EXPLORING THE GAPS IN GLOBAL DIGITAL DIVIDES: EVIDENCE FROM A COMPOSITE DIGITAL DIVIDE INDEX

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Abstract

In the twenty-first century, the global digital access and connectivity have become a major force behind global integration, economic advancement, and social development. Despite widespread internet access, mobile communications and broadband infrastructure, significant differences in digital connectivity and access, often referred to as the 'digital divide', persist across countries. This study aimed to identify the gaps in the first-order digital divides across countries from 2000 to 2023. Four key indicators namely fixed phone subscriptions, mobile cellular subscriptions, broadband subscriptions, and internet usage were combined into a composite Digitalization Index using Principal Component Analysis. Moreover this study utilized the secondary data obtained from the World Bank. Cluster analysis was employed to classify countries into low, medium, and high digitalization groups over time. The clustering results identified three district groups: cluster one with 1101 observations, cluster two with 755 observations, and cluster here with 902 observations. To better understand global digital inequality, this study provided a simple and comprehensive measure through the constructed Digital Divide Index. In addition to that, this study highlights the importance of constructing digital infrastructure in order for individuals to be able to participate in the digital economy globally..

Keywords: *digital access and connectivity, digital divide, first-order digital divides, global digital inequality*

1. INTRODUCTION

In the today's 'society, social development, economic growth, and International Corporation cannot be imagined without digital technologies and digitalization. Therefore it can be regarded as one of the most remarkable phenomena in the contemporary age (Criveanu, 2023). However, especially during the last decades, the introduction of such innovations such as mobile devices, internet devices and other form of digital technologies have greatly influenced each aspect of human activity and for their life, from how people communicate and consume information to its acquisition. Therefore as a result of past growth of these digital technologies such as broadband infrastructures, mobile communication devices, and internet access devices there has been a noticeable impact on the process of social networking, governance, education, production etc. Nowadays, the majority of people also believe that digital connectivity is the one of the key factor for inclusive development, productivity, and innovation (The World Bank, 2016).

Besides its impact on the economy and society, digital connectivity is also very vital in national governance and service delivery. E-governance, E-education as well as e-healthcare are just a few of the many services that various governments in the world are using digital connectivity to deliver to their citizens. Therefore it is evident that countries with higher levels of digital access are in a position to deliver such services to their citizens, while others with low levels of digital access are unable to do so (International Telecommunication Union, 2023).

Nevertheless, the COVID-19 pandemic has also made it clear that the need to utilize digital technologies as well as digital access devices are more important than it has ever been in the history of mankind (Aissaoui, 2020). As a matter of fact, during the period of covid-19 pandemic, there was a notable change in the employment and education sector with regards to the utilization of digital technology. This, in itself, makes it clear that having access to digital technology is also more of a need rather than a luxury in today's world (OECD, 2020).

Another significant factor is that policy frameworks, affordability, and infrastructure all have an impact on digital access. Access can be limited even in cases where infrastructure is available due to high internet service costs and a lack of supportive policies. As a result, comprehending digital divides necessitates taking into account the accessibility and cost of digital technologies at the national level (International Telecommunication Union, 2023).

Whereas this development of digital technologies across the world can help create equal access to digital technologies amongst nations, there is still a large inequality gap between them (International Telecommunication Union, 2023). This inequality gap is termed to as "digital divide" (OECD, 2020). While the term of "digital divide" has focused mainly on the disparity related to the availability of the technologies such as internet access and telecommunications facilities, according to the Norris, (2001) the term "digital divide", which was mainly concerned with the disparities in technologies and disparities in their skills or utilization of digital technologies. Van

Dijk, (2006) also stated that this concept of digital divide was primarily based on differences in digital infrastructure.

As per the International Telecommunication Union, (2023) factors like economic growth, investments in infrantructure, quality of the institution, regulatory environments, as well as the financial cost of digital services are required for mesuaring digital divides on a national scale. In lower, middle income countries, barriers exist in providing universal broadband connectivity.In developed nations, digital infrastructure is also well implemented. Hence global digital divide has made a close linkage among digital inequalities and broader economic inequality patterns around the world (Hilbert M. , 2011).

In light of increasing important association with the participation of counties in the digital economy and its relationship with connectivity, there emerge an important need to understand trends and its relationship with connectivity, there emerges important need to understand trends from the point of view of access in this regard. Greater connectivity allows countries to leverage their advantageous positions and participate effectively in the global society as well as attract investments while boosting innovations as per their capacity (OECD, 2020). Therefore the absence of access may influence economic diversification and social inclusion.

According to these advancement with regard to global connectivity, there have been inequalities formed concerning the global reachability when it comes to digital connectivity. Still there are certain countries that do not meet international standard of digital connectivity, while there are few nations that have provided worldwide access to internet and digital networks by itself (International Telecommunication Union, 2023).

Past research works have also remained the strategic importance of digital infrastructure for socio-economic growth (Bohlin & Srinuan, 2011). But there is a scarcity in the present body of evidence in relation to the overall digital access trends at the national level, which generally represent global inequalities. Therefore, his study is more precise, because of the lack of clarity in national trends that policymakers might find it difficult to formulate an appropriate strategy to ensure the development in the digital-dimensions.

For a more profound comprehension of the characteristics of the persistence and progression of reducing disparities in digital access and connectivity across nations, there is an equal need for discussing the issues of digital divides from a cross-national perspective. Therefore the objectives of the study included investigating the trend of digital access and connectivity at national level. In addition to this, the study aimed at assessing the level of digital access between countries over time, and analysing the development of disparities of first level digital divide over time.

1.1 Research Question

What differences exists in first level digital divide and how can it be classified over time?

1.2 General Objective

To analyse the first-level digital divide across countries from 2000-2023.

1.3 Specific Objectives

- To construct a composite digital divide index to measure the first-level digital divide.
- To classify the observations into different digitalization groups based on levels of digital access and connectivity.

2. LITERATURE REVIEW

2.1 Global Digital Divide

The inequality in terms of accessibility and utilization of information and communication technologies is called the global digital divide, and according to the definition, it also shows that there are great differences in terms of information and communication technologies across countries as well. It helps illustrate the inequality in accessing and using the internet (Aissaoui, 2020). The reason behind the inequality mentioned above can be explained by the dynamic and changing nature of the digital divide, which makes it difficult to analyse, and involves various factors (OECD, 2020). In other words, according to the OECD, (2020) the term digital divide can be defined as the gap existing between people, households, firms, and regions based on their socio-economic status in relation to the opportunity to use ICT and internet for different purposes.

As per the findings World Bank, (2016) the digital divide is also affected by demographic factors. As a result of expensive infrastructure investments and insufficient motivation for investment, rural and isolated communities are likely to be less connected compared to urban communities. Such inequalities in connectivity may translate into further developmental inequalities and economic opportunities.

Additionally digital inequality is also influenced by demographic variables like age and gender. Compared to men and younger people, women and older populations are less likely to access and use digital technologies. According to studies, these differences demonstrate that the digital divide is considered to besocial as well as technological (Hilbert, 2011).

In order to capture the multifaceted nature of the digital divide, researchers have divided it into three levels. The primary focus of the first level digital divide is inequality in internet connectivity and access to digital devices (The World Bank, 2016). These inequalities in terms of access to the digital device and the internet constitute the core issue of concern regarding the first level of digital divide (The World Bank, 2016). Inequalities, in terms of the skill needed to operate digital devices constitute the core topic of discussion at the second level of the digital divide (The World Bank, 2016). Inequalities in benefits or the consequences of adopting and implementing digital technology is the primary subject of investigation regarding the third level of the digital divide (The World Bank, 2016). In particular, the first-level digital divide and its inequalities across nations is the sole subject of this paper.

2.2 Empirical studies related to the study

As per Bohlin & Srinuan, (2011), United States and Canada are at the forefront of research done on the first digital divide in the world, followed by Europe, Asia Pacific, Africa, Latin America, and the Middle East. In terms of the national approach to digital divide research, the United States leads the pack followed by the United Kingdom, India, and China. However, research conducted on the global digital divide is minimal in developing countries. Because these researches deal with regional differences or the difference between individuals within a country, they have dealt with the individual or domestic digital divide. The cross-country split researches, on the other hand, have addressed the digital divide as a whole (Chipeva, Cruz-Jesus, Oliveira, & Irani, 2018). Moreover, the study adopts a cross-national approach to explore global disparities in the digital divide.

One aspect of technological determinism has been used by researchers in several empirical examinations of the primary level of the digital divide (Lentz & Oden, 2001), (Chowdary, 2002), (Lim, 2002), and (Akselsen & Hartviksen, 2002). Deterministic approaches takes technology as the key factor behind the development of societies whereby social and human factors act in a supportive manner relative to other factors (Bohlin & Srinuan, 2011). In this case, it is believed that it is very important to incorporate the telecommunications marketplaces for reducing the digital divide. Besides, from this perspective, everybody can use and enjoy the ICT if the problem of accessibility of these technologies is addressed. Considering the limitations of the deterministic approach regarding the explanation of the digital divide, socio-economic factors have also been included in their analyses of the digital divide based on technological determinism.

As some recent studies examine the digital divide under the light of the globalization of ICT access, more attention is increasingly being given to the gap in terms of digital skills and use (Hilbert M. , 2016), (van Dijk & van Deursen, 2018). Moreover, it has become evident that the aspect of access in the context of the digital divide has never been more relevant and is highly important in real life (Hilbert M. , 2016).Therefore it goes without saying that future investigations into the digital divide should be more focused on the first-level digital divide.

Accordingly, Menzie & Robert , (2004) conducted important study that used cross-country regression analysis to examine the indicators that contribute to the global digital divide. It was found out by the authors that the major determinants of digital access are the level of income, education, and institutions. As per their results, it can be said that there still exist differences in the access to ICT despite the presence of the income variable.

Cirera, Comin, & Cruz, (2022) made another recent contribution that looked at firm-level digital adoption in various nations. As pointed out in the literature review, even with the available basic infrastructures, firms conducting business in emerging countries seem to have been behind when it comes to digitization. Thus, it seems that financial, institutional, and human resource limitations influence digital performance.

In addition, Comin & Mestieri, (2010) conducted research study on the diffusion process of innovations such as ICT over time among different countries. It was found that the diffusion of technology varies greatly between developed and developing nations, which illustrates the reason behind the digital divide persisting despite global technology advances.

Another study conducted by Howard & Mazaheri, (2009) mentioned that the importance of digital connectivity for the political development and governance. From the results of this research, it is clear that democracy, participation, and transparency are directly related to increased access to the Internet. However, keeping in mind the differences between people regarding their access to the Internet, it becomes clear that there are inequalities in benefits as well.

Moreover, Koutroumpis, (2009) provided empirical evidences on the impact of broadband infrastructure on economy in European countries. The outcomes of the study indicated that, there was a strong relationship between broadband penetration and GDP growth through the use of panel data models. However, these results suggested that this would be significant more developed economies that have a well-established digital economy. This may lead to an increase in global inequality.

Aker & Mbiti, (2010) also examined how mobile phones can improve economic outcomes and market efficiency in developing nations in Africa. According to the study, having a mobile phone improves price transparency, decreases information asymmetries, and increases market participation, especially in rural areas. This illustrates that how digital technologies can support development that is inclusive.

For instance, the International Telecommunication Union has come up with the concept of ICT Development Index (IDI) which measures the overall effectiveness of digitalization by using several indicators concerning accessibility, usage, and skills (ICT Development Index, 2017). In the same manner, there is the creation of the Networked Readiness Index (NRI) by the World Economic Forum which evaluates the involvement of nations in using information technology in developing their socio-economic status (Dutta & Lanvin, 2019). Furthermore, there is the development of the Digital Economy and Society Index (DESI), which specifically targets the digital competitiveness of the nations in Europe (European Commission, 2020). It is essential to note that the above indices have largely focused on the overall effectiveness of digitalization rather than exploring the disparities associated with access to basic digital resources despite the fact that they help create useful aggregate values for comparison among different nations. Therefore, this study also uses an aggregated index but the focus will be on the first-order digital divide.

However, apart from the economic consequences, some of the studies carried out have sought to identify the effects of the digital divide on society at large. Among the studies undertaken in this context was one by DiMaggio & Hargittai , (2001) where the concept of digital inequality was first coined, and it was emphasized that the divide is related to the level of education, income, and social capital possessed by an individual.

Moreover, according to Pick & Sarkar, (2015), an index was created to evaluate the global digital divide among nations using digital readiness criteria. Countries in Western Europe and East Asia were at the highest tier, whereas regions in Sub-Saharan Africa and South Asia fared poorly. In here the authors also demonstrated that improvements in education and infrastructure investment significantly narrow the divide, suggesting a strong policy link between ICT advancement and human development. Using cluster analysis and multivariate techniques, the study classified countries into different levels of digital development and found that income level, education, and institutional quality are key determinants of digital access. Their findings support the use of composite indices, similar to the approach adopted in this study, to capture the multidimensional nature of digital connectivity.

Another important contribution to this concept is made by Billon, Marco, & Lera-Lopez, (2009), who studied the ICT diffusion patterns among nations using cluster analysis. They illustrated that clusters of digitalization were designed based on socioeconomic, institutional, and infrastructural determinants. Their findings implied that income and governance quality as major explanatory factors for technological disparities. In additionally, the study identified distinct groups of countries based on their level of ICT adoption and found that economic development and technological readiness are major factors influencing digital access. The authors also pointed that disparities between country groups persist over time, indicating the long-term nature of the digital divide.

More recent empirical study by Vu, (2011) examined the contribution of ICT to economic growth using panel data set from a significant number of countries around the world. The outcomes of the word implied that ICT act as a major role in enhancing productivity as well as economic performance, particularly when supported by human capital development and institutional quality. Accordingly, this research work suggests that not only the digital access but also complementary factors are essential to maximize its benefits. Moreover, Vu's research outcomes significantly contributed to policy discussions regarding digital transformation in Asia. His study influenced frameworks adopted by the World Bank and Asian Development Bank to assess ICT's role in economic modernization. Not only that beyond academia, also he has served as a consultant for governments and international organizations seeking to leverage ICT for inclusive growth.

Moreover, Prieger, (2012) emphasized the significance of the mobile telephone in bridging the digital divide. According to the research, the use of mobile technology has considerably enhanced access to communication services in developing nations, particularly in rural and underdeveloped regions. Nonetheless, the research revealed that the digital gap regarding internet access still exists despite the widespread use of mobile phones.

The other piece of research worth mentioning in relation to this topic was conducted by Dewan, Ganley, & Kraemer, (2010), who studied the effect of digital infrastructure on the level of productive capabilities of the organizations. It turns out that organizations operating in nations with good digital infrastructure have better productivity and innovation capacities.

Further, there is evidence on the impact of the availability of high-speed internet on the job market in Africa from Hjort & Poulsen, (2019). Based on data collected from firms, the findings reveal that having access to high-speed internet enhances job creation potential and increases productivity.

3. METHODS

In this study, which used a quantitative approach and utilized secondary data, the focus was on the digital divide amongst countries. The trends that were considered for analysis in this case include those that emerge with regard to digital access and connectivity in national contexts. Data related to the variable under study were gathered from Development Indicators available on website of the World Bank. Data from this particular source were reliable and consistent for several countries within a particular period of time. In order to analyse the first-order digital divide, the present study employed four indicators such as: internet usage, fixed telephone subscriptions (per 100 persons), mobile cellular subscriptions (per 100 persons), and broadband subscriptions (per 100 persons) which emphasizes inequalities in internet connectivity and access to digital devices (The World Bank, 2016). These measures were chosen because they encompassed the essential aspects of national connectivity, accessibility to digital infrastructure, and fundamental digital services (Aissaoui, 2020).

Moreover, this study applied multivariate analysis techniques to manage multiple indicators and summarize overall connectivity. First, a composite index of digital index for each nation was created by combining the four variables using Principal Component Analysis. Through this process, dimensionality was reduced and a single component used to capture the overall degree of digital infrastructure and connectivity at the national level is produced. By using the composite digital dividend index as the foundation for additional categorization and analysis, the study was able to methodically arrange the number of observations over time, based on their degree of digital access.

Each yearly data was categorized into varying levels of digital connectivity after constructing the composite digital divide index. In addition, groups of digital divides with similar characteristics with respect to their digital connectivity and access were analysed through multivariate analysis like pattern recognition and classification techniques. This method offered a methodical comprehension of how nations vary with regard to digital infrastructure and connectivity trends over time. Further, the classification makes it easier to identify year wise observations with low, medium, and high levels of digital access.

The study looked at national-level digital access trends during the study period to see how patterns of connectivity change over time. Through trend analysis and multivariate techniques, the study was able to shifts in the relative positions of nations and the general framework of digital divides. In order to provide an objective assessment of the differences in digital access across countries while maintaining comparability and consistency in the analysis, the methodology placed a strong emphasis on the application of systematic, quantitative approaches.

4. ANALYSIS

The main results and empirical analysis of this paper dealing with the problem of digitalization in different countries during the period of 2000 to 2023 are described in this study. The following are the main tasks that the analysis aims to accomplish – develop an index of digitalization; examine its changes with time; make a cluster analysis of different country clusters; analyse the main digitalization infrastructure parameters. These tasks can be performed using appropriate statistical methods and techniques.

Because, when working with multiple correlated variables, Principal Component Analysis (PCA) is especially helpful. It lowers the dataset's dimensionality while maintaining the majority of the data's variability. Because of this, it is a suitable technique for creating composite indices in research on digital development (Abdi & Williams, 2015).

Additionally, the use of standardized data guarantees comparability between nations and eras. Standardization assisted in removing scale discrepancies and enhancing the reliability of the findings because the variables used in the analysis are measured in various units. This techniques are often utilized in empirical studies across nations around the world (Jolliffe & Cadima, 2024).

Accordingly, this study employed the data from 2000 to 2023. The primary variables for the analysis are: Fixed phone subscriptions per 100 individuals, also known as BBS. Mobile phone subscriptions per 100 persons are also known as MPS. Internet users, expressed as a percentage of the population, is a variable called the Digital Cluster. It is a categorization of nations according to the Digitalization Index. Principal Component Analysis (PCA) was used to create the Digitalization Index. The variables were standardized as needed prior to the analysis.

4.1 Descriptive Statistics

Table 1
Descriptive Measures

Statistic	FPS	BBS	MPS	IU
Min.	0.0	0.0	0.0	0.0
1st Qu.	4.0	0.5	48.7	10.0
Median	15.2	6.1	96.9	39.7
Mean	19.7	11.9	87.7	42.6
3rd Qu.	31.7	22.0	123.4	72.9
Max.	74.5	48.7	319.9	100.0
NA's	38.0	338.0	19.0	38.0

(Note: FPS refers to fixed telephone subscriptions per 100 persons, BBS refers to broadband subscriptions per 100 persons, MPS refers to mobile cellular subscriptions per 100 persons, and IU refers to internet usage as a percentage of the population.).

Source: Developed by author based on survey data (2026)

The dataset comprises 3120 observations and four key indicators that represent the digital access and connectivity:

1. Number of fixed phone subscriptions per 100 individuals (FPS)
2. Subscriptions to broadband per 100 persons (BBS)
3. The number of mobile phone subscriptions per 100 individuals (MPS)
4. The percentage of people who use the Internet (IU)

There is a considerable differences among countries over time, according to the summary statistics. Broadband penetration varies greatly, as evidenced by the mean of 11.86 broadband subscriptions (BBS) per 100 persons, which ranges from 0 to 48.67. With the greatest mean value of 87.67 9 (per 100 people) and the widest range from 0 to 319.85, mobile cellular subscriptions (MPS) demonstrates the swift global spread of mobile technology. Strong cross-country variations in internet adoption are highlighted by the Internet usage percentage (IU), which has a mean of 42.64% and values ranging from almost zero to full penetration (100%). The mean for fixed telephone subscriptions (FPS) is comparatively lower (19.71), indicating a slow transition from fixed-line to mobile technologies. Since some variables had missing values, Principal Component Analysis was only applied to complete cases.

4.2 Correlation Matrix

Table *2*
Output of the Correlation Matrix

	FPS	**BBS**	**MPS**	**IU**
FPS	1	0.5729	0.2993	0.5032
BBS	0.5729	1	0.5672	0.8420
MPS	0.2993	0.5672	1	0.7306
IU	0.5032	0.8420	0.7306	1

(Note: FPS refers to fixed telephone subscriptions per 100 persons, BBS refers to broadband subscriptions per 100 persons, MPS refers to mobile cellular subscriptions per 100 persons, and IU refers to internet usage as a percentage of the population.).

Source: Developed by author based on survey data (2026)

Referring to the correlation matrix above, all four indicators are positively related. Moreover, the association between internet usage and broadband subscriptions is particularly very strong (r = 0.842), and it normally implies that the higher the broadband subscriptions in a country, the higher the internet usages. Not only that, but there was also a strong positive association among internet usage and mobile subscription with r = 0.731. Overall, these robust positive correlations support the creation of a composite Digitalization Index through PCA and provide evidence that the selected variables essentially measure more related dimensions of digital development.

1.3 Principal Component Analysis

Table 3
Results of the PCA

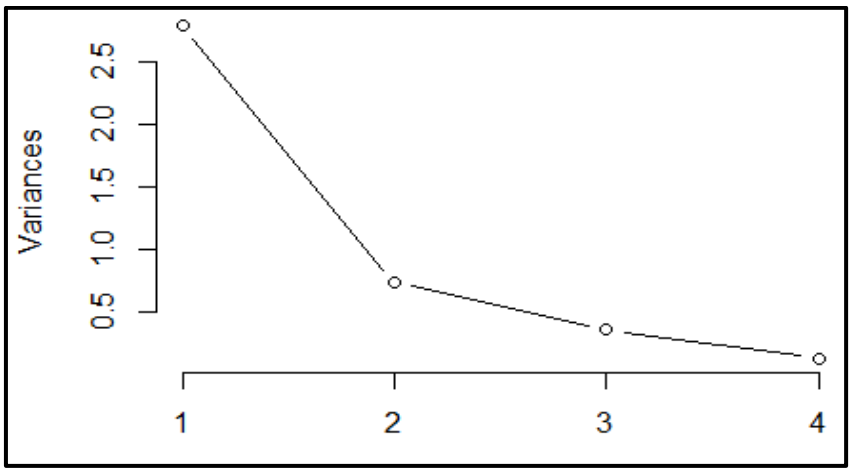
Importance of Components	PC1	PC2	PC3	PC4
Standard deviation	1.6710	0.8546	0.59535	0.35058
Proportion of Variance	0.6981	0.1826	0.08861	0.03073
Cumulative Proportion	0.6981	0.8807	0.96927	1.00000

(Note: PC1–PC4 represent the first to fourth principal components obtained from PCA. Standard deviation shows the variation captured by each component, while the proportion of variance indicates the percentage of total variation explained. The cumulative proportion shows the total variance explained up to each component.)

Source: Developed by author based on survey data (2026)

PCA was carried out after standardizing the variables in order to construct a Digitalization Index. The results indicate that the first principal component (PC1) explains approximately 70% of the total variance in the data. The second principal component (PC2) accounts for 18.26% of the variance. Further PC3 explain 8.86 % of the total variation, indicating that a large proportion of the information is captured by the first component.

Figure 1
Scree Plot of PCA



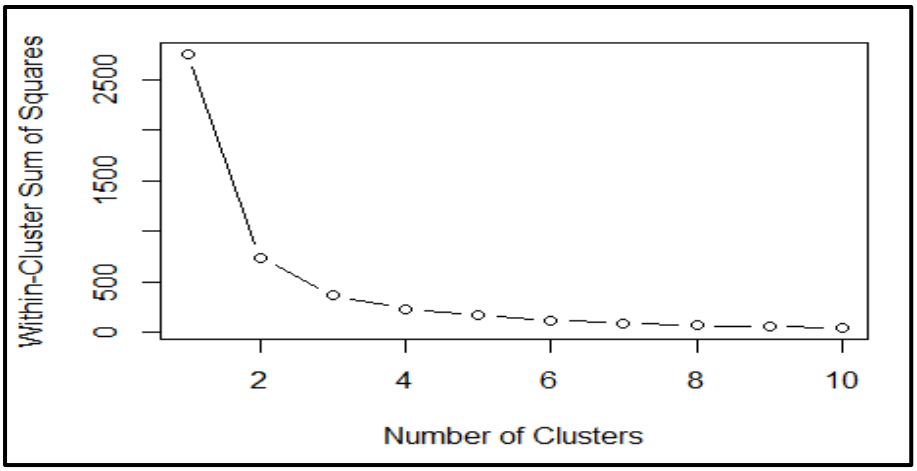
Source: Developed by author based on survey data (2026)

The distribution of the variance explained by the principal components is depicted by the scree plot. A sharp decline is observed from PC1 to PC2, followed by a gradual flattening from PC2 onwards. This clear "elbow" in PC1 indicates that the first principal component captures the majority of the variance in the data, while the remaining components contribute relatively small and decreasing variances. Therefore, can be conclude that, PC1 is the most important component and justifies its use in constructing the digitization index.

4.4 Cluster Analysis

The K-means clustering method was used to categorise countries into distinct groups based on their digitalization levels following the creation of the Digitalization Index. Using standard evaluation criteria, such as variation within a cluster, the optimal number of clusters was chosen before the clustering process could begin. Based on Euclidean distance, the algorithm then assigned each country-year observation to the cluster with the closest centroid. This iterative procedure continued until cluster memberships stabilized, maximizing differences between clusters and minimizing variation within the cluster. Different levels of digital connectivity, such as low, medium, and high digitalization groups, were interpreted as the resulting clusters.

Figure *2*
Scree Plot result of Cluster Analysis



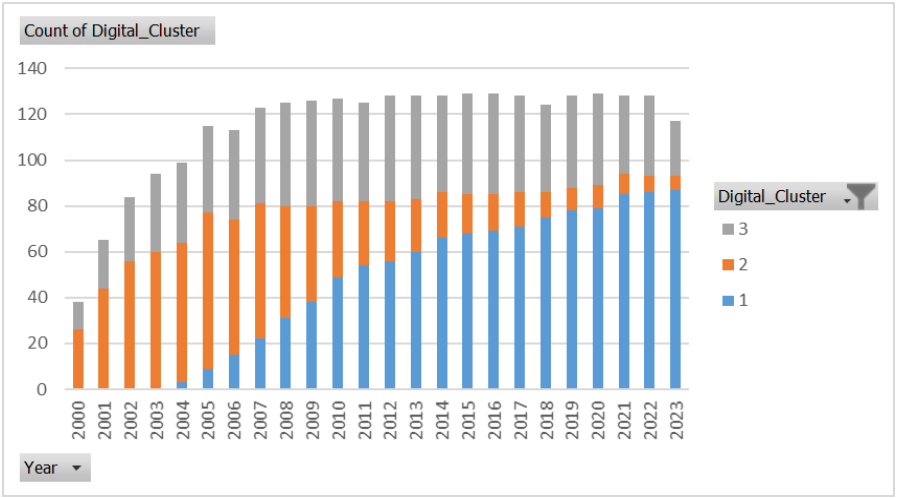
Source: Developed by author based on survey data (2026)

The results from clustering include:

1. Cluster_1: 1,101 observations
2. Cluster_2: 755 observations
3. Cluster_3: 902 observations.

These identified clusters show different levels of digitalization: Accordingly, Cluster one shows the period characterized by low levels of digitalization, Cluster two indicates the period marked by moderate levels of digitalization, while Cluster three includes the period characterized by high levels of digitalization. This clearly illustrates that there is indeed a digital divide among nations.

Figure *3*
Counts of Digital Divide Clusters as a Summary



Source: Developed by author based on survey data (2026)

In conclusion, the yearly breakdown of cluster affiliations can be considered our source of knowledge about the dynamic nature of the evolution of digitalization in various countries. Specifically, there were 1,101, 755, and 902 instances classified as being in the low-level, medium-level, and high-level groups, respectively, according to the sample size, it was equal to 2,758. From the first year to the last year of the sample period, an obvious trend was noticed in relation to cluster affiliation; in the early years, a larger amount of observations were found to be in the medium and high categories compared to the later years when there was a consistent downward trend in the number of observations in the medium group, with the opposite happening for the low cluster. Thus, we can conclude that the cross-country digital divide is indeed a dynamic phenomenon.

5. CONCLUSION AND DISCUSSION

This research was conducted to determine the variations between countries in terms of digital connectivity. A composite variable of digital access was developed to represent connectivity trends across years based on information about the number of fixed-line telephone subscriptions, mobile-cellular subscriptions, broadband subscriptions, and internet users in different countries. Data was classified based on the level of digital connectivity through multivariate analysis, which resulted in a systematic approach to global variations over time.

It can be seen from the final results as indicated in chapter four that there are some differences in terms of digital access in relation to the countries as well as time periods. It can be said that even though digital connectivity has gradually increased with respect to various countries, yet it is not constant with regard to various countries. In some time periods, the digital access and infrastructural level was high in internet usage; hence, it was a high period of development in the field of telecommunication infrastructure. In some time periods, there were low levels of internet connectivity; hence, it was a low period of development in the field of telecommunication infrastructure, thus justifying the theory of Van Dijk, (2006).

Moreover, the stratification of countries based on their degrees of access to digital technology is an indicator of how the digital divide phenomenon cannot be viewed in binary terms. This means that it can be measured using more than one level of classification, which is related to the level of development in the technological sphere. Following the multi-level digital divide model, the degree of development in the telecom sector and digital technologies in different countries, together with their economic potential, can influence digital inequalities.

Looking at the trend at the national level reveals that although the interconnectivity across the globe is evident from the reports published by the International Telecommunications Union, (2023) and the disparities between countries are yet to come down entirely. Each country has its trends regarding the development of digitalization, causing a disparity in access and connectivity. The outcomes are in line with those of Chowdary, (2002), Chipeva et al., (2018), and Akselsen & Hartviksen, (2002) and suggest that despite successes at the global level, each country has not achieved equal success.

Taking everything into account, this study contributes to the understanding of digital divides through its cross-country perspective based on systematic quantitative analysis. What is really significant from this research is that the focus on digital connectivity and access leads to infrastructure as the fundamental element of digital inclusion. Results confirm the need to continue efforts in enhancing digital infrastructure and developing connectivity with a further reduction of access inequalities between nations. It is imperative to address these disparities if inclusive participation in the global digital economy is to be promoted along with more extensive social and economic development.

While this study strives to conduct an analysis of digital divides in an organized manner by studying trends in digital access and connectivity in national countries, there are some issues that must be addressed in the future. One important area that could be examined in the future is the conduct of a thorough comparative analysis of the identified country clusters. The features of economic, institutional, socio-demographic, and policy elements related to the groups with high, medium, and low access to the Internet can be compared to find out what caused the differences in the level of connectivity. This is what future studies need to examine regarding the impact of governance on digitalization. As this study examines mainly the access and connectivity dimensions, the role played by the quality of governance, effectiveness of regulation, and political stability in shaping the outcome of digitalization needs to be analysed in further empirical research. For instance, studies like those conducted by Chinn & Fairlie, (2004) point out the critical role that institutions play in ICT adoption.

Rapidly developing technology poses challenges and opportunities in terms of bridging digital gaps. These new technologies, such as 5G technology, artificial intelligence, and IoT, possess immense opportunities to create value, generate innovations, yet at the same time can intensify inequalities if the distribution of their application is unequal. Those countries that do not embrace new technologies will experience lagging in the digital economy. Thus, it becomes essential to devise

solutions to achieve the equal application of these new technologies. Several areas for further study can include the expansion of new technologies across the globe and the impact of new technologies on bridging disparities.

In addition, there is way for expansion in the analysis through an assessment of digital competencies, use frequency and digital outcomes, which represent the second and third levels of digital divide research. Unfortunately, for reasons of time and scope this current paper had to limit itself to analysing the first-order digital divides, specifically those dealing with connectivity and accessibility issues. However, this approach may not be as effective in future papers.

Moreover, studies conducted in the future can analyse the differences within countries by making use of regional or household-level data. National average can overlook any differences that may exist within countries, whether they be urban versus rural areas or differences between various income levels.

In addition, international cooperation and exchange of information may also prove to be extremely useful in dealing with the problem of digital divide on an international scale. Developed countries as well as international agencies can assist developing nations through technical aid, financial aid, and other modes of collaboration. International collaboration among various nations is necessary for realizing global digital inclusion and other development goals. It has been seen earlier from some research studies that international collaboration and policies are necessary to achieve rapid digitalization and avoid any national differences (OECD, 2020). In future research studies, it may be important to consider the impact of international digital development initiatives, digital projects crossing borders, and international collaboration.

Another research path that could be considered in future is the application of econometrics and machine learning algorithms in digital divides literature. While the present article uses the methods of principal components analysis and clustering algorithms, future research may consider employing panel regressions, causal inferences, and forecasts to understand the drivers behind the digital divide and possible future developments.

To conclude, addressing digital divides necessitates the need for an interdisciplinary and futuristic approach that considers efforts geared towards infrastructure development, policy considerations, capacity building, and international collaboration. In this case, future studies will play a critical role in informing such efforts through the identification of important insights concerning the changing nature of digital divides as well as means of handling them.

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