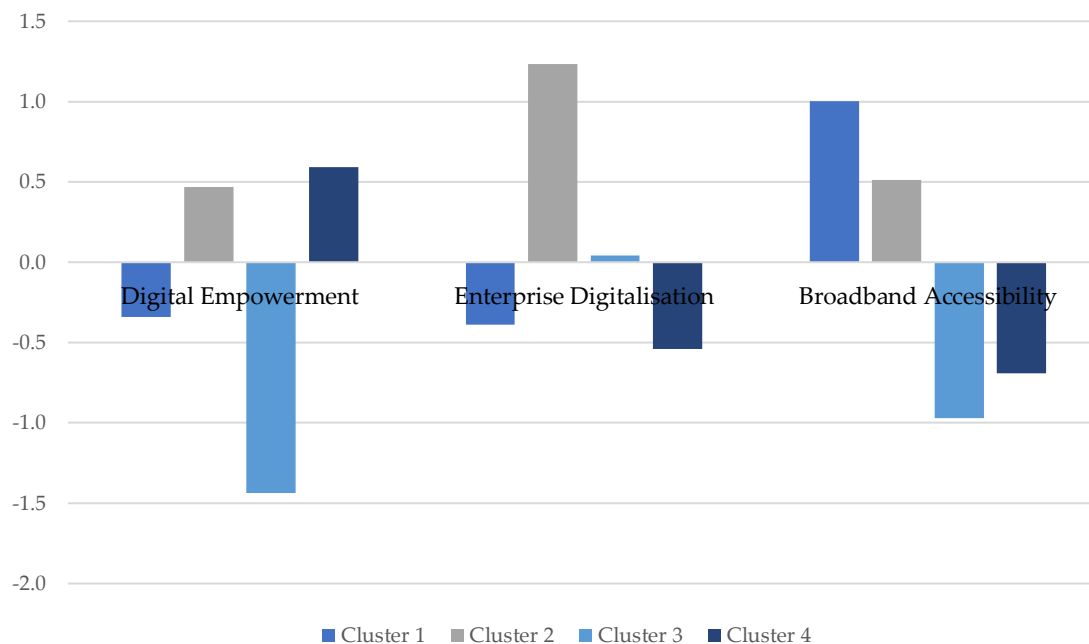
is a need to focus on equipping individuals with digital skills and promoting the adoption of digital technologies in enterprises.

Cluster 2 was called “Digital Transformation Champions” since it demonstrates above-average performance across all analysed factors, indicating their strong commitment and success in digital transformation. They have made significant progress in digital empowerment, enterprise digitalisation, and broadband accessibility. Their proactive efforts in promoting digital skills, adopting advanced technologies, and ensuring widespread access to broadband services make them role models for other countries looking to achieve comprehensive digital transformation.

Cluster 3, referred to as “Digital Empowerment Laggards” consists of countries with weak performance in digital empowerment and limited broadband accessibility. However, they show slightly positive performance in enterprise digitalisation. This suggests a need for these countries to prioritize initiatives that enhance individuals' digital skills and promote wider internet access. While they have made progress in integrating digital technologies within enterprises, there is still work to be done to bridge the gap in digital empowerment and broadband availability.

Cluster 4, named “Empowerment-Driven Disparities” demonstrates above-average performance in digital empowerment but lags behind in enterprise digitalisation. Countries in this cluster face challenges in broadband accessibility. While they have shown a commitment to equipping individuals with digital skills and promoting digital participation, there is a need to focus on integrating advanced technologies within enterprises and improving broadband availability to achieve a more balanced digital ecosystem.

**Figure 2.** Latent dimensions and comparative performance of clusters.

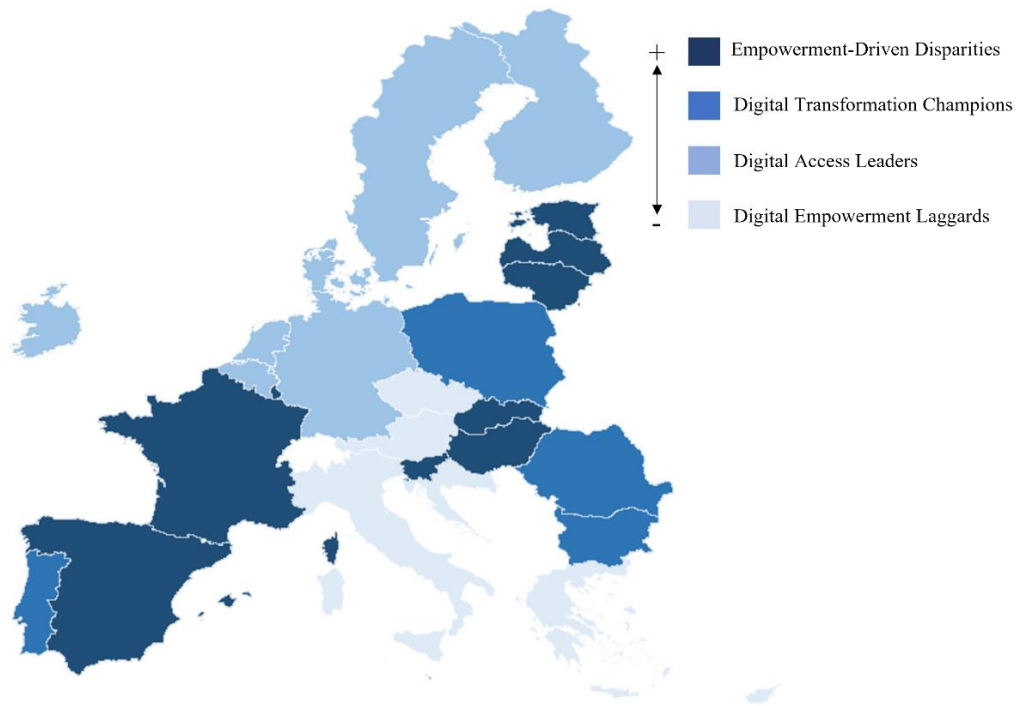


Source: Author's elaboration.

Understanding the nuances and significance of cluster performance on each factor allows policy makers and stakeholders to develop targeted digital transformation strategies and initiatives. Figure 3 focuses on countries' performance on Digital Empowerment, highlighting the clusters with the highest scores. The best-performing clusters in this dimension are those categorised as Empowerment-Driven Disparities, followed by Digital Transformation Champions. Underperforming clusters are Digital Access Leaders and Digital Empowerment Laggards.

In today's rapidly evolving world, digital technologies serve as a catalyst for innovation, enabling countries to drive economic growth, enhance productivity, and foster societal progress (Sarren & Haarstad, 2021). Understanding how digital skills, internet access, and e-government services intersect with innovation performance provides a comprehensive perspective on a nation's ability to leverage digital technologies to foster innovation-driven economies. In this way, it is important to compare the cluster's performance in the dimensions under analysis with the last results of the European Innovation Scoreboard<sup>1</sup> (EC, 2022).

**Figure 3.** Digital Empowerment.



Source: Author's elaboration.

Comparing the information on the performance of digital empowerment clusters and the European Innovation Scoreboard (EIS), certain correlations can be observed. France emerges as a country that shows a positive relationship between its performance in digital empowerment and innovation. It is classified as an Empowerment-Driven Disparity cluster in terms of digital empowerment and also as a Strong Innovator in the European Innovation Scoreboard. Luxembourg is also mentioned as a Strong Innovator in the European Innovation Scoreboard and is part of the Empowerment-Driven Disparity cluster, indicating a correlation between its innovation performance and digital empowerment.

On the other hand, there are notable differences between the two sets of data. Sweden, the EU's top innovator according to the European Innovation Scoreboard, and Ireland, a Strong Innovator, fall into the category of Digital Access Leaders, implying a discrepancy between their innovation performance and digital empowerment. Similarly, countries such as Austria and Cyprus, recognised as Strong Innovators in the European Innovation Scoreboard, are categorised as Digital Empowerment Laggards, further highlighting the disparities. In addition, countries such as Estonia, Slovenia, the Czech Republic, Italy, Spain, Portugal, Malta, Lithuania and Greece are categorised as Moderate Innovators in the European Innovation Scoreboard but have different levels of digital empowerment.

<sup>1</sup> The European Innovation Scoreboard classifies the EU countries into four performance groups: Innovation leaders, Strong innovators, Moderate innovators and Emerging innovators (EC, 2022).

The differences between a country's innovation performance and its digital empowerment classification suggest that there may be underlying factors that influence individuals' digital skills, internet access and use of technology. According to Novak et al. (2018), people with limited levels of education or living in rural areas may have restricted access to technology or lack the necessary skills to make full use of digital tools. This can create disparities within a country, leaving some individuals and communities behind in technological advancement. Another factor may be economic conditions. In countries with strong economies, digital empowerment levels are usually higher due to greater access to technology and resources. Moreover, these countries often have more advanced education systems that emphasise digital literacy and technological skills. It is also important to consider the cultural and social aspects that shape individuals' attitudes to technology. In some cultures, the adoption of certain technologies may be limited by a preference for in-person rather than virtual communication. Also, an individual's willingness to engage with new technologies may be influenced by specific attitudes to risk and failure that are typically more common among older people.

It is possible that countries classified as Digital Access Leaders, such as Sweden and Ireland, may excel in innovation due to other factors such as research and development, but their efforts to equip individuals with digital skills or ensure widespread internet connectivity may be comparatively lower. Similarly, countries such as Austria and Cyprus, recognised as Strong Innovators but classified as Digital Empowerment Laggards, may have strong innovation ecosystems and skilled ICT professionals, but may face challenges in providing widespread internet access or prioritising data protection. This highlights the importance of not only fostering innovation, but also addressing the foundational elements necessary for individuals to fully participate in the digital age, such as promoting accessible e-government services and enabling online transactions. The varying categorisations of countries classified as moderate innovators by the EIS suggest that their innovation efforts may not be fully translated into comprehensive digital empowerment initiatives.

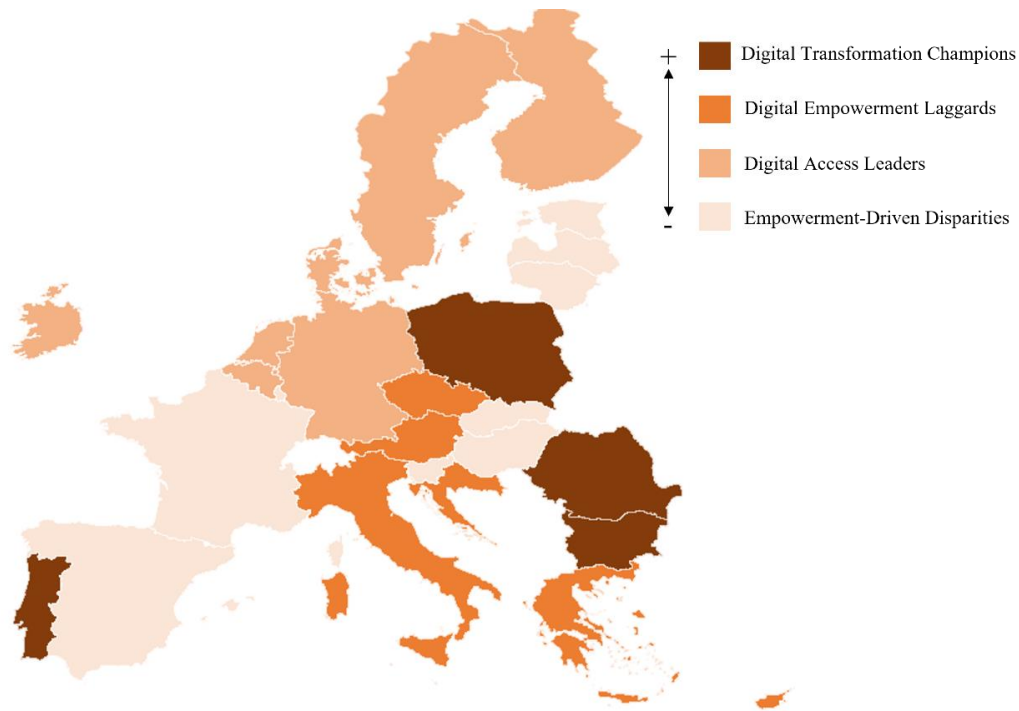
Figure 4 shows the performance of the clusters in terms of enterprise digitalisation. The best-performing clusters in this dimension are the Digital Transformation Champions. The other clusters tend to perform poorly in this dimension: Digital Empowerment Laggards, Digital Access Leaders and Empowerment-Driven Disparities. In this case, the differences are even more visible.

It appears that there may be an imbalance or underperformance in the digitalisation of enterprises among the countries classified as digital access leaders (Belgium, Denmark, Germany, Ireland, Malta, the Netherlands, Finland and Sweden). The term 'digital access leaders' suggests that these countries have advanced digital infrastructure and high levels of digital access. However, when it comes to the digitalisation of enterprises, which includes variables such as ICT training, cable modem use, digital intensity, adoption of AI technologies and internet-based meetings, these countries may not perform as well. This points to a potential gap between digital infrastructure and the extent to which firms have adopted and integrated digital technologies. It suggests that while these countries excel in providing digital access to their populations, there may be room for improvement in promoting and implementing digitalisation efforts within their enterprises. While governments may have invested in providing digital access to their citizens, enterprises may not have the necessary infrastructure or resources to implement it effectively (G20, 2017; OECD, 2021)

The Digital Transformation Champions cluster stands out for its strong performance in integrating advanced technologies into businesses. This suggests that these countries have made significant progress in implementing digitalisation efforts within their business sectors. While the Digital Transformation Champions cluster shows high performance in the digitalisation of enterprises, it appears that some countries within this cluster are not classified as strong innovators in the EIS. This suggests that while these countries have made significant progress in implementing enterprise digitalisation efforts, their overall innovation performance may not be

at the same level as countries classified as strong innovators or innovation leaders. This suggests that while digitalisation is an essential step towards innovation, it is not sufficient on its own.

**Figure 4.** Enterprise Digitalisation.



Source: Author's elaboration.

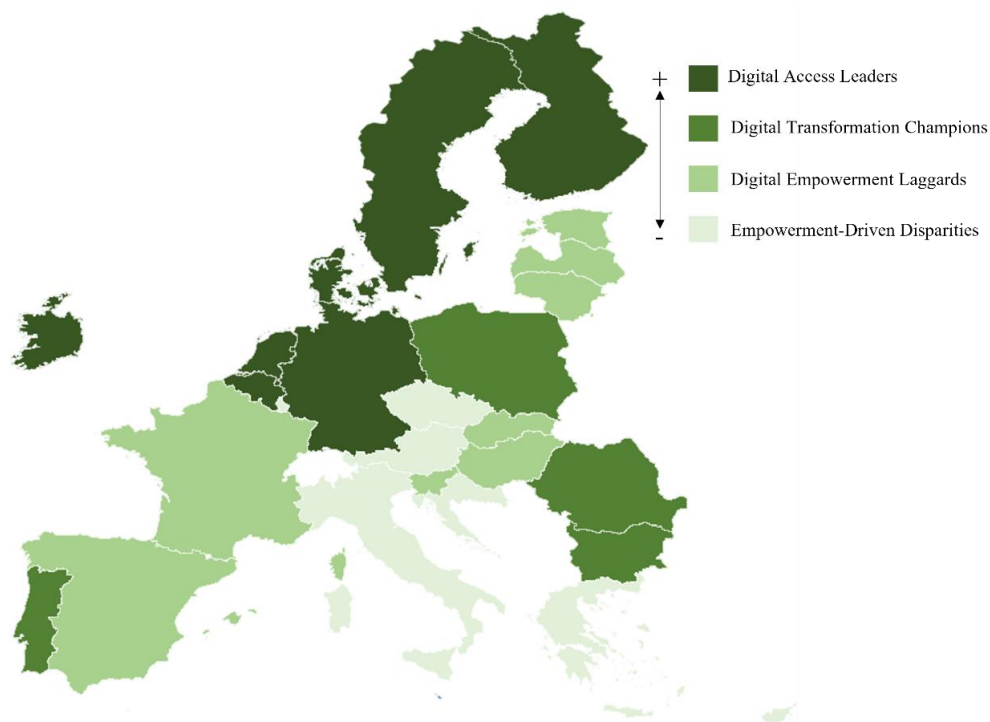
This analysis reveals an imbalance in the digitalisation of enterprises among countries classified as digital access leaders, despite their advanced digital infrastructure. While these countries stand out in providing digital access to their populations, they still need to improve the promotion and implementation of digitalisation efforts within their enterprises. In contrast, the Digital Transformation Champions cluster, comprising Bulgaria, Poland, Portugal, and Romania, demonstrates strong performance in integrating advanced technologies into businesses, emphasizing their commitment to driving innovation and competitiveness. However, their innovation rankings might not reflect their high performance in enterprise digitalisation. To bridge these gaps, it is crucial to address the imbalance in enterprise digitalisation among digital access leaders and foster further innovation, thus fully leveraging the potential of digital technologies.

Figure 5 concerns the performance of broadband access. The best-performing clusters in this dimension are the Digital Access Leaders, followed by the Digital Transformation Champions. On the other hand, Digital Empowerment Laggards and Empowerment-Driven Disparities show below-average performances. The countries that perform well in terms of broadband accessibility, such as the Digital Access Leaders cluster (Belgium, Denmark, Germany, Ireland, Malta, the Netherlands, Finland and Sweden), are also likely to have strong innovation performance, as indicated by their positions as Innovation Leaders in the European Innovation Scoreboard. These countries have prioritised investment in broadband infrastructure and have established robust connectivity, providing a solid foundation for innovation-driven activities. By ensuring widespread access to broadband services and advanced mobile networks, these countries provide a favourable environment for research, development and adoption of new technologies. The availability and accessibility of high-speed internet contributes to the digital transformation of industries, encourages entrepreneurship and fosters a culture of innovation, ultimately leading to their strong performance in both dimensions (EU, 2015; Buhr, 2017;

Ignatow, 2020; Sarren & Haarstad, 2021; Dhondt et al., 2021; Nagy & Somosi, 2022). In other words, countries with a strong internet connectivity infrastructure make it easier for people to access information and resources online. This can foster innovation in sectors such as technology, healthcare and education. In addition, the availability of high-speed internet can promote entrepreneurship by facilitating the creation of online businesses.

Inconsistencies between broadband accessibility and the European Innovation Scoreboard may arise if countries differ in their performance along these dimensions. For example, there may be countries such as the Digital Empowerment Laggards cluster (Czech Republic, Greece, Croatia, Italy, Cyprus and Austria) facing challenges in broadband accessibility despite their innovation potential. These countries may have lower levels of broadband penetration and limited fibre coverage, hampering the accessibility and availability of high-speed internet. As a result, this may hinder the adoption of advanced technologies, research collaboration and innovation activities in their economies. As the world becomes more digitised, access to broadband internet is becoming increasingly critical for economic growth and development. Countries with lower levels of broadband penetration are left behind as they may not be capable of keeping up with the pace of technological advancement. This can result in a competitive disadvantage in the global marketplace and hamper the growth potential of these economies (Novak et al., 2018; Sarren & Haarstad, 2021; OECD, 2021). Similarly, countries classified as moderate or emerging innovators in the European Innovation Scoreboard, such as Estonia, Slovenia, the Czech Republic, Italy, Spain, Portugal, Malta, Lithuania, Greece, Hungary, Croatia, Slovakia, Poland, Latvia, Bulgaria and Romania, may struggle with broadband accessibility, limiting their potential for technological development and innovation. These contradictions highlight the importance of addressing broadband infrastructure and accessibility challenges in order to unlock the innovation potential of these countries and create a more balanced digital ecosystem.

**Figure 5.** Broadband Accessibility.



Source: Author's elaboration.

The analysis of digital performance and the identification of clusters underlines the importance of understanding and tackling the digital divide. The heterogeneity observed between countries in terms of their digital characteristics underlines the need for tailored approaches to bridge the gap between digitally empowered and lagging regions. By considering the links between digital empowerment, innovation and technological development, policymakers and stakeholders can gain a comprehensive understanding of the complexities of digital transformation and ensure that all individuals and communities have access to its benefits.

## 5. Conclusions

Digitalisation is today an omnipresent process. The digital is expanding into many sectors, from smart applications, healthcare, banking, and urban mobility to the sharing economy. Digitalisation - the use of digital technologies to transform social, economic and cultural systems - is a crucial process for the transformation of society in the following decades and will shape not only informational processes but many other aspects that will define the possibilities for a sustainable transition. Digitalisation is not only about technology. It is about leading to new social practices – the Digital transformation. Skills and access to infrastructure are fundamental for this change. The recent pandemic has emphasized the need to break the digital divide, as remote work and delivery of public services through the internet gained relevance. Developing and implementing digital technologies can be a way to instigate solutions for several types of unanswered social needs. Digitalisation processes that impact society are often a result of a social innovation process. Without proper social innovation, the mere implementation of a digital technology may lack the acceptance of its potential users.

This study has provided relevant insights into the digital landscape of the EU-27 countries, highlighting the importance of bridging the digital divide and taking an integrated approach to digital transformation. The analysis of cluster performance based on digital literacy, digitalisation of enterprises and broadband accessibility has shed light on the heterogeneity between countries and highlighted the interdependencies between different dimensions of digital performance.

The results have demonstrated the positive correlation between broadband accessibility and innovation performance, highlighting the importance of addressing gaps in broadband infrastructure to unlock innovation capacity. In addition, the study has revealed the discrepancies between a country's innovation performance and its digital empowerment classification, highlighting the need to prioritise initiatives that enhance digital skills, promote wider internet access and ensure comprehensive digital empowerment. In addition, the results also showed an imbalance in the digitalisation of enterprises among countries classified as digital access leaders, highlighting the importance of further efforts to promote and implement digitalisation initiatives in these countries. On the other hand, the strong performance of the Digital Transformation Champions cluster in integrating advanced technologies into enterprises demonstrates their commitment to fostering innovation and competitiveness.

When considering the need to address the digital divide, which remains a pressing challenge in today's societies, the results tend to highlight the disparities that exist in terms of digital development. By recognising the interdependencies between these dimensions and identifying the factors that contribute to the digital divide, policy makers can develop targeted strategies to bridge the gap. Understanding the nuances of each country's digital performance and its relationship with innovation and technological development enables policymakers to design context-specific policies that address the unique challenges and opportunities faced by different countries.

An integrated approach to the dimensions under analysis can inform comprehensive policies that promote them, helping to narrow the digital divide and ensure that the benefits of digitalisation are accessible to all individuals and communities, regardless of their socio-economic background or geographical location. In particular, addressing gaps in broadband infrastructure and accessibility could be a priority, as it not only promotes digital empowerment,

but also fosters innovation and competitiveness. In addition, efforts should be made to encourage and support the digitalisation of enterprises, especially in countries classified as digital access leaders. By implementing effective public policies that prioritise digital empowerment, enterprise digitalisation and broadband access, countries can foster inclusive and sustainable digital development, ultimately contributing to economic growth, social progress and improved quality of life for their citizens.

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## Appendix

### Appendix 1. Total Variance Explained.

Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	8.725	54.532	54.532	5.622	35.140	35.140
2	1.716	10.726	65.258	4.302	26.886	62.025
3	1.473	9.204	74.463	1.990	12.437	74.463
4	0.855	5.342	79.805			
5	0.749	4.678	84.483			
6	0.562	3.513	87.996			
7	0.489	3.056	91.052			
8	0.349	2.181	93.233			
9	0.331	2.066	95.299			
10	0.228	1.422	96.722			
11	0.156	0.972	97.694			
12	0.150	0.940	98.634			
13	0.080	0.503	99.136			
14	0.061	0.380	99.516			
15	0.050	0.310	99.826			
16	0.028	0.174	100.000			

Source: Author's elaboration.

### Appendix 2. KMO and Bartlett's Test.

KMO and Bartlett's Test		
Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		<b>0.803</b>
Bartlett's Test of Sphericity	Approx. Chi-Square	338.015
	df	120
	Sig.	<b>0.000</b>

Source: Author's elaboration using SPSS.



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