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Information and Communication Technology Indicators and Their Role in Promoting the Knowledge Economy in Algeria (Analytical Study)

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Abstract:

This study addressed the issue of information and communication technology indicators and their impact on enhancing the knowledge economy in Algeria from an analytical perspective. At the beginning, the importance of the knowledge economy was emphasized as a pivotal element for achieving sustainable development. The challenges facing Algeria were also addressed, such as weak investment in research and development and reliance on traditional resources, which raises questions about the effectiveness of its efforts to transition to a knowledge economy.

The study included an analysis of the reality of the ICT sector in Algeria, including the development of fixed and mobile telephone networks and the quality of Internet services. In conclusion, the measures taken by the government to enhance the technological infrastructure were reviewed, along with current challenges and future directions necessary to achieve the sustainable development goals.

The results showed that Algeria has huge potential to transform into a knowledge economy, but it needs effective strategies to overcome challenges and enhance its competitiveness. For example, Algeria has increased broadband internet coverage to more than 85% of urban areas, and launched a fiber optic program to improve internet speed and quality. As of 2022, Algeria has begun developing data centers and promoting the use of cloud computing in the public and private sectors, with about 30% of government institutions now relying on cloud computing to store data and operate systems.

Keywords: Knowledge economy, ICT, sustainable development, technological infrastructure, innovation and research.

Introduction: In an era of accelerating technological and economic transformations, the knowledge economy has become the cornerstone of sustainable development for countries. Algeria is one of the countries striving to achieve this transformation by investing in information and communication technology (ICT) and developing its infrastructure. Performance indicators in this vital sector show the importance of enhancing innovation and improving economic efficiency, which contributes to Algeria's ability to integrate into the global knowledge-based economy. However, Algeria faces several challenges in this context, including weak investment in research and development and reliance on traditional resources. These challenges raise questions about the effectiveness of efforts to achieve a knowledge economy, and accordingly this research seeks to answer the following question: To what extent does Algeria's performance in ICT indicators reflect its opportunities and challenges in the context of the knowledge economy?

To address this problem, we will review a set of previous studies that have addressed the subject, then we will address the theoretical foundations of the knowledge economy and information and communication technologies. We will present the basic concepts of the study and the relationship between these two fields. We will also analyze the reality of information and communication

technology in Algeria, by studying the development of the fixed and mobile telephone network and the quality of fixed and mobile Internet services.

We will also present the measures taken by the Algerian state to enhance the technological infrastructure, in addition to the challenges it faces. In conclusion, we will present a set of future trends for developing this infrastructure in a way that contributes to achieving the sustainable development goals in Algeria.

Previous studies:

Previous studies on the subject of the knowledge economy and information and communication technologies in Algeria are important for understanding the local and regional context of economic and technological developments, as Algeria faces multiple challenges in moving towards a knowledge-based economy, including gaps in digital infrastructure, lack of technical skills, and cultural determinants. The studies highlight the efforts of the government and private initiatives to support innovation and promote the effective use of information and communication technologies, in addition to the impact of these efforts on economic and social development. Therefore, we will review a set of previous literature, to discover the opportunities and challenges facing Algeria in building a knowledge-based economy, and the role of education and training in this.

- Study by Hakima Harakat, Mahri Abdelmalek (2023) entitled "The Reality of the Knowledge Economy in Algeria, an Analytical Study According to the World Bank KAM Methodology During the Period 2010-2020", this study aimed to know the reality of the knowledge economy in Algeria during the period 2010 to 2020 based on the World Bank methodology, which measures knowledge indicators through four main indicators, the education index, the information and communication technology index, the innovation index, and the economic incentive system index and the institutional system. This study concluded that despite Algeria's attempt to adopt a knowledge economy, its ranking in the knowledge economy indicators came within the low level according to the World Bank guide with a score of less than five points in all indicators due to the weak use of information and communication technology and the low rate of spending on research and development.
- Study by Houari Ali (2023) entitled "Algeria's Position in the Knowledge Economy, Reading in Information and Communication Technology Indicators", this study aimed to try to know the position of the knowledge economy in Algeria through an analytical reading of the information and communication technology indicators, which has become known as digitization. From the researcher's analysis of the indicators, he concluded that these indicators have witnessed significant progress through the acceptable numbers achieved in the development of the number of subscribers to the telephone and Internet network of Algeria Telecom and the economic operators of mobile phones. These results indicate the existence of a real political will and efforts by decision-makers to promote this sector in Algeria, in order to improve Algeria's position in the knowledge economy, which is considered the gateway to sustainable development.
- The study of Ashour Saeed, Kawash Khaled (2022) entitled "The reality of the knowledge economy and its indicators in Algeria, Egypt and Jordan, an analysis of the Global Knowledge Index for the year 2021", this study aimed to stand on the performance of the knowledge economy in Arab countries, by comparing a sample of three countries based on their position in the Global Knowledge Index of the United Nations Development Program UNDP for the year 2021 and analyzing their sub-indicators. The study reached a number of results, the most important of which are: Egypt is ahead of Algeria and Jordan in all indicators and exceeds the global average in most indicators, while Algeria and Jordan are close and below the global average for most of these indicators, and Algeria is very late in the field of research, development, information technology and communications.
- Hamza Zakaria's study (2021) entitled "The knowledge economy in Algeria: state of the art and challenges", this study aimed to know the importance and role of the knowledge economy in Algeria through the competitiveness of companies and the growth of national economies. The success of

the knowledge-based economic strategy (KBE) requires the creation of an environment conducive to innovation and creativity that stimulates competition and guarantees intellectual and industrial property rights. Algeria has adopted a development strategy based on the knowledge-based economy in the past few years to enhance economic growth, and after studying the various pillars of this new economy, the study showed that despite the great efforts made by Algeria in the field of the knowledge economy, the expected results, especially at the qualitative level, were not achieved. Rather, the level of competitiveness of knowledge is lower than that. Especially in the field of research and development, we note that it is far from meeting the requirements of competitiveness and integration in the knowledge-based economy due to the old nature of the acquired knowledge. The study recommended that Algeria should establish these efforts in this field.

The first axis: The theoretical foundation of the knowledge economy and information and communication technologies

1.The concept of the knowledge economy and its characteristics:

It is the economy that revolves around obtaining, sharing, using, employing, innovating, and producing knowledge with the aim of improving the quality of life in all its fields, through advanced technological applications, using the human mind as a valuable knowledge capital, and employing scientific research to bring about a set of strategic changes in the nature of the economic environment and its organization to become more responsive and in harmony with the challenges of globalization and information and communication technology. (Alyan, 2010, p. 114)

It is also known as the economy that relies on the production of goods and services through knowledge processes and intellectual capabilities, instead of focusing on material and natural resources. This includes integrating improvement efforts into all stages of the production process through research and development, which contributes positively to increasing the gross domestic product. (Powell W, 2004, p. 201)

1. The importance of the knowledge economy:

The knowledge economy is gaining increasing importance in the contemporary world, as it represents one of the main pillars for achieving sustainable development and innovation. This type of economy relies on knowledge as a major factor in production, which enhances the competitiveness of countries and contributes to improving the quality of life (Harakat, Mahri, 2023, p. 44). Its importance lies in the following:

 Contributing to improving performance, raising productivity, reducing production costs and improving quality

Increasing production and national product, increasing project revenues and contributing to achieving added value in economies.

 Contributing to generating job opportunities in areas that use advanced technologies included in the knowledge economy (Hussein, 2007, p. 22)

 Contributing to the modernization and development of economic activities and their expansion to a large extent.

 Shifting the focus of labor from manufacturing to knowledge industries, which increases interest in education, research and development.

 Stimulating the expansion and growth of investments, which contributes to the growth of demand for knowledge resources and expertise at the local and international levels and the growth of new labor in many fields of knowledge.

 Finding a new pattern for specialization and international division of labor, due to its association with various and advanced technologies, including e-commerce, virtual markets, e-marketing, e-government and e-administration (Qarqad, 2022, p. 544)

2.Knowledge Economy Indicators:

There are many global knowledge indicators associated with different international bodies, as the composition of these indicators varies from one environment to another. The Global Knowledge Index, created by the United Nations Development Program and the Mohammed bin Rashid Al Maktoum Knowledge Foundation, was chosen, and was announced during the Knowledge Summit in 2016. This indicator reflects the strategic role of knowledge and the importance of providing methodological tools to measure and manage it effectively. The following chart shows us the most important indicators related to the knowledge economy;

Knowledge economy indicators are essential tools for understanding and analyzing the factors that affect economic and social development. By reviewing these indicators, the Information and Communications Technology Index in Algeria was chosen as a main element of our current study. This choice reflects the importance of the role played by information technology in promoting the knowledge economy. Therefore, our study will focus on analyzing this indicator in Algeria, highlighting the relationship between information and communication technology and the knowledge economy, which contributes to a deeper understanding of the challenges and opportunities available in this field.

3.The concept of information and communication technology:

Information and Communication Technology (ICT) is an expanded term for information technology (TI), which consists of a set of devices and tools that help in storing, processing, retrieving, and communicating information via various communication devices to anywhere in the world. (Khadija Belalia, 2011, p. 07). It can also be defined more broadly as follows: "Information and Communication Technology (ICT) refers to a set of technologies used to collect, store, process, and transmit information. This technology includes many tools, software, and systems that contribute to facilitating communication and information exchange between individuals and institutions." (Sedkawi, 2014-2015, p. 16)

Basic components of information and communication technology:

- Computers: include desktop and laptop computers, tablets, and smartphones, which are used to process data and information.
- Software: includes operating systems, programming applications, and data management programs, which contribute to organizing and analyzing information. (Tocan:, 2012, p. 157)
- Communication networks: include local area networks (LAN) and wide area networks (WAN), which facilitate the transfer of information over the Internet or through internal networks.
- The Internet: is considered one of the most prominent components of information and communications technology, as it allows access to information and communication with others across multiple platforms.
- Cloud applications: allow data storage and software operation over the Internet, making it easy to access from anywhere. (Roberts, 2009, p. 289)

How do ICTs contribute to establishing a knowledge economy?

Information and communication technologies (ICTs) are essential factors that contribute to establishing a knowledge economy, as they improve production efficiency and enhance innovation. According to a report by the Organization for Economic Co-operation and Development (OECD), countries' investments in information technology increase GDP by 0.3% to 1.5% annually. There are some forms of ICTs' contribution to driving the knowledge economy;

- Enhancing access to information: ICTs facilitate quick access to information and knowledge, enabling individuals and businesses to make informed decisions. According to a study conducted by "Statista", the number of Internet users worldwide exceeded 4.9 billion people in 2021, reflecting the importance of access to information. (Rapport statista, 2024)

 Improving business efficiency: Digital systems contribute to improving operational processes and reducing costs, which enhances productivity. Reports indicate that companies that rely on information technology have seen an increase in productivity of up to 20% (Saeed Ashour, 2022, p. 72)

 Facilitating communication and collaboration: Communication technologies provide platforms for collaboration between teams and individuals, which contributes to the exchange of ideas and knowledge. According to a study conducted by Deloitte, 75% of companies that use digital collaboration tools noticed an improvement in overall performance. (Lasbaa, 2017, p. 15)

 Encouraging innovation: Information technology contributes to the development of new products and services through research and development, which enhances competitiveness. According to the World Economic Forum report, companies that invest in digital innovation expect an increase in revenues of at least 30%.

 Supporting education and training: E-learning platforms provide opportunities for continuing education and training. According to UNESCO statistics, 30% of students worldwide use e-learning platforms as part of their studies. (World Economic Forum, 2024)

 Expanding markets: Information technology allows companies to reach new markets, which enhances growth opportunities. An IBM study indicates that 60% of small and medium-sized businesses that use e-commerce saw their sales increase by up to 20%.

 Promoting transparency and accountability: Information technology helps provide information in an open and transparent manner, which enhances trust between citizens and governments. According to a Transparency International report, the use of information technology in governments can reduce corruption by up to 25%. (Transparency International, 2024)

 Developing infrastructure: Information technology contributes to building an advanced digital infrastructure that facilitates e-commerce and digital services. According to a report by the International Telecommunication Union, digital infrastructure investments contribute to enhancing economic growth by up to 3%. (International Telecommunication Union, 2024)

The second axis: Analysis of the reality of information and communications technologies in Algeria

1. The fixed telephone network of Algeria Telecom

1.1 Development of the number of subscribers to the telephone network

We note that the number of fixed-line telephone subscriptions in Algeria has shown remarkable positive growth in recent years. According to the annual report on telephone users, this number reached more than 5.9 million subscriptions in the first half of 2023. This figure shows an increase of 6.42% compared to 2022, and by 24% compared to 2020.

This growth reflects improvements in the country's ICT infrastructure, which enhances access to fixed-line telephone services. The saturation rate for fixed-line telephones in the first half of 2023 reached about 60.76%, indicating that the market is beginning to approach the limits of its capacity to absorb more subscriptions. These data confirm that Algeria is making progress in developing communication services, which contributes to strengthening the knowledge economy and reflects the trend towards improving digital services. The following figure shows the distribution circle of fixed-line telephone subscriptions for the first half of 2023;

The professional fixed-line telephone subscription rate of 77% is evidence of businesses and companies' reliance on this service as a means of communication. This is due to several factors:

Communication stability: Fixed-line telephones provide more stable and reliable communications compared to mobile phones, which is essential for businesses.

Costs: Sometimes, the cost of calls via fixed-line telephones is lower than mobile calls, making them a preferred option for companies.

Various uses: Fixed-line telephones can be used to manage customer service centers, provide

technical support, and internal communications, which enhances efficiency.

Table No. (01): Development of the fixed-line telephone penetration rate per household

2023	2022	2021	2020	2019	2018	Year
67%	64%	59%	57%	56%	51%	Fixed line penetration rate

Source: Prepared by researchers based on a report on the development of indicators of wired and wireless telecommunications services https://www.mpt.gov.dz/wp-content/uploads/2024/03/rapport_TIC_-S1-2023-AR.pdf

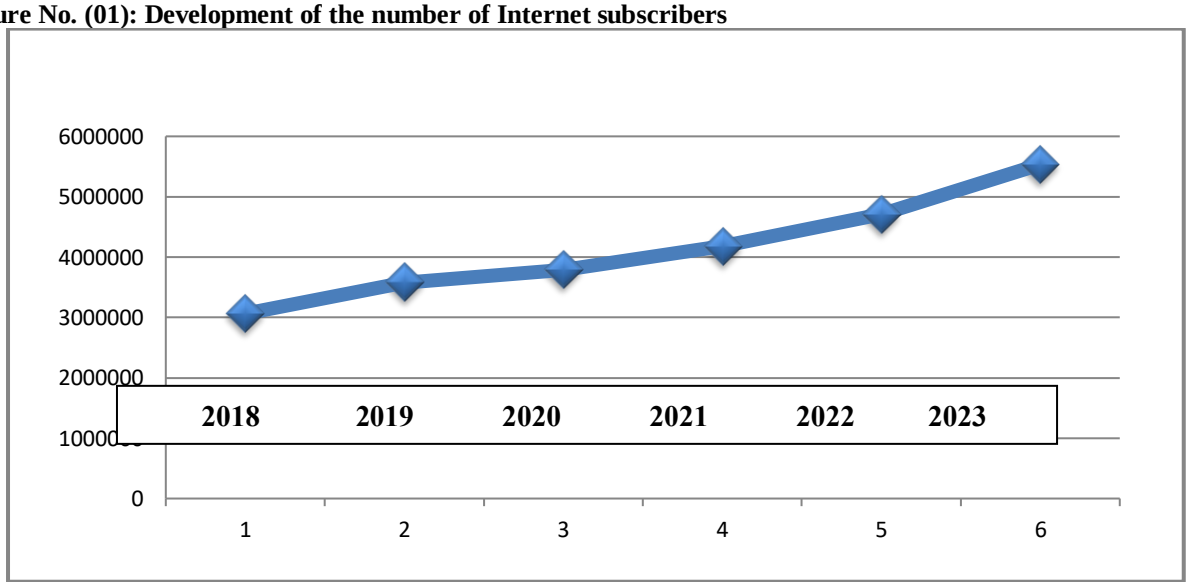
We note from the table above that residential subscriptions have always been the most dominant in the fixed-line telephone market, accounting for 92.25% of total subscriptions during the first half of 2023. This trend reflects the continued demand for fixed-line communication services in homes, indicating the importance of the fixed-line telephone as a primary means of family communication.

Despite the increasing trend towards mobile phones and digital communications, wired subscriptions still play a vital role in meeting the communication needs of many families. This also includes basic uses such as emergency communication and home internet services, which enhances the position of the fixed-line telephone as a reliable and convenient option in people's lives.

Overall, this growth in wired subscriptions reflects Algeria's continued commitment to improving the communications infrastructure and enhancing access to basic communication services.

1.2 Development of the number of Internet subscribers:

Figure No. (01): Development of the number of Internet subscribers



Source: Prepared by researchers based on the report of the Regulatory Authority for Post and Electronic Communications

The fixed internet market in Algeria recorded a significant increase of 17.66% in one year, as the number of subscribers increased from 4.70 million subscribers at the end of 2022 to 5.53 million subscribers by the end of 2023. This increase shows the importance of information and communication technology in improving access to internet services.

According to reports by the Regulatory Authority for Post and Electronic Communications, out of 5.53 million subscribers as of December 31, 2023, more than 2.72 million subscribers were registered for the ADSL service, while the number of subscribers to the fourth generation (4G) amounted to about 1.71 million. These figures indicate the diversity of options available to users, reflecting their interest in moving towards advanced communications technology. In addition, the fiber optic network to the home witnessed a significant increase in the number of subscribers, as the number increased from 478,172 subscribers to more than 1.08 million subscribers during the same period. This increase is an indication of the continuous improvements in the telecommunications infrastructure, which contributes to enhancing the quality of service and the speed of the Internet. In general, this growth in the fixed Internet market reflects the trend towards digitization of services and increasing reliance on the Internet in daily life, which contributes to strengthening the digital economy in Algeria.

The number of Internet subscribers reached 4.7 million in 2022, representing 2.7 million subscribers to the high-frequency Internet service (ADSL). These figures indicate a strong growth rate of 52.88% compared to the base year 2015, reflecting a significant increase in the adoption of this service among users.

(Houari Ali, 2023, p. 133)

As for the fourth generation technology (4G), the number of subscribers reached 1.4 million, with an increase of more than one million subscribers since 2015. This growth reflects the shift of users towards modern communication services that provide higher speeds and a better experience.

As for the fiber optic network, the number of subscribers reached 478 thousand, representing an increase of nearly 7 times compared to the base year 2015. This remarkable increase reflects improvements in the ICT infrastructure in Algeria, which helps provide faster and more reliable Internet services.

Overall, these figures indicate the success of the Algerian government's efforts to enhance access to Internet services, which contributes to supporting the digital economy and enhancing innovation in various sectors.

1. Mobile phone network:

1.2 Development of the number of mobile phone and internet users for all operators in Algeria

We note that the mobile phone market in Algeria has witnessed significant developments between the main companies: Mobilis, Ooredoo, and Djezzy, during the period from 2015 to 2023. This development reflects changes in the companies' strategies and their response to the growing needs of users.

Mobilis: Mobilis is the leader in the mobile phone market, having witnessed a steady increase in the number of subscriptions. Since 2015, the company has been able to strengthen its market share thanks to improving the quality of its services and expanding its coverage. During the first half of 2023, Mobilis showed a 0.73% increase in subscriptions, demonstrating the continued attractiveness it enjoys in the market.

Ooredoo: Initially experiencing challenges in attracting customers, it has managed to achieve a significant improvement in its performance. Although the subscription growth rate was lower than Mobilis (0.62% in the first half of 2023), its marketing strategies and the innovation of new services have contributed to attracting a new segment of customers. Since 2015, Ooredoo has been working on improving its data services and enhancing the user experience, which has contributed to improving its position in the market.

Djezzy, despite being one of the market leaders, has witnessed a decline in the number of subscriptions in the recent period. This decline is evident from the results that showed a decline of 2.76% in some periods. This decline is attributed to several factors, including strong competition from other companies and the challenges in providing innovative services that meet the changing needs of users.

2.3 Total number of subscribers to third and fourth generation networks

Table No. (02): Total number of subscribers to third and fourth generation networks

Evol 22 -S1 2023	S1 2023	2021	2022	2020	2019	2018	
-11.49%	3 770 875	5 235 558	4 260 261	6 783 111	8 514 105	10 811 663	GSM
-8.33%	5 464 880	7 272 657	5 961 291	9 265 682	11 989 157	17 422 312	3G
2.27%	39 679 729	34 507 542	38 797 214	29 506 880	24 922 271	18 920 289	4G

Source: Prepared by researchers based on the report of the Postal and Electronic Communications Regulatory Authority

We note that the second generation (GSM) subscription pool has been suffering from a continuous decline since the launch of third generation (3G) and fourth generation (4G) mobile phone technologies. This decline reflects the gradual shift of users towards more advanced technologies, as 4G technology, which was adopted at the end of 2016, now allows for better internet speeds and an improved user experience.

This phenomenon is part of the general trend towards digital transformation, as users now prefer subscriptions that provide them with high speeds and better quality of service. With the advancement of telecommunications technology, many users have moved from traditional subscriptions to 4G services, which has led to a significant decline in the number of second generation subscriptions.

Moreover, it is clear that telecommunications companies in Algeria, such as Mobilis, Ooredoo and Djezzy, have responded to these changes by expanding the scope of 4G services and offering competitive data plans, which has contributed to increasing demand for these services.

2.The most important measures taken by the Algerian state to support the technological infrastructure:

The technological infrastructure refers to all the technological systems and facilities necessary to support and operate digital and communications systems. This infrastructure includes; communications networks (Internet and wireless communications), information infrastructure (data centers, cloud computing), digital technology used in various sectors (education, health, e-commerce)

2.1 Strengthening communications and Internet networks: One of the most important aspects of developing the technological infrastructure is investing in communications and Internet networks. Algeria has taken several steps to develop this field, the most important of which are:

2.2 Expanding the Internet and Communication Technology: Algeria has worked to enhance broadband Internet coverage by developing fiber optic networks. By 2023, coverage has increased to more than 85% of urban areas in the country, with plans to expand coverage to include rural and remote areas. 4G network Since its launch, coverage has spread rapidly to include 70% of Algeria's population by 2022, helping to improve Internet speeds and access to digital services. There are also plans to develop the fifth generation network 5G, with initial trials starting in some major cities such as Algiers and Oran.

Improving Internet Speed and Quality: According to statistics from the Ministry of Communications, fixed Internet speed in Algeria reached about 10 Mbps in 2023, a significant improvement compared to previous years. Mobile Internet speed also saw significant growth, reaching about 14 Mbps.

FiberOptic Program: Algeria introduced a fiber optic program to improve Internet speed and quality. As of 2022, about 150,000 kilometers of fiber optics have been extended, allowing many urban and rural areas to be connected to high-speed Internet.

Developing Data Centers: Data centers play a vital role in enhancing technological infrastructure, providing a secure environment for data storage and enabling the operation of electronic services. Algeria’s most notable efforts include:

Establishing National Data Centers: In 2021, Algeria announced the opening of the National Data Center in the capital, which has a high storage capacity and uses advanced technologies to ensure data security. National data centers contribute to enhancing the cybersecurity of government and private data, and facilitate the provision of cloud computing services to institutions.

Developing Cloud Computing Services: Algeria is keen to promote the use of cloud computing across the government and private sectors, as several local cloud services have been provided through national data centers.

Since 2023, about 30% of government institutions have relied on cloud computing to store data and operate systems. Based on these efforts made by Algeria in the field of information and communications technology, we will present a set of obstacles or impediments that it faced:

3.Challenges facing Algeria in developing its ICT infrastructure:

Internet networks and connection speed: The Internet is the backbone of any knowledge-based economy, but Algeria still faces major problems in this aspect: According to the Speedtest Global Index report for 2023, the average fixed Internet speed in Algeria is 11.25 Mbps, which is a low rank compared to neighboring countries such as Tunisia and Morocco, where speeds reach 22.7 Mbps and 25.3 Mbps, respectively.

In the Internet World Stats report for 2022, the Internet penetration rate in Algeria was about 54.2% of the population, which is lower than the global average of 65%.

According to the Algerian Ministry of Post and Telecommunications’ 2022 report: About 1.6 million homes were connected to fiber optics by the end of 2022, but this represents only 10% of Algerian households, and rural areas are severely lacking in these networks, making the development of a knowledge economy more challenging outside major cities.

Cloud infrastructure and data centers: Cloud infrastructure is still weak, as there are some local data centers such as the National Data Center in the Algerian capital, but they are still insufficient to support the country's needs in the field of data storage and running large applications such as artificial intelligence or big data analysis. According to the International Telecommunication Union (ITU) report for 2022, about 60% of companies in Algeria rely on international cloud services due to the lack of local centers, which affects data sovereignty and independence.

3.Challenges of educational and knowledge infrastructure

A. Lack of investment in research and development (R&D): In 2021, Algeria's R&D spending was around 0.6% of GDP, which is much lower than global rates. Advanced countries with knowledge economies typically spend between 2-3% of GDP on R&D.

The World Bank indicated in its 2022 report that the number of researchers in Algeria is around 590 researchers per million people, compared to a global average of 1,250 researchers per million.

B. Weak link between universities and the business sector: The lack of cooperation between universities and companies in Algeria hinders the transfer of technology and knowledge to the market. The 2021 study by the Center for Research in Scientific Systems indicates that only 25% of university research finds its way to practical application or industry.

C. Lack of human skills in technology fields: According to the UNESCO report for 2022, Algeria suffers from a shortage of human skills specialized in the fields of technology and information technology. Despite efforts to improve technical education, the country still needs to develop educational programs to enhance skills in artificial intelligence, the Internet of Things, and data analysis.

4. Future trends to support the technological infrastructure in Algeria:

Transition to the fifth generation 5G: After the success of the fourth generation 4G network experiment, Algeria seeks to transition to the fifth generation 5G network to enhance the speed and quality of communication, and support advanced applications such as artificial intelligence and the Internet of Things. Algeria has already begun conducting initial experiments in some major cities such as the capital and Oran, and the government aims to deploy the 5G network in selected areas by 2025, with long-term plans to cover the entire country.

Supporting innovation in the private sector: The Algerian government is working to stimulate technological innovation by providing a supportive environment for emerging and medium-sized companies operating in the field of technology. In 2022, the government launched several initiatives to support entrepreneurship in technology, including the establishment of technology business accelerators and innovation centers. This will contribute to the development of innovative products and services that help to exploit the technological infrastructure more fully.

Developing smart city networks: One of the future trends that Algeria is working to develop is smart city networks. Through this program, Algeria seeks to transform some major cities such as Algiers and Oran into smart cities that rely on advanced technological infrastructure, where Internet of Things (IoT) and artificial intelligence technologies are used to improve public services such as energy management, transportation, and security.

Conclusion:

In conclusion, this study shows that Algeria has a historic opportunity to transform into a knowledge economy by promoting information and communication technology. The performance in the indicators of this sector has shown promising potential, but it remains associated with challenges that require thoughtful and effective strategies.

Investing in research and development, expanding the scope of digital services, and enhancing cooperation between the public and private sectors are vital steps towards achieving the desired development goals. Addressing the gaps in infrastructure and human resources will also contribute to raising the level of competitiveness and enhancing Algeria's ability to engage in the global economy. In light of the rapid changes in the technological landscape, Algeria must adopt a comprehensive vision based on innovation and adapting to new challenges. Building a sustainable digital future depends on the commitment of all actors in society, from government to the private sector and civil society.

Finally, Algeria's success in the context of a knowledge economy requires continuous efforts and collective cooperation, which makes it possible to achieve comprehensive and sustainable development that meets the needs of current and future generations.

Recommendations:

 Establish effective partnerships between the government and private companies to promote innovation and develop technological projects.
 Increase investment in research and development and encourage companies and institutions to allocate larger budgets for research and development to promote innovation.
 Amend laws and regulations to facilitate business, investment in technology and simplify administrative procedures.
 Improve the information and communication technology infrastructure, i.e. invest in improving and expanding the Internet and communication services to meet market needs.
 Raise community awareness of the importance of the knowledge economy by organizing awareness campaigns to increase community understanding of the importance of innovation and technology in development.
 Encourage universities and research centers to cooperate with industries to apply research in the market.

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