Revue Française d'Economie et de Gestion
ISSN : 2728- 0128
Volume 6 : Numéro 8

Determinants of digitization and the digital divide in African countries: A panel data analysis

Déterminants de la numérisation et de la fracture numérique dans les pays de l'Afrique : Une analyse en données de panel

Ahmed BOUZIT
(0009-0003-0346-7191, PhD Student)
Laboratory of Economic Sciences and Public Policies (LSEPP)
Faculty of Economics and Management
Ibn Tofaïl University, Kenitra, Morocco

Mariem LIOUAEDDINE
(0000-0002-5824-1590, Professor of Economics)
Laboratory of Economic Sciences and Public Policies (LSEPP)
Faculty of Economics and Management
Ibn Tofaïl University, Kenitra, Morocco

Lahcen BOUJDID
(PhD Student)
Laboratory for research in management, innovation, and applied research (MIRA) – Ait Melloul
Faculty of Economics and Management - Guelmim
Ibn Zohr University, Agadir, Maroc

Said TOUNSI
(Professor of Economics)
Laboratory of Economic Sciences (LSE)
Faculty of Legal, Economic and Social Sciences - Agdal
Mohamed V University, Rabat, Maroc

Date de soumission : 22/03/2025

Date d'acceptation : 09/08/2025

Digital Object Identifier (DOI) : https://doi.org/10.5281/zenodo.17064488

Pour citer cet article :

BOUZI. A. & al. (2025) « Determinants of digitization and the digital divide in African countries : A panel data analysis », Revue Française d'Economie et de Gestion « Volume 6 : Numéro 8 » pp : 652- 672.

Abstract

Developments in information and communication technologies (ICT) are having remarkable impacts on social transformations, such as access to basic services and communications. The potential to benefit from digital innovations can strongly depend on the disparities that exist between individuals in terms of income levels, skills, infrastructures, geographical locations and the quality of institutions. Over the years, the concept of the digital divide has evolved to take account of new dimensions. Initially, the concept of the digital divide was based on the dimensions of access to ICTs, such as telephones, computers, broadband and the Internet. In this work, we are interested in assessing and analyzing the determinants of the digital divide for a sample of 35 African countries. The study period runs from 2010 to 2022. To this end, we will use panel data econometrics techniques to identify the relationship between our variables of interest. We will first estimate the fixed-effect model using the Frisch-Waugh method, and then estimate a random-effect model using the generalized least squares (GLS) method. Our results show that digitization is very low, despite the various efforts made in Africa. Similarly, there is a digital divide in the steps studied.

Keywords: digital economy; panel data econometrics; fixed effect model; random effect model; African economies.

Résumé

Les développements dans les technologies de l'information et de la communication (TIC) ont des impacts remarquables sur les transformations sociales, tels que l'accès aux services de base et aux communications. Le potentiel de bénéficier des innovations numériques peut fortement dépendre des disparités qui existent entre les individus en termes de niveaux de revenu, de compétences, d'infrastructures, de lieux géographiques et de qualité des institutions. Au fil des ans, le concept de fracture numérique a évolué pour tenir compte des nouvelles dimensions. Initialement, le concept de fracture numérique était fondé sur les dimensions de l'accès aux TIC, telles que le téléphone, les ordinateurs, le haut débit et l'Internet En effet, nous intéresserons dans ce travail à évaluer et d'analyser les déterminants de la fracture numérique pour un échantillon de 35 pays de l'Afrique. La période l'étude s'étale de 2010 à 2022. A cet effet, nous utiliserons les techniques d'économétrie de données de panel pour dégager la relation entre nos variables d'intérêt. Nous nous estimerons dans un premier temps le modèle à effet fixe à l'aide de la méthode Frisch-Waugh et dans un deuxième temps nous estimerons un modèle à effet aléatoire à l'aide de la méthode des moindres carrés généralisés (MCG). Nos résultats montrent que la numérisation est très faible malgré les différents efforts déployés aux pas de l'Afrique. De même, il existe une fracture numérique dans les pas étudiés.

Mots-clés : l'économie numérique ; l'économétrie en données de panel ; modèle à effet fixe ; modèle à effet aléatoire ; les économies de l'Afrique.

Type de l'article : Recherche empirique.

Introduction

Digitization refers to the process by which information, services, or processes are transformed into digital formats, making them easier to manage, communicate, and analyze. This phenomenon has radically changed many sectors, from the economy to education, health, and culture. However, the digital transition has also revealed inequalities in technology access and use. These inequalities, collectively known as the digital divide, refer to disparities between individuals, social groups, regions, or countries in terms of access to technology and digital skills.

Studying the determinants of digitalization and the digital divide is crucial for several reasons, as it allows us to understand the deep dynamics that influence the adoption of digital technologies and their social, economic, and political effects. This analysis is essential not only to better understand the causes of unequal access to technologies, but also to design appropriate and inclusive public policies that minimize disparities. Here are some key reasons why studying these determinants is of paramount importance.

Digitalization in Africa has made significant progress over the past two decades, with the expansion of the internet, the proliferation of smartphones, and the emergence of new technologies. However, this digital transition has not been uniform, and the digital divide remains a major challenge. In Africa, the digital divide is not limited to access to technology but also encompasses issues related to social, economic, geographic, and educational inequalities. This situation has profound consequences for the continent's economic and social development.

Digitalization in Africa offers numerous opportunities for economic and social development, but it also raises major challenges, notably the digital divide. This divide is manifested by inequalities in access to and use of digital technologies within the continent. Several factors determine how digitalization progresses in Africa and explain the gaps in access to technologies. These determinants are complex and interconnected, encompassing economic, geographic, social, political, and educational aspects.

Therefore, in view of everything that is going on, within the framework of this work, we aim to analyze and evaluate the determinants of digitalization and the digital divide in Africa.

The remainder of this paper is structured as follows: Section 2 presents the theoretical framework, Section 3 presents the empirical literature review, while Section 4 presents a state of the art. Section 5 describes the research methodology. Section 6 discusses the empirical results and Section 7 is a conclusion.

1. Review of theoretical literature

Digitization refers to the process of converting information (whether textual, visual, audio, etc.) into digital formats, thus facilitating its storage, processing, and transmission through digital technologies. This transformation is essential in many fields, such as education, healthcare, industry, and communication, as it allows for better data management, accessibility, and analysis.

However, the digital divide refers to inequalities in access, skills, and use of digital technologies between different social, geographic, economic, and even generational groups. This divide can manifest itself in several ways:

1. Unequal access to technology: Differences in access to high-speed internet, digital devices (computers, smartphones), or suitable infrastructure can create significant gaps between those who have the means to exploit the opportunities offered by digital technology and those who are excluded.

2. Unequal digital skills: The ability to use technology effectively, navigate the internet, or understand digital tools can vary considerably, creating a gap between generations, education levels, or professional environments.

3. Geographic inequalities: In many rural or developing regions, access to digital infrastructure is often limited, exacerbating the digital divide.

4. Social and economic exclusion: People in precarious situations or those with disabilities may find it more difficult to fully integrate into an increasingly digital society, which accentuates social inequalities.

The digital divide thus represents a major challenge for ensuring equitable social inclusion in the digital age. Bridging this divide requires ambitious public policies, support for digital education, and investment in infrastructure to enable all citizens to fully benefit from the advantages of digitalization.

This literature review aims to examine the theories and approaches that explain digitalization and the digital divide, as well as the social and economic implications of these phenomena.

1.1.Digitization: A multidimensional phenomenon

Digitization covers several dimensions that interact and reinforce each other. According to some authors, digitization can be approached from three main angles:

1. Technological: Digitalization involves the adoption of new technologies (IT, Internet, Big Data, etc.), which profoundly transform social, economic, and professional practices.

Christensen's (1997) model of technological innovation highlights how disruptive technologies are changing industries and economic power relations.

2. Economic: Digitalization enables faster productivity, better resource management, and cost reduction. However, Benkler (2006) points out that the digital economy is not limited to the optimization of traditional markets, but also promotes new collaborative modes of production (such as resource sharing, digital public goods).

3. Social and cultural: Access to digital technologies transforms cultural and social practices. Castells (2000) theorizes the information society, where digital networks become the primary means of communication and social interaction, and where access to information becomes a central driver of power and influence.

1.2.The digital divide: A multifactorial inequality

The digital divide is often perceived as a consequence of socioeconomic inequalities that manifest themselves in the area of access to digital technologies. It can be analyzed through several dimensions:

1. Inequalities in access to technology: Disparities in access to broadband internet, computers, and smartphones are at the heart of the digital divide. According to OECD (2019), internet access remains limited in certain geographic areas, particularly rural or remote areas, which can prevent access to education, vocational training, or online services. Ragnedda and Muschert (2013) explain that inequalities in access are also exacerbated by socioeconomic factors such as income, age, and education level.

2. Digital skills inequalities: Acquiring digital skills is essential to take advantage of the opportunities offered by digitalization. According to Hargittai (2010), the digital divide does not only lie in physical access to technologies, but also in the ability of individuals to use them effectively. Inequalities in digital skills are particularly evident among older populations, the less educated, and those in precarious situations. Van Dijk (2005) distinguishes between physical access, access to information, use of technologies, skills, and attitudes toward technology.

3. Inequalities in technology use: Even when access to technology is available, differences in its use remain. Selwyn (2004), in his analysis of the use of educational technologies, explains that uses vary depending on the available resources, needs, and social contexts of users. For example, young people from disadvantaged backgrounds may have limited use of technology, not because of a lack of material access, but because of a lack of support in acquiring digital skills and knowledge.

1.3.The social and economic consequences of the digital divide

The implications of the digital divide extend far beyond access to technology and digital skills. They manifest themselves in several areas:

1. Social and economic inequalities: The digital divide contributes to increasing social inequalities, as Graham (2011) points out. People excluded from the digital world risk finding themselves isolated from professional, social, and even political opportunities. For example, access to online public services (health, education, employment) is becoming a major issue, and those who do not have the tools or skills to access them are disadvantaged. The digitalization of the economy can also lead to employment polarization, with easier access to skilled jobs for those with digital skills, but limited access to unskilled jobs.

2. Exclusion and marginalization: Researchers such as Gurstein (2000) highlight that the digital divide can lead to a form of social exclusion. In an increasingly digital world, those who are not integrated into digital society risk finding themselves marginalized in many areas, from democratic participation to access to education and health.

3. Regulation and public policies: The gap in access to digital technologies calls for political intervention. Public policies aimed at bridging the digital divide are in place in many countries, but they vary widely depending on the local context. McChesney's (2013) work highlights that regulating digital giants and policies aimed at ensuring universal access to technologies are important levers for reducing inequalities in access.

Digitalization offers vast opportunities but also reveals deep inequalities in technology access and use. The digital divide, as an inequality in access, skills, and technology use, has major social and economic consequences. Theoretical research highlights the need for tailored public policies to bridge this divide, and a holistic approach that combines infrastructure, education, and social inclusion to ensure a more equitable digital society.

2. Review of empirical literature

This section presents the most relevant empirical studies to clarify the determinants of digitalization and the digital divide.

Massimo Ragnedda et al. (2019) developed a digital capital index by adopting the definition provided by Ragnedda, which defines digital capital as the accumulation of digital skills and digital technologies, and the measurement model developed by Ragnedda and Ruiu. Their work makes a theoretical and empirical contribution to the literature by (a) consolidating the concept of digital capital as a specific capital and (b) measuring it empirically. A digital capital index is developed through exploratory factor analysis (EFA) and validated through a survey with a

representative sample of 868 British citizens. The validation procedure shows that the digital capital index is associated with socioeconomic and sociodemographic characteristics, such as age, income, educational level, and place of residence, while it does not appear to be related to gender.

Godwin Myovella et al. (2020) attempted to analyze the determinants of the digital divide in Sub-Saharan Africa (SSA) by considering inequalities in internet usage and broadband subscriptions. The study covers 41 geographically linked countries in the region and accounts for spatial interdependence. It also accounts for differences in demographic characteristics as well as social, political, and economic infrastructure that influence ICT access and use. They applied spatial panel analysis using the Spatial Durbin Model (SDM) specifications for 451 observations from 2006 to 2016. Their estimation results show that there is strong spatial interdependence among Sub-Saharan African countries, implying that internet access and broadband subscriptions in one country are affected by internet access and broadband subscriptions in another country, most likely due to spillover effects. They found that GDP per capita, gross capital formation, political stability, regulatory effectiveness, and electricity infrastructure directly affect the digital divide. In addition, GDP per capita, population growth, government consumption, trade openness, and electricity infrastructure also indirectly affect the digital divide through spillover effects.

Marinko Skare and Domingo Riberio Soriano (2020) which examined the relationship between digitalization and firm agility in fifteen advanced EU economies between 2009 and 2018. They used dynamic panel data modeling. Their results suggest that the level of impact of digitalization differs across firms depending on the type of ownership (family or non-family firms). The national/industrial level of digitalization and investments in intangible assets (including the creation of own organizational capital) have a significant influence on the agility of family firms. Non-family firms have flexibility based on investments in human capital, the design and creation of new products, and, to a lesser extent, the national/industrial level of digitalization. The agility of family firms can be significantly increased through digitalization and gross investments in intangible assets (elasticity coefficient of 85 for profit margins). Policymakers who implement a policy to promote national/industrial digitalization can have a significant impact on economic growth.

Gonçalo Paiva Dias (2020) studied the determinants of e-government implementation by local governments. Their empirical model results from the systematic review of 59 primary studies published in scientific journals between 2002 and 2018. As a starting point, a conceptual map

linking concepts such as preparation, diffusion, adoption, implementation, and institutionalization is presented. The author concluded that there is a common set of determinants that explains the implementation of local e-government in general, and three other sets of determinants that contribute to differentiating each of the three dimensions of e-government: e-participation, e-transparency, and e-services.

Manaf Al-Okaily et al. (2020) conducted a study to assess the determinants of digital payment system acceptance based on cultural orientation differences in Jordan using data collected through a field survey questionnaire from 270 Jordanian public sector employees and analyzed using the Partial Least Squares (PLS) method. The results mainly reveal that the intention to use the JoMoPay system is strongly and positively impacted by performance expectation, social influence, price value, security, and privacy, which together explain 0.612 of the variance in behavioral intention. Second, unlike what was predicted, culture does not mediate the relationship between social influence and intention to use the JoMoPay system; therefore, the related hypothesis was not confirmed.

Le Thanh Ha et al. (2022) assessed the impact of digitalization on environmental performance using two dimensions, human health protection and ecosystem protection, to reflect environmental performance using a database of 25 European countries over the period 2015-2020. Digital connectivity, human capital with digital skills, internet use, and integration of digital technology in businesses are elements that capture digitalization as well as digital public services that come from Eurostat - Community Survey and eGovernment Benchmarking Report. The results show that the digital transformation process, especially digital skills, digitalization of businesses, and digital public services, improves environmental performance. Digitalization of businesses and digital public services is of paramount importance for environmental health, as are digital connectivity, digital skills, and digitalization of businesses for ecosystem vitality.

Mohammed Amin Almaiah, et al. (2022) modeled the determinants influencing the continued intention to use digital technologies in higher education. To do so, they proposed an integrated model that measures teacher quality, uncertainty avoidance effects, and student satisfaction with concepts (TAM), and perceived experience with digital information in education (DIE). The model and hypotheses were validated using data collected through a survey of 553 students at a higher education institution. The results highlighted that users can see the importance of using digital information in education based on various external elements that promote the improvement of their learning and teaching experiences. Continued use of technology can be

strongly influenced by other elements such as information flow, uncertainty avoidance, and satisfaction.

Mohammed Amin Almaiah et al. (2022) presented the results of an evaluation of an initiative that seeks to transcend the application of digital information in the higher education sector by recommending an integrative approach that quantifies both digital information flow and tutors' qualitative impacts regarding the constructs of the Technology Acceptance Model (TAM) and the perceived Digital Information Education Experience (DIE). Data collected through a survey of 485 students were used to evaluate the model and hypotheses. The results show that users' perceptions of the value of DIE may depend on several extrinsic conditions that enhance their learning and teaching experiences. User characteristics, such as technological readiness, are critical in determining perceived ease of use. In some cultures, higher tutor quality may further increase the perception of the usefulness of the technology. Intention to adopt technology may also be strongly influenced by other variables such as information flow. Therefore, educational institutions need to re-evaluate the usefulness of digital information technology as a tool for improving educational sections.

Jarosław Brodny et al. (2022) studied the level of digitalization and the use of innovative technologies in companies in the 27 EU countries. The research was conducted using selected determinant indicators that characterize the main digital technologies and the infrastructure associated with their implementation in the studied companies. Based on these indicators, the Multi-Objective Entropy-Optimization Ratio Analysis (MOORA) method was used to determine the digitalization index of companies in the EU-27. The level of use of digital technologies and infrastructure for Industry 4.0 was also determined. Another important objective of the study was to determine a relationship between the values of the digitalization index for the EU-27 countries and the economic parameters characterizing their economies. Their results offer great possibilities for interpretation and practical application, especially in terms of building an innovative knowledge-based economy. They show the great diversity of the EU-27 countries in the field of digitalization and the poor results achieved in this area by the so-called new EU countries.

3. Digitization and digital divide in Africa: State of play

Digitalization in Africa represents a major strategic axis for the continent's economic, social, and cultural development. However, it highlights a digital divide that translates into inequalities in access to information and communication technologies (ICTs) between different regions, populations, and socioeconomic groups.

3.1.Digitization in Africa: A growing trend

The African continent has experienced rapid digitalization in recent years. Digital technology penetration has increased significantly thanks to the rise of mobile telephony, the expansion of internet infrastructure, and the emergence of new digital services.

- **Telecommunications infrastructure:** Investments in mobile networks, including 3G, 4G, and even 5G, have led to significant improvements in connectivity. Companies like MTN, Airtel, and Orange are playing a key role in expanding services.
- **Internet and mobility:** By 2023, approximately 45% of the African population will have access to the internet, a figure that is constantly increasing, thanks in particular to mobile phones that facilitate access to connectivity. Smartphones are now essential tools for a large proportion of Africans, even in remote rural areas.
- **Sectors transformed by digitalization**: Sectors such as finance (with the rise of mobile banking services such as M-Pesa in Kenya), agriculture (with agricultural technologies), education (through online learning platforms) and health (through telemedicine) are being profoundly transformed by the integration of ICT.

3.2.The digital divide in Africa

Despite these advances, the digital divide remains one of the continent's most significant challenges. It manifests itself in several forms, including:

3.1.1. Geographic divide

The geographic digital divide refers to the differences in access to technology between urban and rural areas. While major cities enjoy increasingly widespread internet coverage, rural areas remain largely underconnected. The lack of telecommunications infrastructure in these areas makes access to digital services, such as broadband internet, difficult.

3.1.2. Socio-economic divide

Unequal access to technology is also fueled by economic factors. The high cost of equipment (smartphones, computers) and services (internet subscriptions, mobile plans) is a barrier for a large portion of the population, especially in low-income countries. This financial barrier excludes a large portion of the population from accessing the opportunities offered by digitalization.

3.1.3. Gender divide

The digital gender divide is particularly pronounced in Africa. Women, especially in rural areas, have less access to digital technologies, which hinders their participation in the digital

revolution. Factors such as lack of education, gender stereotypes, and socio-cultural barriers explain this unequal access.

3.1.4. Digital skills divide

In addition to limited access to digital tools, a lack of digital skills is another major obstacle. Many Africans, especially young people, have not been trained in the digital skills needed to fully exploit available tools. The lack of formal digital education and the inadequacy of specific training programs limit the potential for digital inclusion.

3.2.Initiatives to bridge the digital divide

In response to these challenges, several initiatives are being implemented to bridge the digital divide in Africa. These initiatives are being led by governments, private companies, and international organizations.

3.2.1. Improvement of infrastructure

- **Internet connectivity:** Projects to expand internet coverage are underway in several African countries. UNESCO's Giga Initiative aims to connect all African schools to the internet by 2025.
- **Reducing the cost of technologies:** Some companies have implemented solutions to reduce the cost of digital devices, such as low-cost smartphones. For example, Google's Mobile Internet Skills project, in partnership with MTN, aims to make the internet more accessible.

3.2.2. Digital skills training

To address the skills gap, training programs are being offered on a large scale. For exemple :

- **Google Africa Developer Scholarship**: A program to help African developers acquire coding skills.
- **Microsoft 4Afrika**: Initiative aimed at strengthening digital skills and stimulating digital inclusion through training, partnerships and scholarships.

3.2.3. Public policies and government support

Several African countries have implemented national digital transformation policies. Rwanda, for example, has invested in the digitization of its public services and in digital infrastructure projects. The Senegal Digital Plan 2025 also aims to strengthen connectivity and internet access throughout the country.

3.2.4. Initiatives for women and digital inclusion

Initiatives specifically targeting the inclusion of women in digital transformation have emerged:

- **She Means Business:** Facebook, in partnership with local organizations, trains African women entrepreneurs in digital tools.
- **Women in Tech Africa**: A network that supports women in technology in Africa, by promoting their participation in events and training.

3.3.Persistent challenges and future prospects

Despite the progress made, several challenges remain to be overcome to bridge the digital divide in Africa:

- **Insufficient investments**: Infrastructure funding, particularly in rural areas, remains insufficient to enable complete coverage of the territory.
- **Lack of uniformity in public policies**: Digital policies vary considerably from country to country, making it difficult to achieve consistent results at the continental level.
- **Cost reduction**: The high cost of internet access and devices remains a significant barrier, particularly in low-income countries.

However, the outlook for the future is positive:

- The expansion of 5G and satellite internet could help extend coverage to more remote areas.
- African and international companies are increasingly investing in digital infrastructure and services to address inequalities in access.

Digitalization in Africa represents a major lever for economic and social development, but the digital divide remains a considerable challenge. Limited access to infrastructure, the high cost of services and equipment, and a lack of digital skills are all factors that hinder wider adoption of technologies. However, local, regional, and international initiatives are in place to bridge this divide, and increased investment in infrastructure and training could help overcome these obstacles in the future. Africa's digital transformation remains a major opportunity, provided that inequalities in access are reduced and maximum inclusivity is ensured.

4. Research methodology

To assess the determinants of digitalization and of the digital divide, we will first estimate the fixed effect model using the Frisch-Waugh method and secondly we will estimate a random effect model using the generalized least squares (GLS) method using the "plm" package on R software to estimate the coefficients of our model.

A fixed-effects model is an approach that controls for unobserved differences between units of observation (e.g., individuals, firms, countries) that do not vary over time. These differences

are captured by unit-specific fixed effects. The model focuses on analyzing within-unit variations over time, ignoring differences between units.

Properties :

- Fixed effects are treated as parameters to be estimated. They capture the unobservable characteristics constant over time of each unit.
- The model focuses on the analysis of intra-individual or intra-unit variations. This means that it examines how changes in the explanatory variables affect variations in the dependent variable, controlling for constant (unobserved) characteristics of each unit.
- The model ignores inter-unit variation or differences between individuals (fixed effects absorb these differences).

Benefits :

- Allows control for bias due to unobserved characteristics constant over time.
- Avoids simultaneity bias due to omitted variables that are constant over time.

The random effect model assumes that differences between observation units (unobserved effects) are uncorrelated with the explanatory variables in the model. These differences are considered random and are modeled as random errors.

Properties :

- The effects are assumed to be random variables independent of the error and explanatory variables.
- Unlike the fixed-effect model, random effects are not estimated as fixed parameters. Instead, they are modeled as random terms.
- The random effect model uses both within-unit variation (like the fixed effect model) and between-unit variation (i.e., differences between units). This means that the model considers all differences between individuals or units, both within and between each unit.

Benefits :

- Allows estimation of the effect of time-constant variables (such as fixed characteristics like gender, age, etc.) that cannot be captured by a fixed-effects model.
- Less expensive in terms of setup, because there is no estimation of fixed unit effects.

The choice between a fixed-effect model and a random-effect model depends on the nature of the data and the assumptions about the relationship between the explanatory variables and the unobserved individual effects. In general:

- **Fixed effect model**: If you believe that unobserved differences between units are correlated with the explanatory variables.
- **Random effect model**: If you assume that the unobserved differences between units are uncorrelated with the explanatory variables.

Hausman test:

A common statistical test, the Hausman test, can be used to decide between the two models. It compares the estimates of the two models and tests whether the random effects are indeed uncorrelated with the explanatory variables. If the test rejects the null hypothesis, this indicates that a fixed-effect model is preferable.

To conduct our analysis, we selected a sample of 35 African countries. Our sample spans from 2010 to 2022, a period for which all the selected variables are almost available for all the cross-sectional units considered. Ten variables are selected for this study:

Table 1: Description of variables

Variables	Rating	Definition	Unit of measurement	Source
Internet users	UI	Percentage of people using the internet	Percentage	World Bank
Broadband subscriptions	HD	Fixed-line broadband access service subscriptions (per 100 inhabitants)	Unit	World Bank
Gross Domestic Product per capita	GDP	GDP per capita (current US$)	Dollar	World Bank
Commercial Opening Rate	TO	Average of the sum of exports and imports of goods and services measured as a percentage of gross domestic product.	Percentage	Calculated by the authors
Population growth rate	TC	The annual population growth rate for year n is the exponential population growth rate from mid-year n-1 to n, expressed as a percentage	Percentage	Calculated by the authors
Gross fixed capital formation per capita	FBC	Formerly gross domestic investment, includes land improvements, machinery, road construction, divided by mid-year population	Dollar	Calculated by the authors
Electrical infrastructure	EC	Percentage of the population with access to electricity	Percentage	World Bank
Urbanization	UR	Urban population relative to total population	Percentage	Calculated by the authors
Gross national expenditure	DN	Gross national expenditure in constant local currency units	Dollar	Calculated by the authors
Unemployment rate	TCH	Total unemployment as a % of the population	Percentage	World Bank

Source: Developed by the authors

The data used in this study to estimate the model coefficients come from the database published by the World Bank.

Our models are specified as follows:

Model 1 :

$$UI_{i,t} = \alpha_1 + \alpha_2 \ln PIB_{i,t} + \alpha_3 TO_{i,t} + \alpha_4 \ln FBC_{i,t} + \alpha_5 EC_{i,t} + \alpha_6 UR_{i,t} + \alpha_7 \ln DN_{i,t} + \alpha_8 TC_{i,t} + e_{i,t}$$

Model 2 :

$$HD_{i,t} = \beta_1 + \beta_2 \ln PIB_{i,t} + \beta_3 TO_{i,t} + \beta_4 \ln FBC_{i,t} + \beta_5 EC_{i,t} + \beta_6 UR_{i,t} + \beta_7 \ln DN_{i,t} + \beta_8 TC_{i,t} + e_{i,t}$$

Or $UI_{i,t}$ and $HD_{i,t}$ are variables to be explained, $PIB_{i,t}$, $TO_{i,t}$, $FBC_{i,t}$, $EC_{i,t}$, $UR_{i,t}$, $DN_{i,t}$ and $TC_{i,t}$ are explanatory variables, α_n and β_n are coefficients to be estimated, $i = 1,2, \dots, N$, $t = 1,2, \dots, T$, $e_{i,t}$ is the error and ln is the natural logarithm.

5. Discussion of results

First, we developed descriptive statistics. According to Table 2, internet use, for our sample, varies between a minimum of 0.83% in Niger (in 2010) and a maximum of 89.90% in Morocco (in 2022). Similarly, the minimum subscription rate for broadband access services in Chad has been around 0.00% since 2010, while the maximum subscription rate for broadband access services is around 13.93% in Tunisia (in 2022).

It is evident that the mean and median values are within the limits of the maximum and minimum values, which shows that the variables are statistically independent.

Table 2 : Descriptive statistics

Variable	UI	HD	GDP	TO	TC	FBC	EC	UR	DN	DC	TCH
Min	0.83	0.00	217	10.61	0.39	21.93	5.30	10.64	3,967	785 888 453	0.32
Average	25.11	1.17	2,534	27.45	2.45	597.43	52.23	44.06	767,924	32 324 922 285	8.59
Median	19.10	0.25	1,419	23.97	2.55	301.29	49.80	42.95	330 379	9,586,482,940	5.20
Max	89.90	13.93	18,756	72.12	4.87	8732.91	100.00	90.74	7,277,575	393 422 492 401	37.85
Standard deviation	20.67	2.08	2,726	12.42	0.82	853.32	27.69	18.66	1,226,340	60 187 080 144	7.42

Source: Developed by the authors using R software

From Table 3, we notice that:

- The internet usage variable is strongly and positively correlated with the electrical infrastructure variables, urbanization and unemployment rate, while it is weakly and positively correlated with the GDP variables, the commercial openness rate and gross

fixed capital formation per capita. In addition, it is strongly and negatively correlated with the population growth rate variable and it is weakly and negatively correlated with the gross national expenditure variable.

- The broadband access services subscription variable is strongly and positively correlated with the electricity infrastructure variable, while it is weakly and positively correlated with the GDP variables, the Commercial Openness rate, gross fixed capital formation, urbanization and the unemployment rate. Furthermore, it is weakly and negatively correlated with the population growth rate and gross national expenditure variables.

Table 3 : The correlation coefficient matrix

	UI	HD	GDP	TO	TC	FBC	EC	UR	DN	TCH
UI	1									
HD	0.67	1								
GDP	0.42	0.29	1							
TO	0.25	0.11	0.45	1						
TC	-0.54	-0.49	-0.12	-0.35	1					
FBC	0.24	0.22	0.91	0.42	0.04	1				
EC	0.74	0.64	0.54	0.15	-0.52	0.41	1			
UR	0.60	0.42	0.66	0.32	-0.14	0.57	0.69	1		
DN	-0.12	-0.19	0.20	0.00	0.33	0.26	-0.07	0.06	1	
TCH	0.52	0.35	0.58	0.61	-0.58	0.39	0.48	0.42	-0.16	1

Source: Developed by the authors using R software

According to the Hausman test, the p-value is of order 0.0000 for both models. Therefore, we reject the null hypothesis and conclude that the fixed-effects model is more appropriate. This means that the individual effects are correlated with the explanatory variables, and that the random-effects model is biased.

Table 4 : Estimation results of the two models

	Model 1: UI			Model 2: HD		
Variable	**Coefficient**	**Standard deviation**	**t-statistics**	**Coefficient**	**Standard deviation**	**t-statistics**
LOGPIB	3.7382	8.3886	0.4456 (0.6561)	0.5003	1.1179	0.4475 (0.6547)
TO	-0.3513	0.0794	-4.4211 (0.0000) ***	-0.0125	0.0106	-1.1818 (0.2830)
TC	-5.9033	1.4664	-4.0257 (0.0000) ***	-0.3171	0.1954	-1.6228 (0.1054)
LOGFBC	-19.8183	5.3420	-3.7099 (0.0002) ***	-1.5895	0.7119	-2.2327 (0.0261) *
EC	0.1273	0.0683	1.8638 (0.0630)	-0.0188	0.0091	-2.0696 (0.0391) *
UR	4.3574	0.2726	15.9825 (0.0000) ***	0.1841	0.0363	5.0669 (0.0000) ***
LOGDN	76.4424	12.6134	6.0604 (0.0000) ***	6.7296	1.6810	4.0033 (0.0000) ***

Source: Developed by the authors using R software

The results of the estimation show that:

- On the economic level:
  - The coefficients of the variables GDP, EC, UR and DN are of order 3.73, 0.12, 4.35 and 76.44 respectively, this means that an increase of 1% of these variables leads to an increase of 3.73%, 0.12%, 4.35% and 76.44% of internet users respectively. This indicates a positive relationship between these variables.
  - The coefficients of the TO, TC and FBC variables are -0.35, -5.90 and -19.81 respectively, this suggests that an increase in these variables is associated with a decrease of 0.35%, 5.90% and 19.81% of internet users respectively.
  - The coefficients of the TO, TC, FBC, and EC variables are negative. This suggests that a 1% increase in TO, TC, FBC, and EC could reduce broadband access service subscriptions by 0.01%, 0.31%, 1.58%, and 0.01%, respectively.
  - The coefficients of the variables GDP, UR and DN are of order 0.50, 0.18 and 6.72 respectively, this means that a 1% increase in these variables leads to an increase of 0.50%, 0.18% and 6.72% in subscriptions to broadband access services respectively. This indicates a positive relationship between these variables.
- Statistically:
  - The variables TO, TC, FBC, UR and DN are statistically significant while the variables PIB and EC are not statistically significant for the first model.

- While for the second model, the variables FBC, EC, UR and DN are statistically significant, on the other hand the variables PIB, TO and TC are not.

Table 5 : The coefficient of determination and Fisher's test

	Model 1: UI	**Model 2: HD**
R^2	0.7556	0.21745
Fisher test	177.164 (0.000) ***	15.9183 (0.000) ***

Source: Developed by the authors using R software

The first estimated regression model gives a coefficient of determination of 0.75. This means that 75% of the variability of internet users can be explained by the independent variables included in our model. In other words, the variables are able to effectively predict internet user performance 75% of the time. The remaining 25% of internet user variability is not explained by the model. This means that there are other factors not accounted for in the model that affect the results.

The second estimated regression model yields a coefficient of determination of 0.21. This implies that 21% of the variation in broadband subscriptions is explained by the variables in your model while the remaining 79% is due to other factors not considered in the model.

This would indicate that your model is not very good at predicting broadband subscriptions, because there are still other important elements.

After performing the F-test for Model 1, we obtained an F-statistic of 177.16 with a p-value of 0.000. The chosen significance level is , and the p-value is less than 0.05, we reject the null hypothesis. $\alpha = 0.05$ So the regression model is significant. This means that there is a significant linear relationship between the dependent variable and the explanatory variables in the model.

After estimating Model 2, we obtained an F-test with the statistic F = 15.91 and a p-value of 0.000. We note that the p-value = 0.0000 is significantly less than 0.05, so we reject the null hypothesis. This means that the regression model is significant overall.

Conclusion

In conclusion, this study highlights the multiple determinants of digitization in Africa, as well as the factors contributing to the persistent digital divide on the continent. The results show that disparities in access to technology are influenced by economic, social, and infrastructural variables, such as GDP per capita, trade openness rate, population growth rate, fixed capital formation per capita, electrical infrastructure, urbanization, gross national expenditures, and unemployment rate. While notable progress has been observed in some regions, gaps between and within countries remain a major obstacle to inclusive digitization. To foster a true digital

transformation, public policies must focus on improving digital infrastructure, access to technological education, and initiatives aimed at reducing economic and social inequalities. An integrated and coordinated approach involving government, private sector, and civil society stakeholders will be crucial for a more equitable digital future in Africa.

The issue of the determinants of digitization and the digital divide in African countries is complex and multidimensional. Several factors contribute to this divide while also influencing the digitization process across the continent. One of the main obstacles lies in infrastructure and connectivity. Although some urbanized regions benefit from relatively reliable internet access, vast areas, particularly rural ones, still suffer from a severe lack of modern telecommunications infrastructure. This geographical disparity further widens digital inequalities between regions. Another major challenge is access to technology. The high cost of digital devices, such as smartphones and computers, along with their limited availability in certain markets, restricts their adoption by a large portion of the population. These economic barriers reinforce the divide, excluding many Africans from the opportunities offered by digital technology. The lack of digital skills and education also exacerbates this exclusion. A significant portion of the population lacks the necessary knowledge to effectively use digital tools, due to an education system that still inadequately integrates technological training. Without targeted initiatives to strengthen digital literacy, an increasing segment of society risks being left behind.

Economic and social factors play a decisive role in this dynamic. Poverty, persistent inequalities, and low purchasing power lead many households to prioritize basic needs (food, healthcare, primary education) over technological expenses. This socioeconomic reality severely limits digital inclusion for the most vulnerable populations. Lastly, public policies and regulation remain key levers, though they are underutilized. While African governments have a central role to play in promoting digitalization, delays in adopting appropriate reforms, insufficient investment in infrastructure, and sometimes inadequate regulatory frameworks significantly hinder progress. A more proactive and coordinated approach to public policies is essential to accelerate the continent's digital transformation. Thus, the digital divide in Africa stems from a combination of structural, economic, and political factors, requiring integrated solutions to ensure inclusive and sustainable digitization.

This study has certain limitations that should be noted. First, the limited availability of data restricted a comprehensive analysis of some key variables, such as the quality of digital education or the impact of the informal economy, which nevertheless play an important role in the digital divide. Second, significant regional disparities—between North Africa and sub-

Saharan Africa, or between urban and rural areas—could not be analyzed as thoroughly as needed, which may qualify some of the findings. Finally, the rapid pace of ongoing technological and socioeconomic transformations means that the conclusions of this research may require frequent updates to remain relevant. However, these limitations open interesting avenues for future, more in-depth research.

Moreover, this research makes several significant contributions to understanding the digital divide in Africa. First, it proposes an innovative multidimensional approach, systematically intersecting economic factors (such as GDP per capita and unemployment rate), infrastructural factors (such as electrification and urbanization), and social factors (notably education and access to technology). From a policy perspective, the study provides concrete recommendations, including the need to increase investment in digital and energy infrastructure, sustainably integrate digital education into school and professional curricula, and implement fiscal incentives to democratize access to technological devices. Finally, this work establishes a solid foundation for future research, offering a relevant analytical framework for assessing the effectiveness of public policies and local digital initiatives. These contributions make this study a valuable tool for both policymakers and the academic community.

Ultimately, to overcome the digital divide in Africa, it is imperative to adopt a comprehensive approach that integrates strategies for improving infrastructure, developing digital skills, and reducing economic and social inequalities. Cooperation between governments, the private sector, international organizations, and civil society will be essential to ensure inclusive and sustainable digitization, enabling Africa to fully leverage the opportunities offered by digital technologies.

References

(1) Almaiah, MA, Alfaisal, R., Salloum, SA, Al-Otaibi, S., Al Sawafi, OS, Al-Maroof, RS, ... & Awad, AB (2022). Determinants influencing the continuous intention to use digital technologies in Higher Education. Electronics, 11(18), 2827.

(2) Almaiah, M.A., Alhumaid, K., Aldhuhoori, A., Alnazzawi, N., Aburayya, A., Alfaisal, R., ... & Shehab, R. (2022). Factors affecting the adoption of digital information technologies in higher education: an empirical study. Electronics, 11(21), 3572.

(3) Al-Okaily, M., Lutfi, A., Alsaad, A., Taamneh, A., & Alsyouf, A. (2020). The determinants of digital payment systems' acceptance under cultural orientation differences: The case of uncertainty avoidance. Technology in Society, 63, 101367.

(4) Benkler, Y., & Nissenbaum, H. (2006). Commons-based peer production and virtuality. Journal of political philosophy, 14(4).

(5) Brodny, J., & Tutak, M. (2022). Analyzing the level of digitalization among the enterprises of the European Union member states and their impact on economic growth. Journal of Open Innovation: Technology, Market, and Complexity, 8(2), 70.

(6) Castells, M. (2000). Toward a sociology of the network society. Contemporary sociology, 29(5), 693-699.

(7) Dias, GP (2020). Determinants of e-government implementation at the local level: an empirical model. Online Information Review, 44(7), 1307-1326.

(8) Gurstein, M. (2000). Community informatics: Enabling community uses of information and communications technology. In Community Informatics: Enabling Communities with information and communications technologies (pp. 1-30). IGI Global.

(9) Ha, LT, Huong, TTL, & Thanh, TT (2022). Is digitalization a driver to enhance environmental performance? An empirical investigation of European countries. Sustain Prod Consum 32:230–247.

(10) Hargittai, E. (2010). Digital na(t)ives? Variation in internet skills and uses among members of the "net generation". Sociological inquiry, 80(1), 92-113.

(11) Myovella, G., Karacuka, M., & Haucap, J. (2021). Determinants of digitalization and digital divide in Sub-Saharan African economies: A spatial Durbin analysis. Telecommunications Policy, 45(10), 102224.

(12) Ragnedda, M., & Muschert, G. W. (2013). The digital divide. Florence, KY: Routledge.

(13) Ragnedda, M., Ruiu, M.L., & Addeo, F. (2020). Measuring digital capital: An empirical investigation. New media & society, 22(5), 793-816.

(14) Selwyn, N. (2004). The information aged: A qualitative study of older adults' use of information and communications technology. Journal of Aging studies, 18(4), 369-384.

(15) Škare, M., & Soriano, DR (2021). A dynamic panel study on digitalization and firms' agility: What drives agility in advanced economies 2009–2018. Technological Forecasting and Social Change, 163, 120418.