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Digitalization and the Information Society in Algeria: Digital Transformation Actors and Key Variables

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Abstract: The information society is a product of the intersection of socio-historical-technological contexts, where the development of science and industry has a global reach. The pervasiveness of new information and communication technologies makes it an essential component of a new civilization, affecting every country in varying degrees. Although this techniques approach is grounded in some truth, it neglects other vital aspects that challenge the idea of an information society that prioritizes human needs. The leading nations have achieved this through active research and development, driven by government involvement and the significant contributions of universities. Furthermore, the collaboration of diverse economic, institutional, social, and civic actors has played an essential role in its advancement. However, constructing and promoting an information society transcends infrastructure. It involves political actions that consider the socio-technological nature of this development and its impact on society and other sectors of activity. The objective of this article is twofold. On the one hand, the study analysed the situation of Algeria and its position in relation to other countries regarding the information society, and the other examined the factors that influence the development of the information society

in Algeria, trying to identify the most important ones. Finally, the authors proposed a development strategy in this area. The research thesis was formulated as follows: What are the key variables that have an impact on the development of digitalization and the information society in Algeria? Thus, the regulatory frameworks of the most advanced countries are central to the initiatives aimed at its development. To foster the emergence of an information society in Algeria, solidarity must be strengthened, diversity promoted, and the potential of all citizens catalysed.

Keywords: Information society, digitalization, Network Readiness Index (NRI), information and communication technologies (ICT), Algeria.

1. Introduction

The economy has undergone a profound transformation in recent years, marked by the emergence of information and communication technologies (ICT) as a determining engine of economic growth. ICT have radically changed the state of play in developed countries, which are now information societies, and have generated a strong interest in developing countries, which seek to leverage them to accelerate their development. This digital revolution has led to the emergence of a computer culture that has transformed practices and social relations in society. In contemporary economies, technology is the main driver of improving the quality of life for people in developing countries, but it is also a lever for economic growth in industrialised, developed, and emerging countries (Mattelart, 2009).

Moreover, ICT occupy a crucial and even central place in our economies, as the transfer of knowledge and information (usually done through interpersonal contacts) has undergone a transformation (Fadel et al., 2021). The concept of the new economy refers to the increase in growth generated from the late 1990s by new information and communication technologies (NICT). While this change was initially seen as a new industrial revolution, this new economy permeates all layers of our society, and it now seems to animate and inspire all sectors of economic activity, productivity and innovation. Gradually, it is fueling discussions about the emergence of the new economy, characterised by a significant presence of ICT that are viewed as instruments of economic and technical progress" (Accart, 2004).

Today, it is generally recognised that the shift towards an information society is not a matter of choice, but a necessity. Information and communication technologies (ICTs) have become an indispensable tool for decision-making and achieving sustainable development goals. In this context, many countries, such as the United States, have understood the vital importance of this new economy, both for wealth creation and social progress, and are promoting its development by investing in high-speed transmission infrastructure programs, also known as "information highways" (Chevalier, 1997).

However, so far this technological transformation has been marked by extreme disparities in access to this new culture between developing and developed countries.

While the provision of infrastructure is a necessary condition, it is not sufficient to address these diffusion inequalities. Indeed, there are gaps not only in access to ICTs and their use between industrialised nations and developing countries, but also between the rich and poor within a single country, as well as between different regions within a single country (Gollac & Afriat, 2003).

To analyse the technological revolution in its entirety and in a practical manner, it could be useful to study the experiences of global and regional leaders recognised for their remarkable contributions to economic performance through ICTs (Aísa et al., 2011). However, this should not prevent from paying closer attention to other developing countries, such as Algeria, for their advanced positioning in the fields of the information society. Although the information society has become a new culture and way of life for citizens in developed countries, its presence in third-world countries remains thin and limited to certain sectors such as higher education, scientific research, airlines, and financial companies, which have a strong capacity for using ICTs (Nwamen, 2006).

The objective of this article is twofold. First, the authors analysed the situation of Algeria and its position in relation to other countries regarding the information society. Next, they examined the factors that influence the development of the information society in Algeria, trying to identify the most important ones. Finally, a development strategy in this area was proposed. The research thesis was formulated as follows: ***What are the key variables that have an impact on the development of digitalization and the information society in Algeria****?* To provide answers to the questions raised above, the authors relied on the following two hypotheses:

- **H1:** Investment in emerging technologies has an impact on the development of digitalization and the information society in Algeria.
- **H2:** The low impact of investment in emerging technologies on the development of digitalization and the information society is explained by cultural and legal factors.

To explain the measurement variables of the information society and their grouping into homogeneous sub-groups, the study used a multidimensional analysis method to identify classes of countries and observe Algeria's position among the countries of the world. The authors also determined the characteristics of the leaders' class in order to conduct a comparative analysis between the class in which Algeria is positioned, and the reference class where the most advanced countries are located. Next, the study examined the available data and used advanced statistical tools to process the data and study the characteristics of Algeria's group. This allowed to identify the most influential variables and propose strategies to help Algeria move from one group to another in terms of the development of the information society and digitalization. In summary, the study aimed to understand the different dimensions of the information society and propose solutions to help Algeria improve its position in this field (NRI, 2020).

2. Literature review

The development of the information society in a country or group of countries is closely linked to their level of economic and social development, as evidenced by statistics. Indeed, the classification of countries into three categories (advanced, developing, and least developed) is based on quantifiable scientific indicators that evaluate the degree of development of the information society in a country or region, based on the mastery of information and communication technologies (ICT). ICT play an important role in promoting other socio-economic and industrial sectors and also constitute a separate sector of activity, contributing to the increase of GDP and job creation (Dańska-Borsiak, 2022). The economic and performance indicators such as GDP, generated revenue and profits, the number of jobs created each year, and the budget allocated to research and development in these sectors, allow for an assessment of the level of development of the information society (Bojnec & Ferto, 2012). The penetration rate of ICT in different layers of society is also a key element for evaluating this development. Among these indicators, the number of stationary telephone lines and personal computers per 100 inhabitants constitute the basic data necessary for any evaluation (Bensiam & Marquaire, 2018).

According to the ITU, the United States, Japan, and the countries of the European Union are the leaders in the field of information society, thanks to their policies and actions promoting ICT. The importance given by public authorities to this sector is reflected in several indicators. National-level actions and cooperation efforts among EU countries show a common vision of the information society, based on principles such as promoting dynamic competition, encouraging private investment, establishing a flexible regulatory framework, guaranteeing open access to networks, providing universal services, promoting equal opportunities for all citizens, promoting diversity of content, and developing international cooperation in this field (CNUCED, 2019).

In France, the ICT sector represents just over 8% of the value added by businesses, which is similar to the European level. By comparison, in the United States, this figure is 11.1% and 9.6% in Japan. However, in some small European countries specialising in telecommunications (such as Finland) or in the assembly and re-exportation of computer hardware (such as Ireland), the weight of ICT in value added exceeds 15%. In contrast, in Germany and the Netherlands, the percentage is around 6% (Philip et al., 2010).

The global production of ICT is marked by three major trends. Firstly, the United States confirms its leadership by producing 30% of ICT goods in the world, surpassing Western Europe (21%) and Japan (19%). The US is competitive in all segments except for consumer electronics. They were the first to benefit from the industrial fallout of the new economy. Secondly, new players are emerging in the ICT sector, particularly Korea which is increasingly present in all ICT industrial sectors, as well as Taiwan in components, along with Chinese companies. Finally, Ireland has become one of the most important platforms for assembly and re-exports in the

computer field, thanks to the inflow of foreign investments. European performance is mainly due to the Scandinavian model, particularly that of Finland, which specialises in the mobile phone industry. However, the French model is distinguished by the importance given to services, which represent 62% of the sector's production (UIT, 2018).

In 2022, the information society continued to develop, with widespread diffusion of ICT around the world. Key points to note include (UIT, 2022):

- Since 2005, fixed-line telephony has continued to decline, particularly in developed countries, where the number of mobile phones exceeds that of fixed lines.
- According to the latest available statistics, the penetration rate of mobile phones in developed countries continues to be at high levels, often exceeding 100%. According to 2021 data, some countries such as the UK, Germany, and the United States have penetration rates of over 120%. This means that there are more mobile phones than people in these countries. Due to this saturation, the growth of the mobile phone market in developed countries is limited. In 2022, the growth rate was only 6%, according to Statistic data. In contrast, the mobile phone market in developing countries remains very dynamic, with a growth rate of 4.4% in 2022. This growth rate is mainly driven by increasing demand for affordable smartphones and the expansion of mobile connectivity in these regions.
- The analysis shows that universal and meaningful connectivity – the possibility for everyone to enjoy a safe, satisfying, enriching, productive and affordable online experience – remains a distant prospect for LDCs. For example, only 36% of the population in LDCs used the Internet in 2022, compared with 66% globally. As many as 17% of the population in LDCs did not even have access to a fixed or mobile broadband network, the so-called *access gap*. The remaining 47% offline population, representing the *usage gap*, were facing other barriers, such as the affordability of ICT services. Accessing the Internet in LDCs is more costly than anywhere else. The price of a benchmark mobile broadband basket with a 2 GB monthly allowance in a typical LDC amounts to almost 6% of the average income – around four times the typical world price of 1.5%. Only two LDCs met the UN Broadband Commission's affordability 2% target.
- The number of internet users doubled in the last five years, with over 3.9 billion internet users worldwide. Growth is driven by large countries such as Brazil, China, India, Nigeria, and Russia.
- 65.6% of the entire world's population has Internet access. There are 4.28 billion unique mobile internet users worldwide, which makes up 54.6% of the global population. Internet users spend an average of 6 hours and 56 minutes online every day. Overall, the trend is towards greater adoption of ICT globally, with developing countries showing significant growth potential in the mobile and broadband sectors.

Like many other countries, Algeria has chosen digital technology as a solution to diversify and boost its economy. The foundations for a digital economy in Algeria were laid in the early 2000s with the adoption of Law No. 2000-03 on 5 August 2000, which sets out the general rules for postal and telecommunications services with the main objective of introducing competition in the telecommunications sector. The strategies for developing ICTs in Algeria are integrated and cover several fundamental aspects, including the revision of institutional and regulatory frameworks, reorganisation of operational structures, and improvement of the telecommunications infrastructure. The primary objective of the public authorities is to adopt and appropriate ICT to modernise operations and produce competitive goods. In 2001, revenues from the ICT sector represented around 0.9% of GDP, which equates to an average annual consumption of approximately $16 US per inhabitant (Toumache et al., 2014).

3. Methodology

The importance of measuring the information transformation within societies lies in identifying the extent of what they have accomplished on the path to their transformation into an information society (Kaczmarczyk, 2021). The measurement process enabled to define the following objectives: providing the basis of information and data to guide decision-makers and contribute to the formulation of macro--level technology policies to address partial imbalances, and measuring the level of information maturity, which allows for the comparative process between different countries and international groups, examined at the level of the digital divide between countries as such. This enables to formulate a global map of the information society and understand the level of development of each country in order to rank them according to a specific indicator. The study then proceeded with the analysis of the position and characteristics of Algeria.

3.1. Definition of the NRI indicator

NRI stands for Networked Readiness Index, a composite indicator that measures the ability of a country to leverage information and communication technologies (ICT) for increased competitiveness and development. The NRI is calculated by the World Economic Forum and is based on a combination of data from publicly available sources and a survey of business executives in the country being assessed. In its latest 2020 version, the NRI report maps the landscape of state readiness based on a network of 134 economies according to their performance in four different pillars: Technology, People, Governance, and Impact. Each of these is composed of three sub-pillars that are powered by a total of 60 variables (NRI, 2020).

3.1.1. Pillar (Technology)

Technology is at the heart of the networked economy. This pillar therefore aims to assess the level of technology that is an essential condition for a country's participation in the global economy. This pillar brings together 16 variables out of 60 that make up the NRI global index, divided into three sub-pillars as follows:

a) ***Access (7 variables)*****:** represents the fundamental level of ICT in countries, including communication infrastructure and affordability issues.

b) ***Content (4 variables)*****:** the type of digital technology produced in countries and the content/applications that can be deployed locally.

c) ***Future Technologies (5 variables)*****:** measures the extent to which countries are prepared for the future of the networked economy and new technological trends such as artificial intelligence (AI) and the Internet of Things (IoT).

3.1.2. Pillar (People)

The availability and level of technology in a country are only of interest to the extent that its population and organizations have the access, resources, and skills necessary to use it productively. This pillar contains 16 variables mainly concerning the application of ICT by people at three levels of analysis: individuals, businesses, and governments.

a) ***Individuals (6 variables)*****:** how individuals use technology and how they use their skills to participate in the networked economy.

b) ***Businesses (6 variables)*****:** how businesses use ICT and participate in the networked economy.

c) ***Governments (4 variables)*****:** how governments use and invest in ICT for the benefit of the population at large.

3.1.3. Pillar (Governance)

This pillar contains 14 variables and includes the following three levels of analysis:

a) ***Trust (4 variables)*****:** the security of individuals and businesses in the context of the networked economy. This concerns not only actual crime and security, but also perceptions of privacy security.

b) ***Regulation (5 variables)*****:** measures the extent to which the government encourages participation in the networked economy through regulation.

c) ***Inclusion (5 variables)*****:** digital divides within countries where governance can address issues such as gender, disability, and socio-economic status inequalities.

3.1.4. Pillar (Impact)

Ultimately, readiness in the networked economy is a means of improving society and economic growth and well-being. This pillar therefore aims to assess the economic, social, and human impact of participation in the networked economy – 14 variables describe this pillar.

a) ***Economy (5 variables)*:** the economic impact of participation in the networked economy.

b) ***Quality of Life (4 variables)*:** the social impact of participation in the networked economy.

c) ***Contribution to the SDGs (5 variables)*:** the impact of participation in the networked economy in the context of the SDGs – the goals agreed by the UN for a better and more sustainable future for all. The focus is on goals in which ICT has an important role to play, including indicators such as health, education, and the environment.

3.2. Variable definitions

- ***Mobile Tariffs (V1)*:** refers to the cost of three different basket profiles, distinguished in part by their monthly usage allowances (100 MB, 500 MB, and 1 GB, respectively). The tariffs are given as a percentage of monthly GDP per capita.
- ***Handset Prices (V2)*:** refers to the least expensive smartphone that allows users to access the Internet.
- ***Internet Access (V3)*:** the proportion of households that have access to the internet at home via a fixed or mobile network. A household with internet access is defined as the Internet being available for use by all members of the household at any time. This indicator may include both estimated and survey data on the proportion of persons using the Internet, based on national household surveys. The number should reflect the total population of the country, or at least individuals aged 5 and over.
- ***Mobile Network Coverage (V4)*:** measures the percentage of the population outside the total population who are within range of a mobile cellular network, such as LTE/LTE-Advanced and WiMAX/WirelessMAN mobile networks, regardless of whether they are subscribers.
- ***Fixed-Broadband Subscriptions (V5)*:** refers to the number of fixed subscriptions per capita to high-speed Internet access.
- ***International Internet Bandwidth (V6)*:** This indicator refers to the use of all links, including fibre optic cables, radio links, and traffic processed by ground satellite stations and teleports to orbiting satellites.
- ***Internet Access in Schools (V7)*:** refers to the proportion of primary schools that have access to the internet via a fixed, broadband, or mobile network for educational purposes.

- ***GitHub Commits (V10)*:** the largest source code platform, this is a suitable indicator for programming skills that are otherwise difficult to measure.
- ***Wikipedia Edits (V11)*:** refers to data on economies with over 100 000 edits on the Wikipedia website for a given year.
- ***Internet Domain Registrations (V12)*:** provides a measure of Internet content production.
- ***Mobile App Development (V13)*:** includes connectivity and the development of mobile applications.
- ***Adoption of Emerging Technologies (V14)*:** the World Economic Forum's Executive Opinion Survey (EOS) is conducted each year to gather information from business leaders on topics for which data sources are scarce or nonexistent. Data are collected from average responses to a question phrased the same way regarding five emerging technologies: "To what extent are companies in your country adopting artificial intelligence, robotics, web-based markets, big data analytics, and cloud computing?" (1: not at all; 7: to a great extent – on par with the most technologically advanced economies).
- ***Investment in Emerging Technologies (V15)*:** the average response by business leaders to the question: To what extent do companies in your country invest in emerging technologies (e.g. Internet of Things, advanced analytics and intelligence, augmented virtual reality, advanced robotics, 3D printing)? [1 = not at all; 7 = to a great extent].
- ***ICT PCT Patent Applications (V16)*:** number of information requests and communication technology patents filed and processed under the Patent Cooperation Treaty (PCT) (per million of population).
- ***Computer Software Spending (V17)*:** includes the total value of purchased or leased software such as operating systems, database systems, programming tools. It excludes internal software development expenses. The data are a combination of actual figures and estimates, presented as a percentage of GDP.
- ***Robot Density (V18)*:** number of operating robots per 10,000 employees in the manufacturing industry.
- ***Internet Users (V19)*:** refers to the proportion of people who have used the Internet in the past 12 months. The data are generally based on national household surveys whose percentage should reflect the total population of the country.
- ***Active mobile-broadband subscriptions (V20):*** number of active mobile broadband subscriptions per 100 inhabitants, i.e. the sum of active broadband mobile Internet subscriptions and computerised public internet subscriptions, where users have accessed the internet in the last three months. It covers actual subscribers, not potential subscribers, even if the latter may have broadband devices.
- ***Use of Virtual Social Networks (V21)*:** refers to the penetration of active social media user networks, expressed as a percentage of the total population. The original data comes from various sources, including statements and reports from reputable media companies.

- ***Tertiary Enrollment (V22)*:** refers to the ratio of the total number of students enrolled in tertiary education, regardless of age, to the population of the age group that officially corresponds to the level of higher education. Higher education, whether or not it is an advanced research qualification, normally requires the successful completion of secondary education as a minimum admission requirement. The tertiary level is based on the International Standard Classification of Education (ISCED) levels 5 to 8.
- ***Adult Literacy Rate (V23)*:** defined as the percentage of the population aged 15 and over who can read, write, and understand a short, simple statement about their daily life.
- ***ICT Skills (V24)*:** the average response by business leaders to the question: To what extent does the active population in your country have sufficient digital skills? (e.g. computer skills, basic coding, reading) [1 = not at all; 7 = to a great extent].
- ***Firms with Website (V25)*:** this indicator is based on surveys of companies conducted by the OECD and the World Bank. The former source is used for OECD countries and key candidate or partner countries, while the latter source is used for all other countries.
- ***Ease of Doing Business (V26)*:** this index aggregates percentile rankings on ten topics covered in the World Bank's Doing Business series of reports. The topics are: starting a business, dealing with construction permits, getting electricity, registering property, getting credit, protecting minority investors, paying taxes, trading across borders, enforcing contracts, and resolving insolvency. A high ranking indicates that the regulatory environment is more conducive to business creation.
- ***Professionals (V27)*:** refers to the number of professionals as a proportion of the total workforce.
- ***Technicians and Associate Professionals (V28)*:** refers to the number of technicians and associate professionals as a percentage of the total workforce.
- ***Business Use of Digital Tools (V29)*:** the World Economic Forum's Executive Opinion Survey (EOS) is conducted annually to collect information from business leaders on topics for which data sources are scarce or nonexistent.
- ***R&D Expenditure by Businesses (V30)*:** the percentage of business expenditures on research and development (R&D), including both private and public companies.
- ***Government Online Services (V31)*:** the Government Online Service Index evaluates the quality of online service delivery by a government on a scale of 0 to 1 (best). The evaluation is conducted by researchers who assess "national data from each country, website in the native language, including the national portal, online service portal, and online participation portal, as well as the websites of relevant ministries of education, labor, social services, health, finance, and environment."

- ***Publication and Use of Open Data (V32)*:** refers to the fourth edition of the Open Data Barometer, an index that provides a measure of how governments publish and use open data based on the following three dimensions (weights indicated in parentheses): readiness (35%), implementation (35%), and impact (30%).
- ***Government Promotion of Investment in Emerging Technologies (V33)*:** the World Economic Forum Executive Opinion Survey, questions regarding five different emerging technologies.
- ***R&D Expenditure by Governments and Higher Education (V34)*:** refers to the combined expenditures by governments and higher education institutions on research and development (R&D) as a percentage of GDP.
- ***Secure Internet Servers (V35)*:** i.e. servers that use encryption technology in Internet transactions.
- ***Cybersecurity (V36)*:** the Global Cybersecurity Index (GCI) provides a measure of the level of countries' engagement in cybersecurity.
- ***Online Access to Financial Account (V37)*:** the percentage of individuals who used a mobile phone or the Internet to access a financial institution account in the last year.
- ***Internet Shopping (V38)*:** refers to the percentage of respondents aged 15 or older who used the Internet in the last year to purchase something online.
- ***Regulatory Quality (V39)*:** provides a measure of the existence and characteristics of ICT legal and regulatory frameworks.
- ***Legal Framework's Adaptability to Emerging Technologies (V40)*:** the average response to survey questions regarding the extent to which the legal framework adapts to five types of emerging technologies.
- ***E-commerce Legislation (V41)*:** i.e. whether a country has adopted legislation (or has a pending bill) in four areas: electronic transactions, consumer protection, privacy and data protection, and cybercrime.
- ***Privacy Protection by Law Content (V42):*** refers to expert responses on privacy protection given by several countries on a scale of 0 to 4.
- ***E-Participation (V43)*:** the e-Participation Index evaluates, on a scale of 0 to 1 (best), the quality, relevance, and usefulness of government websites in providing online information and participatory tools and services to their citizens.
- ***Socioeconomic Gap in Use of Digital Payments (V44)*:** the difference between rich and poor income groups that made or received digital payments in the past year (% age 15+).
- ***Availability of Local Online Content (V45)*:** the average response to the question: To what extent in your country are internet content and services adapted to local populations (e.g., in the local language)? (1 = Not at all; 7 = To a large extent).
- ***Gender Gap in Internet Use (V46)*:** the difference between the female and male population in the Internet use.

- ***Rural Gap in Use of Digital Payments (V47)*:** the difference between the rural population and the total population who have made or received digital payments in the last year (% age 15+).
- ***Medium and High-Tech Industry (V48)*:** refers to the percentage of value added by the medium and high-tech industry as a share of total value added of production.
- ***High-Tech Exports (V49)*:** refers to manufactured high-tech products (electronics and electrical and others), as a share of total manufactured exports.
- ***PCT Patent Applications (V50)*:** refers to the total number of Patent Cooperation Treaty (PCT) applications filed, by filing date and nationality of the inventor.
- ***Labour Productivity per Employee (V51)*:** the basis for GDP growth and levels that take into account the rapid decline in ICT prices.
- ***Prevalence of Gig Economy (V52)*:** a survey (EOS) conducted on an annual basis to gather information from business owners on subjects for which data sources are rare or nonexistent.
- ***Happiness (V53)*:** refers to the national average response to the following survey question included in the global Gallup poll: "Please imagine a ladder, with steps numbered from 0 at the bottom to 10 at the top. The top of the ladder represents the best possible life for you and the bottom of the ladder represents the worst possible life for you. On which step of the ladder would you say you personally feel you are on?"
- ***Income Inequality (V54)*:** the Gini index is a measure of income inequality in an economy. Technically, it is based on a Lorenz curve that "represents the cumulative percentages of total income received versus the cumulative number of recipients."
- ***Healthy Life Expectancy at Birth (V55)*:** defined as the "average number of years that a person can expect to live in 'good health'."
- ***Good Health and Well-Being (V56)*:** this index encompasses essential health services including reproductive, maternal, newborn, and child health; infectious diseases; non-communicable diseases; and capacity and access to services, among the most disadvantaged population. Scores are reported on a scale of 0 to 100 and are calculated as the geometric mean of 14 indicators tracking health service coverage.
- ***Quality Education (V57)*:** this indicator is captured by the OECD Programme for International Student Assessment, which are surveys that examine the educational system performance of 15-year-old students or older.
- ***Gender Equality (V58)*:** refers to disparities between women and men in three fundamental dimensions of human development – health, knowledge, and living standards.
- ***Affordable and Clean Energy (V59)*:** refers to the level of energy intensity of primary energy (mega joules per purchasing power parity).

- ***Sustainable Cities and Communities (V60)*:** the safety and sustainability of cities are captured by two indicators: urban pollution and road safety as an official indicator linked to the SDGs.

4. Data and statistical methods

4.1. Data preparation and coding

The selection was based on the availability of the majority of statistical data, total of (60) variables with 134 countries according to the Network Readiness Index (NRI) indicator. To prepare a variable value matrix for the case study, 59 columns were created to represent the proposed variables for measuring the phenomenon of the information society. One variable was eliminated due to a lack of information (Sustainable Cities and Communities (V60)). The 134 rows represent the case study countries, which have been identified and coded according to internationally recognized codes.

4.2. Estimation of missing values

The final result of the data includes some missing data, which amounts to 8.58% of the required data size, as shown in Table 1.

Table 1. Percentage and size of the data according to the case study

Number of variables	Number of individuals	Total data	Missing data	%
59	134	7906	679	8.58

Source: own elaboration.

In this case, missing values were replaced with estimated values in order to proceed with the statistical analysis. The XLSTAT software was used for the analysis of data and statistics, these values were calculated using the NIPLAS algorithm. It is important to note that there are various methods for replacing missing values, such as mean, median, mode, linear regression, multiple imputation, etc. (Alvarez et. al., 2015). The selection of the replacement method depends on the type of missing data and the distribution of existing data. The choice of method also depends on the objective of the analysis and the nature of the data (Fadel & Rouaski, 2021). However, it is important to exercise caution when replacing missing values as it can have an impact on the results of the statistical analysis. Therefore, it is recommended to verify the results after replacing the missing values.

4.3. Statistical methods

4.3.1. The automatic classification method

The automatic classification method is a powerful tool for data analysis allowing to categorise a set of n individuals from Ω into a defined number of classes. To use this method, one first needs a measure of dissimilarity between the individuals. In the case of points located in Euclidean space, one can use distance as a reliable measure of dissimilarity. The measure of distance adapted in this classification is the Euclidean distance, the matrix that represents the Euclidean distances between countries is symmetric and its diagonal elements are all zero. To continue with the clustering process, the next step involves grouping the countries that have the shortest Euclidean distance, using an appropriate aggregation criterion. After the initial grouping, a new matrix is created by merging the two countries with the smallest distance, and then the Ward's aggregation criterion is used to find the two closest countries to merge. This iterative process is continued until a second partition is generated that includes the first one, and so on. One of the most popular classification methods is hierarchical agglomerative clustering. This method is called "ascendant" because it starts with each individual alone in a class, and then gradually groups them into larger classes based on their similarities. With this approach, one can gain valuable insights into the underlying structure of the data and identify meaningful patterns that might otherwise go unnoticed (Krzanowski, 2000).

4.3.2. The three steps of the method

a) **Choice of variables representing individuals:** when the observed data are the values of p numerical variables on n individuals, one can choose to perform a classification of individuals or a classification of variables. For example, one may choose to retain certain traits of individuals (i.e. certain variables that were used to describe them) and perform the classification on the individuals described by this choice of variables. Note that this is equivalent to, for example:

– performing a hierarchical clustering analysis (HCA) of individuals based on p centered and standardised variables;
– performing a HCA of individuals based on the p factors obtained using a normalised principal component analysis (PCA) on the preceding variables.

However, it may be of interest to perform the HCA based on the first q factors ($q < p$). This has the effect of eliminating a portion of the variations among individuals, which generally correspond to random fluctuations or 'statistical noise'.

b) **Choice of a dissimilarity index:** many measures of 'distance' between individuals have been proposed. The choice of one (or several) of them depends on the data being studied. This study used the Euclidean distance, which is probably the most commonly used type of distance. It is simply a geometric distance in a multidimensional space.

$$d(I_i, I_j) = \sqrt{\Sigma_k (x_{ik} - x_{jk})^2}.$$

c) **Choice of an aggregation index:** the application of the method also requires to choose a 'distance' between clusters. Here again, many solutions exist. It should be noted that all these solutions make it possible to calculate the distance between any two clusters without having to recalculate those that exist between the individuals composing each cluster. This study used the minimum distance or 'single linkage'. This is the one used above:

$$D(A,B) = \min_{I \in A} \min_{J \in B} d(I,J).$$

Ward's method is well justified when the distance between individuals is the square of the Euclidean distance. Choosing to group the two closest individuals then amounts to choosing the pair of points whose aggregation results in the minimal decrease of the inertia of the cloud. The calculation of new indices between the grouped pair and the remaining points then amounts to replacing the two points forming the pair with their mean point, weighted by 2 (Johnson, 1967).

5. Results and discussion

5.1. Variance decomposition for optimal classification

The variance decomposition for optimal classification involves breaking down the total variance in the data into two components: inter-class variance and intra-class variance (Table 2). Inter-class variance measures the variability between different

Table 2. The variance of the classification

The Variance	Absolute	Percentage
Intra-Class	8479.664	30.62
Inter-Classes	19209.063	69.38
Total	27688.727	100.00

Source: own elaboration.

classes, while intra-class variance measures the variability within each class. For optimal classification, inter-class variance should be maximised, meaning that the different classes should be well separated from each other (Toumache et al., 2013). In contrast, intra-class variance should be minimised, indicating that individuals within each class should be as similar as possible. Using variance decomposition, it is possible to identify the most discriminating variables for classification. These variables are those that contribute the most to inter-class variance and the least to intra-class variance. Overall, variance decomposition for optimal classification is an essential tool for evaluating the quality of a classification model and identifying the most important variables for separating different classes (Fadel et al., 2022).

5.2. The distances between the barycenters of the classification classes

Although the study could not present the distances between individual countries, examining the distances between the class centroids can still provide valuable insights. As shown in the table below, the first and second classes exhibit greater heterogeneity with respect to the third class, while the fourth class is more heterogeneous with the second class. These findings can be further explained by analysing each class in greater detail, which will be the next step in the analysis (Chellai, 2022).

The Hierarchical Clustering Analysis (HCA) allowed to identify and group countries in the world into four classes, each characterised by distinct socio-economic and demographic profiles. The composition of each class is listed below:

- ***First class:*** Australia, Austria, Belgium, Canada, Denmark, Finland, France, Germany, Hong Kong (China), Iceland, Ireland, Israel, Japan, Korea, Luxembourg, the Netherlands, New Zealand, Norway, Singapore, Sweden, Switzerland, United Arab Emirates, the United Kingdom.
- ***Second class:*** Bahrain, Belarus, Bulgaria, Chile, China, Croatia, Cyprus, Czech Republic, Estonia, Greece, Hungary, Italy, Kazakhstan, Kuwait, Latvia, Lithuania, Malaysia, Malta, Oman, Poland, Portugal, Qatar, Romania, Russian Federation, Saudi Arabia, Serbia, Slovakia, Slovenia, Spain, Thailand, Turkey, Ukraine, United States, Uruguay, Vietnam.
- ***Third class:*** Albania, Algeria, Argentina, Armenia, Azerbaijan, Bolivia, Bosnia and Herzegovina, Botswana, Brazil, Cabo Verde, Cambodia, Costa Rica, Dominican Republic, Ecuador, Egypt, El Salvador, Georgia, Ghana, India, Indonesia, Iran, Jamaica, Jordan, Kyrgyzstan, Lebanon, Mauritius, Morocco, Namibia, North Macedonia, Panama, Paraguay, Peru, Philippines, South Africa, Sri Lanka, Trinidad and Tobago, Tunisia, Venezuela.
- ***Fourth class:*** Angola, Bangladesh, Benin, Burkina Faso, Burundi, Cameroon, Chad, Congo, Côte d'Ivoire, Eswatini, Ethiopia, Gambia, Guatemala, Guinea, Honduras, Kenya, Lao PDR, Lesotho, Madagascar, Malawi, Mali, Mozambique, Nepal, Nigeria, Pakistan, Rwanda, Senegal, Tajikistan, Tanzania, Uganda, Yemen, Zambia, Zimbabwe.

  The composition of each class was determined based on data from 60 variables.

5.3. Results analysis

The first class is the reference class for evaluating the delays experienced by the third class, of which Algeria is a part. Indeed, the leading class brings together countries that perform well in most dimensions of the information society, with high use of ICT and strong ICT skills. However, they all rank among the top countries in each of the four pillars and achieve equivalent results in at least two-thirds of the twelve sub-pillars (Access, Content, Future Technologies, Individuals, Enterprises,

Table 3. Grouping of variables according to the difference (first/third class)

Pillar/interval	0% < < 25%	25%< <50%	50% < < 75%	75% < < 100%
Technology	0	7	2	1
People	2	6	1	1
Governance	0	6	0	1
Impact	2	1	2	1
Total	**4**	**20**	**5**	**4**

Source: own elaboration.

Government, Trust, Regulation, Inclusion, Economy, Quality of Life, and Contribution to SDGs). As expected, the top 23 countries are highly technological economies. Two elements highlight the performance of the top-ranked economies with impressive scores in the field of ICT. The next step was to conduct a comparative analysis between the reference class and the third class, in order to dissect the key factors where the third class lags behind the most. In order to do this, the authors calculated the average of the variables that characterise the leading class in each of the four pillars for each class. The objective was to first evaluate the identified gaps for each factor and each pillar, interpret these results, and provide recommendations to improve the level of digital development and information society in the countries that make up the third class.

5.3.1. Results Pillar (Technology)

Based on the results shown in the table 4, the authors were able to identify the gaps between the leading class and the third class, where Algeria is positioned, which allowed to evaluate the delay experienced by Algeria in this field.

- In this regard, in the "Technology" pillar, the highest gap is related to the variable "GitHub commits," which represents the largest completely free programming platform. In fact, compared to the leading class, which has a score of 81.03, the average for Algeria was 5.101, which is surpassed by the rate of 93.69%. This indicates a very low usage of this platform by individuals, despite the fact that it contributes to the development of skills, leading to a very significant impact on the adoption of ICT.
- Regarding the second variable, "Internet access in schools", Algeria has an average of 47.49 and a lower gap of 53.54% compared to the first class. Access to the Internet in schools is crucial as it improves teaching and learning, and also allows students to access a variety of communication services via various devices.
- Regarding "Fixed-broadband subscriptions", despite the increase in the number of subscribers to fixed broadband access service in 2020 according to the World Bank, it is still very insufficient compared to the leader class, with a gap of 53.92%.

Table 4. The average variable relating to the "Technology" pillar

The class	Mobile tariffs	Handset prices	Households with internet access	Fixed-broadband subscriptions	Internet access in schools	Github commits	Wikipedia edits	Mobile apps development	Adoption of emerging technologies	Investment Emerging technologies	The average
1	79.81	72.28	91.18	89.88	102.26	81.03	83.75	88.66	5.09	5100.00	77.11
2	71.39	55.55	80.14	82.58	91.59	24.14	64.15	76.62	3.97	3845.00	61.13
3	53.01	39.81	52.69	41.41	47.49	5.10	44.72	62.59	3.31	3401.00	38.90
(1-3)	26.80	32.47	38.49	48.47	54.77	75.93	39.04	26.07	1.78	1698.00	38.20
%	3357	44.90	42.20	53.92	53.54	93.69	46.60	29.40	34.00	33.29	49,54
4	31.42	20.29	15.25	11.57	7.65	0.78	16.43	41.13	2.72		16.36

Source: own elaboration.

- Regarding the variable "Households with Internet access", it remains low at 42.20%, due to the inaccessibility of the Internet network for residents in rural areas and other disadvantaged groups. To address this issue, it is essential to ensure universal access for everyone so that no one is excluded and can benefit from the advantages of ICT.
- In terms of "Wikipedia edits", Algeria's participation is insufficient, with an average of 39.03 while the maximum is 83.75. The study suggests providing adequate access to official public information through various means of communication, particularly the Internet.
- Regarding the variable "Mobile tariffs", which measures mobile phone tariffs, the observed gap is low, only at 33.57%. This can be explained by financially affordable tariffs for Algerian citizens. In addition, the development of mobile applications is considered sufficient, with a gap of only 29.40% for the variable "Mobile apps development".
- The gaps observed in the variables "Adoption of emerging technologies" and "Investment in emerging technologies" are low compared to other variables, indicating that Algeria has fully participated in the adoption of these emerging technologies, by dedicating significant budgets to acquire them.

5.3.2. Results Pillar (People)

Based on the results shown in Table 5, the authors were able to identify the gaps between the leading class and the third class, where Algeria is positioned.

- The variable "R&D expenditure by businesses" measures the investments made by companies in research and development. This variable shows the highest and most considerable gap. The leading class surpasses Algeria by 93.41%. This unsatisfactory result indicates a lack of a coherent strategy in the research and development field.

Table 5. The average variable relating to the "People" pillar

The class	Internet users	Active mobile- broadband subscriptions	Use of virtual social networks	Tertiary enrollment	ICT	Firms with website	R&D expenditure by businesses	Government online services	Publication and use of open data	Government promotion of investment in emerging technologies	The average
1	90.85	120.76	68.78	75.44	5.20	82.62	1.67	5.51	67.65	4.59	52.21
2	78.38	97.96	64.22	64.62	4.55	66.01	0.51	3.45	35.21	3.65	41.88
3	59.09	68.98	53.46	42.54	3.98	48.94	0.11	3.09	27.46	2.94	31.04
(1-3)	31.75	51.78	15.31	32.89	1.22	33.67	1.56	2.42	40.19	1.65	21.17
%	34.94	42.87	22.25	43.59	23.4	40.75	93.41	43.92	59.40	35.72	40.54
4	23.34	29.44	14.60	10.11	3.55	31.96	–0.20	2.61	9.73	2.61	12.77

Source: own elaboration.

- The variable "Publication and use of open data", which refers to the publication and utilisation of open data, has an average score of 27.46 (with the best average being 67.65), resulting in a gap of 59.40%.
- The variable "Government online services", which refers to online services provided by the government, has a gap of 43.92% compared to the leading class. The study shows that this result is unsatisfactory.
- Regarding the variable "Tertiary enrollment", which refers to enrollments in higher education, the results are just above average. The gap between the leading class and the third class is 43.59%.
- The variable "Active mobile-broadband subscriptions" shows an average of 68.97 for the third class. In contrast, the leading class reached 120.76, which means that mobile broadband subscriptions in leading countries reached saturation point, with penetration rates exceeding 100%. It is worth noting that in Algeria,

according to the latest ITU report, more than 38.77 million subscribers were registered in 2020.

- The variable "Firms with a website" shows that very few companies have a website, and those who do often suffer from a lack of updates. This observation is supported by the gap in this variable, which is 40.75% compared to the leading class.
- The Algerian government is devoting significant investments to promote emerging technologies.
- Despite more than 50% of the Algerian population using the Internet, there is still a moderate gap of 34.94% compared to the leading class.
- The number of social media users in Algeria is close to that of the leading class, with a gap of 22.25%. Social media usage is significant in Algeria, and one can see that Algerians are increasingly active and engaged on social media. Social media platforms are essential tools for accessing information.
- Algeria has the necessary skills to successfully complete major ICT projects, as confirmed by the small gap of 23.46% between the third class and the leading class. These achievements allow to overcome any barriers that arise during the adoption of ICT.

5.3.3. Results Pillar (Governance)

Based on the results shown in Table 6, the following can be inferred:

- Regarding the "Internet shopping" variable, there is a significant gap of 85.64% compared to the leader. The online buying and selling has not taken off yet; indicating that e-commerce in Algeria represents a relatively small portion of trade.

Table 6. The average variable relating to the "Governance" pillar

The class	Secure Internet servers	Cyber security	Internet shopping	Regulatory quality	Legal framework's adaptability to emerging technologies	E-participation	Availability of local online content	The average
1	85.232	90.031	60.812	88.008	4.76	0.894	5.718	47.922
2	69.679	78.922	32.122	62.527	3.823	0.821	5.069	36.137
3	48.503	50.142	8.724	48.771	2.976	0.629	4.198	23.42
(1-3)	36.73	39.889	52.089	39.238	1.784	0.265	1.52	24.502
%	43.09	44.29	85.64	44.57	37.39	29.64	26.61	51.12
4	25.34	31.83	0.833	36.245	2.49	0.41	3.335	14.355

Source: own elaboration.

- In terms of "Regulatory quality", the quality of regulation is average, with a gap of 44.57% compared to the leader.
- As for the "Secure internet servers" and "cybersecurity" variables, the gaps compared to the leader are 43.09% and 44.29%, respectively. This indicates that the security measures are not sufficient.
- In terms of "Availability of local online content", the gap between the leading class and the third class is 26.6%. This suggests that the availability of online content is only average.
- In regard to "Legal framework's adaptability to emerging technologies", the leading class surpasses Algeria by 37.39%, which is considered a small gap.
- As for "E-participation", the leading class surpasses Algeria by 29.64%, which is a satisfactory result. Online participation promotes citizen engagement for participatory governance through ICT.

5.3.4. Results Pillar (Impact)

Based on the results shown in Table 7, the following can be inferred:
- Regarding "PCT patent applications", the number of patent applications related to communication technologies, this variable is the weakest link, with an average that is very insignificant, at 0.54. The leader surpasses Algeria by 99.67%.
- Regarding "Labour productivity per employee", Algeria's productivity is far behind the leader, with a gap of 69.96%.
- As for "Quality education", the quality of education in the leading class has an average of 68.116, while Class 3, to which Algeria belongs, has an average of 30.210, resulting in a gap of 55.64%.
- For "Sustainable cities and communities", there is a small gap of 28.07% compared to the leader.

Table 7. The average variable relating to the "Impact" pillar

The class	PCT patent applications	Labour productivity per employee	Happiness	Income inequality	Healthy life expectancy at birth	Quality education	Sustainable cities and communities	The average
1	175	71	7	32	73	68	90	74
2	21	44	6	34	68	53	72	43
3	1	21	5	40	65	30	65	32
(1-3)	**175**	**50**	**2**	**–9**	**8**	**38**	**25**	**41**
%	**99.67**	**69.96**	**23.89**	**–28.11**	**9.64**	**55.64**	**28.07**	**5594**
4	–47	3	5	42	55	27	47	19

Source: own elaboration.

- "Happiness" and "Healthy life expectancy at birth" are complementary variables and analysed as a pair of factors, especially since the gaps are less than 25%.
- In terms of "Income inequality", the third class significantly surpasses the leading class, with a gap of –28.11%. This suggests that income redistribution is more equitable in the third class, but it does not mean that Algeria should stop pursuing this policy.

6. Conclusion

Algeria has advantages that enable it to engage in the global development of the information society and knowledge economy. The introduction of ICT in Algeria is well underway and can serve as an example for other sectors of the economy, with a tangible and measurable impact. However, the country is still behind others, and there is still a huge effort to be made, particularly in expanding the infrastructure. This is due to several problems such as inadequate security measures, a low share of e-commerce exchanges, a low budget allocated to research and development by companies, a lack of patent filing in ICT, limited internet access in schools, limited publication and use of open data by the government, insufficient labour productivity per employee, and high costs of access and subscription to Internet and international lines.

Additionally, these research results explain that several factors have not favoured the emergence of an information society that matches the country's potential and ambitions. This confirms that the Algerian government has not fully realized the importance of two cultural and legal dimensions. The real challenge is to articulate these two dimensions without sacrificing one at the expense of the other.

In addition to its strategic significance, the ICT sector is characterised by its rapid evolution. Therefore, producing statistics and indicators to measure and monitor the integration of these technologies is of utmost priority and importance. This is why the Algerian government must increasingly focus on statistical data to be able to self-evaluate and improve its services to citizens and, at the same time, it's ranking on the international scale according to various indicators.

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Cyfryzacja i społeczeństwo informacyjne w Algierii: determinanty i uczestnicy transformacji cyfrowej

Streszczenie: Zjawisko społeczeństwa informacyjnego łączy problemy społeczno-historyczno-technologiczne, gdzie rozwój nauki i przemysłu ma zasięg globalny. Wszechobecność nowych technologii informacyjnych i komunikacyjnych sprawia, że jest to niezbędny składnik nowej cywilizacji, wpływający w różnym stopniu na każdy kraj. Ten pogląd jest jednak jednostronny i pomija inne istotne aspekty, które podważają ideę społeczeństwa informacyjnego, stawiając na pierwszym miejscu ludzkie potrzeby. Wiodące państwa osiągnęły to dzięki aktywnym badaniom i rozwojowi, napędzanym zaangażowaniem rządów i badaniami naukowymi. Współpraca różnych podmiotów gospodarczych, instytucjonalnych, społecznych i obywatelskich odegrała zasadniczą rolę w rozwoju społeczeństwa informacyjnego. Budowanie i promowanie społeczeństwa informacyjnego wykracza poza odnoszenie się jedynie do infrastruktury, obejmuje bowiem działania polityczne, które uwzględniają społeczno-technologiczny charakter tego rozwoju i jego wpływ na społeczeństwo i inne sektory działalności. Cele artykułu stanowią analiza sytuacji Algierii i jej pozycji w stosunku do innych krajów w zakresie społeczeństwa informacyjnego, badanie czynników wpływających na rozwój społeczeństwa informacyjnego w Algierii, a także zidentyfikowanie najważniejszych z nich. W artykule zaproponowano strategię rozwoju w tym obszarze. Problem badawczy sformułowano następująco: jakie są kluczowe zmienne wpływające na rozwój cyfryzacji i społeczeństwa informacyjnego w Algierii? Ramy regulacyjne najbardziej rozwiniętych krajów mają kluczowe znaczenie dla inicjatyw mających na celu ich rozwój. Aby wspierać powstawanie społeczeństwa informacyjnego w Algierii, należy wzmocnić solidarność, promować różnorodność i pobudzić potencjał wszystkich obywateli.

Słowa kluczowe: społeczeństwo informacyjne, cyfryzacja, wskaźnik gotowości sieci (NRI), ICT, Algieria.