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The Impact of Investment in the Transfer of Information and Communication Technology on the Growth of Per Capita Gross Domestic Product in Algeria during the Period (1990–2025)

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Abstract:
The study aimed to measure the impact of the transfer of information and communication technology (ICT) on supporting per capita gross domestic product growth (GROWTH_GDPC) in Algeria during the period extending from 1990 to 2025. The study sought to answer the problem of the extent to which digitalization and technological flows contribute to enhancing levels of economic welfare and sustainable growth. An econometric model was constructed expressing the relationship between expenditure on the acquisition and transfer of information and communication technology as an independent variable, and per capita gross domestic product growth as a dependent variable using the ARDL model. The study found the existence of a cointegration relationship (a long-term equilibrium relationship) and the ability of the Algerian economy to correct deviations and return to equilibrium with an adjustment speed reaching 63.6% annually. It also found a positive and statistically significant effect of investment in technology on growth in the short term, where the elasticity of growth with respect to investment reached 1.65, while the long-term effect was positive but lacked statistical significance, which indicates the existence of a “productivity paradox” in the Algerian economy.
Accordingly, the study recommends increasing expenditure allocations for technology projects, acquiring and transferring them to industrial and service activities that would improve the individual’s standard of living and provide fertile ground for the growth and development of production, providing research centers for acquiring modern technological techniques used in information and communication, and the necessity of moving from investment in pure

technological infrastructure to the digital empowerment of production sectors, with the necessity of intensive investment in human capital to ensure transforming technological leaps into sustainable long-term growth.

Keywords: Technology transfer, per capita growth, ARDL model, Algerian economy, productivity paradox.

Introduction:

Information and communication technology (ICT) is considered the main driver of the contemporary global economy, as societies have shifted from reliance on traditional resources to reliance on knowledge and digitalization. In light of the trend toward the "digital economy," technology transfer is no longer merely an option, but an inevitable necessity for developing countries to enhance production efficiency and develop service sectors. Algeria, like other emerging economies, has made considerable efforts since the 1990s to modernize its digital infrastructure and attract investments in this sector, hoping that this would positively reflect on indicators of economic welfare, foremost among them per capita gross domestic product.

This study comes to shed light on the historical and analytical path of this investment in Algeria over a period extending for 35 years, covering the stages of transition from monopoly to liberalization, leading to comprehensive digitalization strategies (2020–2025). Despite the huge investments injected by the Algerian state into the information and communication technology sector, whether through the public budget or through foreign direct investments, debate still exists regarding the effectiveness of these investments in achieving a qualitative leap in the level of real per capita income. Hence, the main problem can be formulated in the following question: What is the impact of investment in the transfer of information and communication technology on the growth of per capita gross domestic product in Algeria during the period (1990–2025)?

The following sub-questions emerge from this question:

- How did the volume of investment in information and communication technology in Algeria develop across different time periods?
- Is there a statistically significant positive relationship between digital indicators (such as internet penetration and broadband) and per capita income?
-Did technology transfer contribute to improving total factor productivity in a way that was reflected in individual economic growth?

The study is based on a set of basic hypotheses that will be tested:

First hypothesis: There is a positive and statistically significant effect of investment in information and communication technology on increasing per capita gross domestic product in the long term.

Second hypothesis: The effectiveness of technology transfer in Algeria was affected by structural obstacles and the slow pace of digital transformation in the early years (1990–2005), before effectiveness improved in the last two decades.

Third hypothesis: Investments in communication infrastructure contribute to reducing the costs of economic transactions, thereby enhancing per capita growth.

This study seeks to achieve the following objectives:

Diagnosing the reality of investment and monitoring the development of investment flows in the information and communication technology sector in Algeria during the period (1990–2025).

Measuring the economic effect using econometric models to determine the size and nature of the relationship between technological variables and per capita income.

Evaluating government policies: providing a critical reading of national strategies (such as Algeria Electronic 2013, and the Digital Transformation Strategy (2020–2025)).

Providing proposals and recommendations to decision-makers on how to maximize the economic return from technological investment to ensure sustainable and inclusive growth.

The study derives its importance from the fact that it covers a long and comprehensive period, allowing the monitoring of deep transformations in the Algerian economy. It also comes at a time when the state is betting on "digitalization" as a strategic alternative to reduce dependence on the hydrocarbon sector and improve citizens' standard of living.

1-Theoretical Framework of the Study:

The concept of technology transfer has become a major concern for both developing and developed countries alike, which explains the great importance that this element (science and technology) has acquired at the level of international business and even at the level of economic development as a whole. To remove the ambiguity surrounding this term, it is necessary to examine the meaning and definition of this term, around which opinions have differed.

1.1 Concept of Technology:

Technology refers to a set of information related to how to apply a scientific theory or invention, meaning that it is the applied aspect of science. It is commonly referred to as know-how or savoir-faire. Science differs from technology, as the former is the search for the truth of things and the clarification of their elements and characteristics and leads to invention, whereas technology is the practical application of the fruits of science and the innovation of the best methods for their use. (Taleb, 2012, p. 36) From this perspective, we chose to define technology from different angles.

The linguistic definition of technology in the French language means the inferential and organized study of techniques, especially industrial techniques. (Walid, 2009, p. 23)[1]

Technology refers to information that can be used in the design, production, manufacture, or reconstruction of materials. Technology can be tangible or intangible. Tangible technology consists of models, diagrams, and operating devices, while intangible technology consists of technical services such as training, providing information, guidance, and investments (Nafiz Khaled, 2001, p. 332).[2]

There is another definition often referred to, which sees technology as the application of knowledge within the stages of production from the research stage to those related to product marketing, and the basic elements may be of different natures (Nasira).[3]

1.2. Technology Transfer:

The process of technology transfer can be defined as translating research conducted in laboratories and scientific research centers into advanced means entering the production process or providing advanced and developed methods for supporting services (Samir, 1981, p. 115) .[4]

That is, it is the process of linking the transfer of scientific knowledge (technological information or technical expertise) with the transfer of material technology (actual machines or other material equipment) to avoid falling into what is known as transfer devoid of technology (Qasim , 1984, p. 28) .[5]

The process of technology transfer is not limited to developing countries themselves, as this transfer also takes place between developed countries. Consequently, technology transfer has become a prominent feature of foreign trade in recent years, and technology has become a commodity bought and sold, exportable, and distinguished from other traditional material goods (Murad , 2010, p. 35) .[6]

The subject of technology transfer can also be approached from two aspects:

- **At the national level:** Technology transfer at the national level can be defined as transforming the results of innovative scientific research conducted by universities, institutes, and research centers into products, services, production methods, and characteristics embodied in capital, intermediate, and consumer goods produced through these methods. This type of technology is called “vertical transfer.”
- **At the international level:** International technology transfer refers to transferring technology from an advanced country where “vertical transfer” has been achieved to a less advanced country currently unable to succeed in vertical technology transfer. An example is the transfer of technological methods and techniques from the former to the latter without making any modifications or attempts to adapt these methods and techniques to the social, economic, and environmental conditions prevailing in technology-importing countries. The more modifications and adaptations are introduced (“horizontal transfer”) to suit local conditions, the more this technology acquires a higher degree of vertical transfer, which gives it a greater degree of success in becoming rooted in the new environment. Therefore, vertical technology transfer is the correct indicator of the existence of real technological development emerging from the local environment. Technology transfer is not considered successful except to the extent that horizontal technology transfer turns into vertical transfer organically and dynamically linked to the structure of local society and its surrounding environment.

Thus, embodied technology represented in machinery and equipment can be imported if financial resources are available to do so. However, importing soft (non-embodied) technology is difficult because it is not offered for sale and purchase, but some of its elements can be acquired through education and practical experience if there is an acceptable level of economic and especially industrial development and national research and development capability (Boulaid , 2011, pp. 236-237).[7]

1.3. Channels of Technology Transfer:

Technology can be transferred from developed countries to developing countries through several methods summarized as follows (Boulaid , 2011, pp. 237-238):[8]

- **Licenses:** Also called production or manufacturing privileges or the use of trademarks, whereby the company owning the technology agrees with a company in another country to use the patent, in-kind advantage, administrative research results, and engineering in exchange for a certain return. Licensing includes engineering and industrial designs, training, quality control methods, interior design of the factory or laboratory, and all other instructions related to the activity. Usually, multinational companies unable or unwilling to invest in a country for certain reasons allow such agreements, which are concluded according to pre-agreed conditions.
- **Turnkey or product-in-hand formula:** In this case, the project owner is tasked with preparing plans, drawings, and technical information, and also providing all means, equipment, supplies, and technologies and training local workers on operating and maintaining the factory. The project owner remains present for a period that may reach 05 years until locals are able to master production. The product-in-hand formula resembles the previous formula with some differences, whereby the supplier trains specialized workers, supervisors, and managers to make the institution capable of reaching the programmed production capacity and required specifications according to international market requirements and supplying the factory with equipment. It may also include supervision of management and marketing. However, the disadvantages of these two methods are the high implementation cost, lack of technological transfer, absence of guarantees related to production, and the lack of involvement of the local element in the implementation process.
- **Offices and investment institutions:** Offices and investment institutions conduct economic feasibility studies and make decisions regarding the technology that should be selected and the institutions suitable for carrying out the implementation process. There are also other channels for technology transfer such as international exhibitions of various goods. Publications containing information about the characteristics of machinery and equipment are another source allowing developing countries to compare different producers in terms of products, quality, and prices.

2.Technology and Economic Growth:

2.1. Concept of Economic Growth:

The word growth linguistically derives from the verb "to grow," meaning that something rises from one position to another, as in saying that wealth grew and increased. Terminologically, its concept raises much controversy simply because it has been defined by specialists in different sciences. Economic growth is the occurrence of an increase in real, not nominal, per capita income, the latter referring to the number of monetary units obtained by the individual during a specific period, usually one year, in return for the productive services he provides (Abdelkader & Abdelkader, 2003, pp. 11-12) .[9]

There are also those who define it as the occurrence of an increase in gross domestic product or gross national income in a way that achieves an increase in average real per capita income (Mohamed Abedl Aziz & Iman , 2000, p. 51) .[10]

From the previous definitions, some characteristics of economic growth can be deduced as follows:

- Economic growth is the continuous increase in the rate of real per capita income because the latter is the accepted measure indicating the standard of living enjoyed by a country.
- An increase in gross domestic product does not necessarily mean economic growth. Rather, that increase must be accompanied by a rise in real per capita income, meaning that the increase in total income growth rate must exceed population growth rate. If population growth exceeds the increase in gross domestic product, there will be no increase in average real per capita income and thus economic growth will not be achieved (Mohamed Abedl Aziz & Iman , 2000, p. 51). [11]
- Economic growth is not concerned with the structure of real income distribution as much as it is concerned with the increase in average income, which does not mean that every individual in society has increased income. This increase may be confined to a small class of the rich who obtain all the increase in total income while the broad class of the poor is deprived of it. Nevertheless, average per capita income increases, which does not apply to several countries such as India and Brazil, for example.
- The use of the real per capita income rate to express economic growth instead of nominal income does not make the latter a marginal element in determining the features of the phenomenon; rather, it is an active element in the equation. The nominal income rate is a part in the equation expressing the real income rate because the latter equals the ratio of nominal income to the general price level (inflation rate), meaning that it indicates the quantity of goods and services an individual obtains from spending his nominal income during a specific period (Abdelkader & Abdelkader, 2003, p. 12).[12]

Since real economic growth is the increase in nominal per capita income minus the inflation rate, it is not a temporary or circumstantial phenomenon. It is considered economic growth only if it is accompanied by continuity.

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2.2 Growth Theories Based on the Technological Factor:

Serious study of how economic growth occurs based on the technological variable began with classical economists, where it became the major concern of its pioneers (Adam Smith, Ricardo, and Malthus). Referring to Adam Smith's conceptions, it is noted that he was fully aware of the main role played by technological improvements in raising workers' productivity, which in turn would provide social welfare. He believed that the multiplication of production in its various forms in a well-governed society would lead to the establishment and spread of abundance affecting the poorer classes of the people. He also praised in his writings the division of labor, which would accelerate the process of technological progress. His conceptions even reached the point of predicting the emergence of what we today call research and development laboratories. Smith linked the invention of improved machines for work to the factor of investment or what is known as capital accumulation or profit. Generally, classical theory relied on assumptions including private property, perfect competition, full employment of resources, and individual freedom in practicing activity. They also relied on the method of microeconomic analysis in studying the causes of long-term growth in national income. As for their assumptions regarding the production process, they said that it depends on three main factors: labor, land, and capital, with almost minimizing the importance of the technology factor.

Despite Adam Smith's expectations that creative individuals and specialized research and development organizations would contribute to driving technological change and economic growth forward, the prevailing thought at that time wandered for nearly two centuries, focusing excessively on production relations in which the factor of change, especially technological change, was absent. Now, however, economists have gradually developed a new view of economic growth, taking into account modern technology not only as an important factor but also as something greatly affected by market requirements and the pursuit of profit (Frederick, 2002, p. 77).[13]

- **Exogenous Growth Theory:** This theory considers technology as an external factor in the economic growth equation, and among its paramount pioneers is Robert Solow, who was the first to introduce the factor of technological change into growth theories. In one of his lectures in 1987, he stated that the reality is that growth theory did not begin in economic thought with his articles of 1956 and 1957, nor did it end with them. It may have begun with *The Wealth of Nations*, and perhaps Adam Smith preceded him in this field. Solow's neoclassical model explaining the phenomenon of economic growth is considered the first contribution containing the seeds of developing neoclassical growth theory. Before his introduction of technological progress into the neoclassical theory of economic growth, the economic process depended on the three previously mentioned factors. In his growth model, technological progress is considered the main source of long-term economic growth (Ahmed, p. 2). [14]

Solow also proved through his model that total output may grow continuously if there is technical progress even if there is no growth in capital or labor. Therefore, relying on labor and capital alone for economic growth in total output will not achieve continuous growth because of the law of diminishing marginal productivity. Thus, investment in technology is necessary to maintain or increase the rate of return achieved on capital and labor. Failure to invest in technology, resulting in no technological growth, will lead to a decline in economic growth due to diminishing productivity in capital and labor, which cannot be maintained except through technical development (Raja , p. 02).[15]

- **New Growth Theories:** Solow aimed through his proposition to search for the causes of disparity between rich and poor countries. He concluded that whenever a country had capital accumulation, major technical development, or weak population growth, it was helped to develop, and whenever the opposite occurred, it was helped to remain in poverty. Another conclusion reached by Solow's model is the idea of convergence between countries, where developing countries can catch up with rich countries in the long run if certain factors such as capital accumulation are available. However, Solow's conclusion was also subjected to severe criticism by a group of economists who later established what became known as endogenous growth models. Paul Romer, in the mid-1980s, introduced the endogenous growth model, which considers technology as an internal variable unlike Solow's model. He considered that technological change is not limited to changing the method of production or the shape of the aggregate production function, but that technological changes often lead to simultaneous changes in the inputs, form, and outputs of the aggregate production function.

Romer did not stop there in his model but introduced the concept of the idea. In his view, the idea is the origin of every innovation; whatever the type of innovation, behind it is an idea that later turns into knowledge. He gave it an economic entity like goods (it has value) but with characteristics radically distinguishing it from traditional private or public goods or both. Its advantage lies in three elements: non-excludability, non-rivalry, and accumulation, which made it fundamentally different from other goods. Its essence is linked to increasing returns, which allowed them to say that knowledge accumulation, unlike physical capital accumulation, can generate itself (Fatima, 2012, pp. 112-114).[16]

Romer also succeeded in giving new life to neoclassical theory through the hypothesis of introducing the factor of learning by doing, such that the institution increasing its physical capital simultaneously learns to produce more effectively. This positive effect of experience on productivity is described as learning through investment. According to him, this factor affects growth through two channels:

• First: Human capital is explicitly integrated through modeling individual educational investment choices as well as through the external effect of human capital.

• Second: The factors causing endogenous growth are clearly linked to the stock of human capital, either by assuming that human capital directly produces new technology or knowledge or that it is a fundamental input in the research and development sector that innovates new technology or knowledge (Faisal , 2010, p. 32).[17]

- **Robert Lucas Model 1988:** This model allows us to perceive that the reason for the existence of differences in wealth and poverty among countries is basically due to differences in the amount of time devoted to training and education. Northern countries are characterized by good development rates because they gave great importance and sufficient time to training, whereas southern countries are characterized by weak development rates due to lack of concern or insufficient concern for training. Thus, a policy aimed at permanently increasing training time and favoring knowledge accumulation will have a positive effect on economic growth (Rafik , 2008, p. 90). [18]
- **Paul Romer Model 1990:** Paul Romer in 1990 studied Solow's ideas, which considered technological progress mainly as originating from outside. Romer confirmed that human capital becomes productive through its interaction with the stock of knowledge. The more knowledge increases, the more productive become research and development efforts based on human capital. Romer's model depends on three sectors: research and development, intermediate goods production, and final goods production (Rafik , 2008, p. 92). [19]

Only some theories were mentioned because they are considered pioneering in the use of the technology factor within economic growth theories. These theories refuted the previously prevailing idea attributing lack of development to what is known as the dilemma of capital scarcity. They proved that the priority acquired by the capital element through reliance on it as the cornerstone of the growth process is no longer sufficient, but that there are other elements that must accompany it if high growth rates are to be achieved, foremost among these elements being technology. Therefore, developed countries paid attention to it, developed and created it, while developing countries, by virtue of their economic position, remained lacking this factor, which has become pivotal in the battle faced by their economies.

Technology has also become one of the most important factors determining the success or failure of development plans, and even a means of preserving national sovereignty through acquiring technology for sensitive industries such as military industries, pharmaceuticals, and the energy sector. This has led developing countries to attempt to acquire, localize, and even create technology in order to reach the ranks of economically advanced countries. Among these methods is attracting multinational companies that possess advanced technology as well as leading research and development centers. The process of technology transfer will remain one of the main objectives of developing and poor countries, as modern technology is the shortest path to development and prosperity.

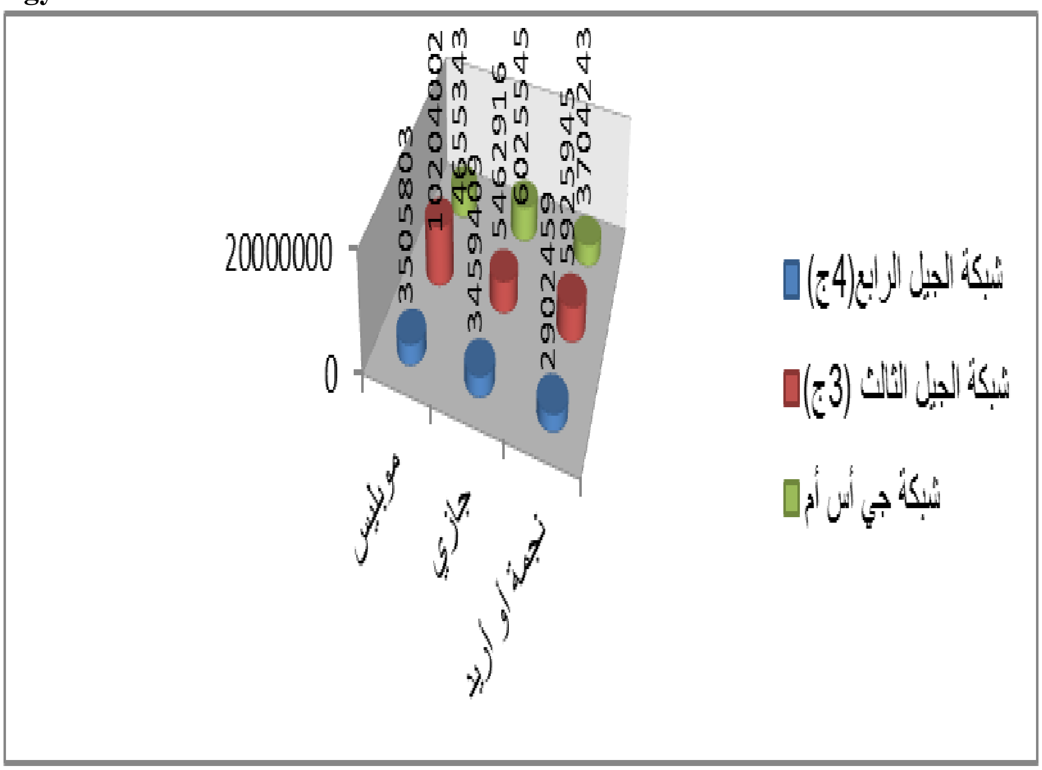
2. Applied Framework of the Study:

It includes an econometric study of the impact of technology transfer on the growth of per capita gross domestic product.

2.1. The Reality of Information and Communication Technology in Algeria

It includes fixed telephony, mobile telephony, the internet, and all other fields of communication. Mobile phone operators in Algeria include three networks: Mobilis (Algérie Télécom agent), Djezzy (Orascom Telecom Algeria), and Nedjma or Ooredoo (National). The number of mobile phone subscribers reached 43,390,965 subscribers in 2015 and increased to 45,845,667 subscribers in 2017, with a penetration rate of 109%; while fixed telephony includes two networks (Algérie Télécom and 4GLTE/WIMAX), where the total number of subscribers reached 4,051,360 subscribers in 2017, distributed as 3,130,171 subscribers for Algérie Télécom and 921,099 subscribers for 4GLTE/WIMAX. The following figure illustrates this:

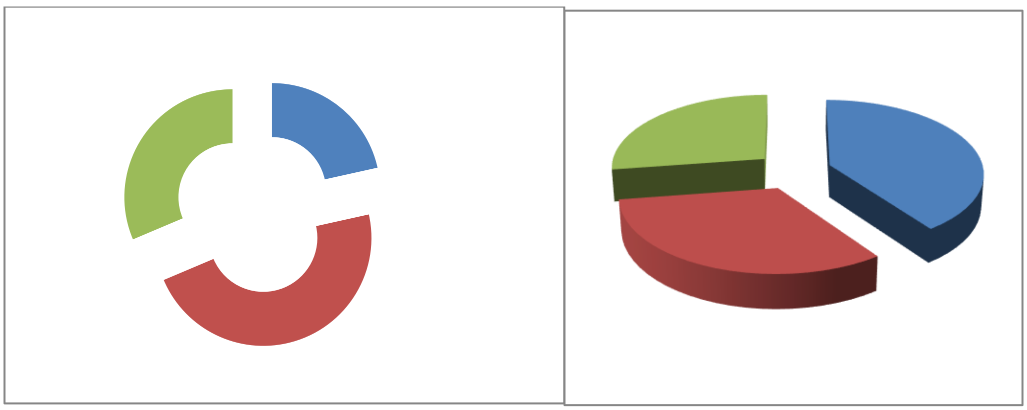
Figure No. (1): Distribution of Mobile Phone Communication Subscribers by Type of Technology in 2017



Source: Prepared by the researcher based on the statistics of the National Office of Statistics.

We note through Figure No. (1), which illustrates the distribution of mobile phone communication subscribers according to the type of technology in 2017, that there is a convergence in the number of subscribers in the GSM network among the three operators, with Mobilis surpassing them by 3,505,803 subscribers. Meanwhile, in the third-generation network (3G), there is a significant superiority of the Mobilis operator with a percentage of 40%, equivalent to 10 million and 204 thousand subscribers, followed by the Djezzy operator with 33% and the Nedjma or Ooredoo operator with 27%. As for the new generation network (4G), Djezzy leads with 41%, equivalent to 6,025,545 subscribers. It is also observed that most subscribers use the third-generation network (3G) at a rate of 47%, followed by the GSM network at 31%, then the fourth-generation network (4G) at 22%, according to the following figure:

Figure No. (2): Percentage of Mobile Phone Communication Subscribers by Type of Technology in 2017



Source: Prepared by the researcher based on the statistics of the National Office of Statistics.

The postal infrastructure also witnessed remarkable development, as the number increased from 3,678 post offices in 2015 to 3,823 offices in 2017. The postal service rate per office also decreased from 10,547 in 2015 to 10,516 in 2017. The following table illustrates this:

Table No. (1): Development of the Basic Infrastructure of the Postal Sector in Algeria

Development of Basic Infrastructure	2015	2016	2017
Number of post offices	3678	3755	3823
Postal service rate per office	10547	10217	10516

Source: Prepared by the researcher based on the statistics of the National Office of Statistics.

By comparing the development of the use of communication indicators for the year 2019 among the Maghreb countries, Morocco ranks first in the percentage of internet use and mobile phone subscriptions per 100 inhabitants, with 74.37% and 127.95 per 100 inhabitants respectively, followed by Tunisia with 66.69% and 126.3 per 100 inhabitants, while Algeria ranks last with an internet usage rate of 50.8% and mobile phone subscriptions of 109.35 per 100 inhabitants. As for fixed telephone subscriptions per 100 inhabitants, Tunisia ranks first with 12.43 per 100 inhabitants, followed by Algeria with 10.76, then Morocco with 5.63 per 100 inhabitants. It is observed that Algeria still remains weak in the use of communication technology, especially the internet.

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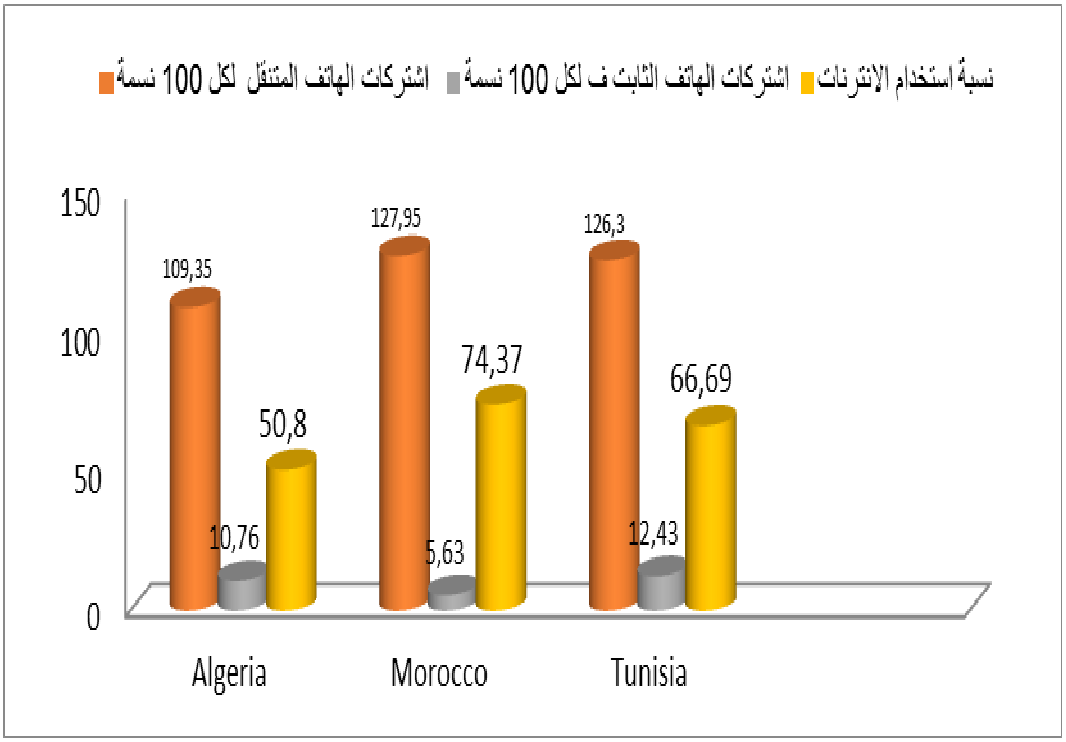
Website: https://fra.st

Figure No. (3): Development of the Use of Communication Indicators for the Year 2019



Source: Prepared by the researcher based on data from the Ministry of Finance.

To determine Algeria's position and ranking among Arab countries in the Information and Communication Technology Index over several years, the following table is presented:

Table (2): Information and Communication Technology Index in Selected Arab Countries (Global Ranking)

Country	**2017 Rank**	**2017 Value**	**2018 Rank**	**2018 Value**	**2019 Rank**	**2019 Value**
Algeria	107	33.60	107	37.20	107	33.60
Tunisia	83	44.50	84	46.34	83	44.60
Morocco	77	47.40	76	49.23	77	47.40
Egypt	78	47.30	90	44.22	78	47.30

Source: (Houari and Daghri, 2021, p. 705).

By comparing Algeria according to the Information and Communication Technology Index, it ranks very low globally, occupying the 107th position out of 131–134–136 countries respectively for the years 2017, 2018, and 2019. In contrast, neighboring countries show better performance, led by Morocco (77th globally), followed by Egypt (78th) and Tunisia (83rd).

Regarding the main ICT infrastructure indicators, they include the percentage of population covered by mobile phone services, international Internet bandwidth per user (kilobytes/second), and the number of secure Internet servers per million people, as shown in the following table:

Table (3): ICT Infrastructure Index (2019)

Country	Mobile Coverage (%) Rank	Value	Internet Bandwidth per User (kb/s) Rank	Value	Secure Internet Servers per Million Rank	Value
Algeria	84	85.30	108	4.3	105	2.20
Tunisia	66	94.2	78	11.3	78	4.9
Morocco	62	96.2	60	18.60	79	4.7
Egypt	47	96.8	38	25.5	111	1.5

Source: (Houari and Daghri, 2021, p. 607).

Egypt ranks highest in mobile phone coverage, reaching 96.8%, and occupies the 47th global position out of 136 countries. Morocco follows in terms of ranking and performance. Algeria ranks relatively low, at 84th globally with 85.30%.

For Internet bandwidth per user, Egypt ranks 38th globally, showing strong performance compared to other countries, while Algeria ranks last at 108th.

Regarding secure Internet servers per million people, Tunisia leads among the comparison countries, ranking 78th globally with 4.9 servers per million people, while Morocco records a lower level of 1.5 per million people.

During the first five-year plan (2005–2009), known as the Complementary Program for Growth Support, a large amount of 4203 billion Algerian dinars (approximately 114 billion USD) was allocated. This program was supplemented by two additional sub-programs: one for southern regions (432 billion DZD) and another for high plateaus regions (668 billion DZD). It also included remaining resources from the Economic Recovery Support Program estimated at 1071 billion DZD, additional funds of 1191 billion DZD, and treasury transfers worth 1140 billion DZD.

The financial allocations were distributed across five main sectors as follows:

Table (4): Distribution of the Complementary Program for Growth Support (2005–2009)

Sector	Total (billion DZD)	Percentage (%)
Improving living conditions of citizens	1908.5	45.5
Development of infrastructure	1703.1	40.5
Economic development support	337.2	8
Public service development	203.9	4.8
ICT development	50	1.1

Sector	Total (billion DZD)	Percentage (%)
Total allocations	**4202.7**	**100**

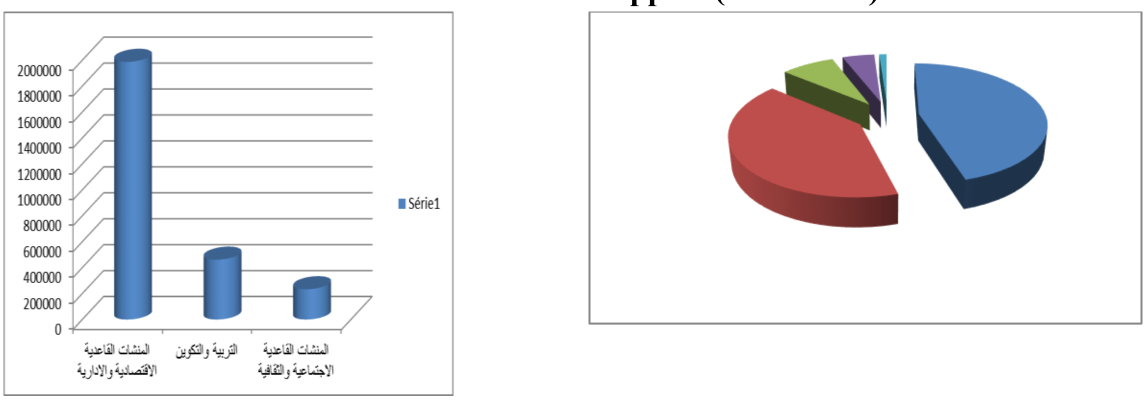
Source: Complementary Program for Growth Support, Prime Minister's Office, p. 2.

Infrastructure received 1753.1 billion DZD (41.6% of the total program budget). Spending on basic economic and administrative infrastructure represented the largest share, at 88.87%, amounting to 1557.9 billion DZD within the infrastructure sector.

These expenditures were distributed across four transport-related areas, including modernization of railway lines and construction of new ones, the establishment of the Algiers Metro, construction of three new airports, and the development of numerous transport stations and urban transport institutions across several provinces. Additionally, 600 km of national and provincial roads were rehabilitated (Genidi, 2015, p. 168).

The following figure illustrates this:

Figure (4): Evolution of infrastructure expenditure under the Complementary Program for Growth Support (2005–2009)



Source: Prepared by the researcher based on the Complementary Program for Growth Support.

2.2 Model Specification and Stationarity Analysis

Through this section, we attempt to construct an econometric model that explains the impact of the transfer of Information and Communication Technology on GDP per capita. This study relies on a time series of annual data for the Algerian economy over the period 1990–2025.

Model Specification:

We assume that the mathematical form takes the following linear specification:

Growth_GDPc = f (ITC) ………………… (1)

Dependent variable:

It represents GDP per capita growth (Growth_GDPc), which is GDP per capita growth measured at current prices in US dollars. The data were obtained from World Bank databases.

Independent variable:

It represents imports of Information and Communication Technology goods (ITC), which is the total value of ICT goods imports in US dollars (% of total goods imports).

Results of the Time Series Stationarity Analysis:

UNIT ROOT TEST TABLE (PP)

At Level

		ITC	GROWTH_GDPC
With Con...	t-Statistic	-2.0598	-3.9135
	Prob.	***0.2614***	***0.0049***
		n0	***
With Con...	t-Statistic	-2.1544	-3.9122
	Prob.	***0.4989***	***0.0220***
		n0	**
Without C...	t-Statistic	0.0608	-3.6652
	Prob.	***0.6956***	***0.0006***
		n0	***

At First Difference

		d(ITC)	d(GROWTH_GDPC)
With Con...	t-Statistic	-4.7369	-10.5245
	Prob.	***0.0005***	***0.0000***
		***	***
With Con...	t-Statistic	-4.6774	-10.3823
	Prob.	***0.0035***	***0.0000***
		***	***
Without C...	t-Statistic	-4.7076	-10.4226
	Prob.	***0.0000***	***0.0000***
		***	***

UNIT ROOT TEST TABLE (ADF)

At Level

		ITC	GROWTH_GDPC
With Con...	t-Statistic	-2.1746	-3.8083
	Prob.	***0.2187***	***0.0064***
		n0	***
With Con...	t-Statistic	-2.3392	-3.7831
	Prob.	***0.4029***	***0.0296***
		n0	**
Without C...	t-Statistic	0.1963	-3.5434
	Prob.	***0.7373***	***0.0008***
		n0	***

At First Difference

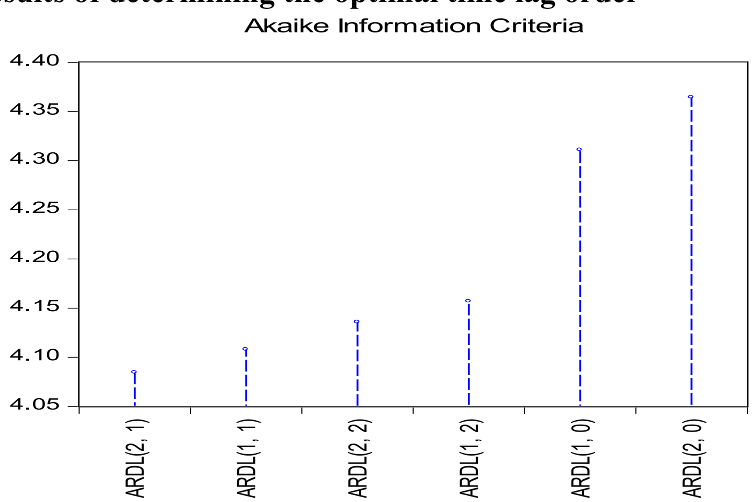
		d(ITC)	d(GROWTH_GDPC)
With Con...	t-Statistic	-4.7621	-9.6953
	Prob.	***0.0005***	***0.0000***
		***	***
With Con...	t-Statistic	-4.7049	-9.5404
	Prob.	***0.0032***	***0.0000***
		***	***
Without C...	t-Statistic	-4.7324	-9.8064
	Prob.	***0.0000***	***0.0000***
		***	***

2. Model Estimation:

- **Determining the optimal lag order:**

Before estimating the model, we must first determine the lag order for each variable using the previously mentioned criteria. The following graphical representation illustrates the method for selecting the optimal model as follows:

Figure No. (1): Results of determining the optimal time lag order



ARDL Cointegrating And Long Run Form
Dependent Variable: GROWTH_GDPC
Selected Model: ARDL(2, 1)
Date: 04/01/26 Time: 18:46
Sample: 1990 2025
Included observations: 34

Cointegrating Form

Variable	Coefficient	Std. Error	t-Statistic	Prob.
D(GROWTH_GDPC(-1))	-0.250678	0.158812	-1.578457	0.1253
D(ITC)	1.658961	0.402590	4.120726	0.0003
CointEq(-1)	-0.636687	0.223573	-2.847789	0.0080

Cointeq = GROWTH_GDPC - (0.5198*ITC -1.4229)

Long Run Coefficients

Variable	Coefficient	Std. Error	t-Statistic	Prob.
ITC	0.519778	0.341648	1.521386	0.1390
C	-1.422882	1.488597	-0.955855	0.3470

- **Testing the significance and sign of the error correction term:**

We observe the significance of the error correction term (CointEq(-1)) with the expected negative sign, which indicates a return to the stable equilibrium state. This is further evidence of the existence of a long-run equilibrium relationship. If GDP per capita deviates from its equilibrium value in the short run in period (t-1), it is adjusted in the long run in period (t) by 63.66%. Its effect is also statistically significant, as the probability value is less than 0.05.

- **Diagnostic tests:** This is done through the bounds test, which provided the following results:

Table No. (2): Bounds test results (Bond test)

ARDL Bounds Test
Date: 04/01/26 Time: 18:49
Sample: 1992 2025
Included observations: 34
Null Hypothesis: No long-run relationships exist

Test Statistic	Value	k
F-statistic	4.940273	1

Critical Value Bounds

Significance	I0 Bound	I1 Bound
10%	4.04	4.78
5%	4.94	5.73
2.5%	5.77	6.68
1%	6.84	7.84

Source: Prepared by the researchers based on EViews 9 software outputs.

It is clear from the table that the calculated F-statistic is greater than the upper bound critical values at the 5% and 10% significance levels. This confirms the existence of a long-run equilibrium relationship.

2.4. Evaluation of the Statistical Significance of Model Parameters:

Residual Diagnostic Tests:

Residual diagnostic tests are an essential step through which the quality of the model can be assessed. The most important residual-related tests are presented in the following table:

Table No. (3): Model Diagnostic Tests

Test Type	**Test Statistic**	**Null Hypothesis**	**Probability Value**
Breusch-Godfrey Serial Correlation LM Test	Obs*R-squared = 0.76	No autocorrelation in errors	0.68
JARQUE-BERA	JB = 0.58	Residuals are normally distributed	0.45
Heteroscedasticity Test (ARCH)	N*R-squared = 1.30	Homoscedasticity of error term	0.324
Ramsey RESET Test	F-stat = 0.98	Model specification is correct	0.328

Source: EViews 9 outputs.

From the previous table, we conclude the following:

- Since the probability value of the LM test is 0.68, which is greater than the 5% significance level, the null hypothesis is accepted. This indicates that there is no autocorrelation problem in the model.
- The JARQUE-BERA test was used to verify whether the estimated residuals follow a normal distribution. The results show that the test value (JB = 0.58) with a probability value of 0.45 is greater than 0.05, which leads to accepting the null hypothesis that the residuals are normally distributed.
- To test homoscedasticity of the error term, the ARCH heteroscedasticity test was used. The results indicate that N*R-squared = 1.30 with a probability value of 0.324 (> 0.05). This leads to rejecting the alternative hypothesis and accepting the null hypothesis of homoscedasticity.
- The Ramsey RESET test indicates the correctness of the functional form of the estimated model. The probability value (p-value = 0.328 > 0.05) confirms that the functional specification of the model is appropriate.

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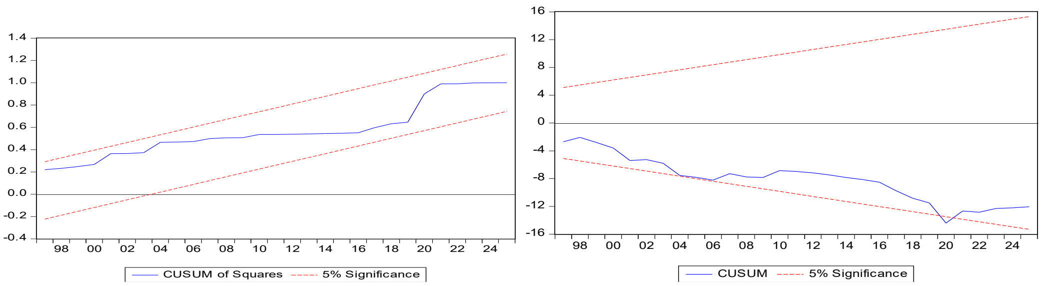
Structural Stability Test of the Estimated ARDL Model:

This test is used to ensure that the data used in the study are free from structural breaks over time. It is conducted using two tests: the cumulative sum of recursive residuals (CUSUM) and the cumulative sum of squares of recursive residuals (CUSUM of Squares).

Figure No. (2): CUSUM and CUSUM of Squares Test Results



Source: Prepared by the researchers using EViews 9 software.

From the two figures, it is clear that the estimated coefficients of the ARDL model used are structurally stable over the study period extending from 1990 to 2025. This confirms a strong stability between the study variables and consistency in the model, meaning there is stability between short-run and long-run results. This is shown by the fact that the graphs of the two test statistics remain within the critical bounds at the 5% significance level.

3. Discussion of Results:

During the period (1990–2025), the imports of Information and Communication Technology (ICT) goods represent one of the factors influencing GDP per capita in Algeria. The estimation results show a positive relationship between ICT imports and GDP per capita growth in both the short and long run, which is consistent with economic theory, since importing ICT goods supports GDP per capita growth.

Short-Run Dynamics Analysis:

The coefficient of the variable D(ITC) is 1.658 and is statistically significant at 5% (Prob = 0.0003), confirming a strong positive short-run effect of ICT investment on individual economic growth.

A 1% increase in ICT investment leads to an immediate 1.65% increase in GDP per capita growth. This reflects the “stimulating effect” of capital expenditure in the telecommunications sector (such as network development), which generates rapid economic activity.

This is explained by the relatively fast responsiveness, since the use of ICT goods requires a short period to be effectively integrated into production processes, which in turn positively affects GDP per capita growth.

Long-Run Analysis (Long Run Coefficients):

The ICT coefficient is 0.519 but is statistically insignificant (Prob = 0.1390). Although the sign is positive (consistent with economic theory), the lack of significance in the long run in Algeria indicates a “productivity paradox.”

This can be explained by several reasons:

- **Weak absorption capacity:** Investments may be directed more toward consumption (communication, entertainment) rather than productive industrial use.
- **Digital gap:** Insufficient human capital training limits full utilization of technology, preventing transformation of short-run effects into sustainable long-run growth.
- **Threshold effect:** The level of investment may not yet have reached the critical mass required to generate long-term cumulative effects.

The constant term is negative, which does not contradict economic theory, given that technology plays a major role in GDP per capita growth.

The Algerian economy shows the ability to return to equilibrium in the long run after short-run shocks. The speed of adjustment is 63.6% annually, which is relatively high. This indicates that income growth deviations take less than two years to return to their normal path due to technological investment.

Long-Run Equilibrium Equation:

From the results, the long-run relationship can be written as:

GROWTH_GDPC = -1.422 + 0.519 ITC

Where the coefficient 0.519 represents the elasticity of growth with respect to ICT investment in the long run.

4. Conclusion:

In recent years, Algeria has given considerable attention to acquiring Information and Communication Technology through several projects such as e-government and e-administration. Technology is one of the most important factors of production in the modern era and contributes to improving living standards through its support of GDP per capita. However, its use in Algeria remains uneven across sectors and below the required level.

Econometric results indicate that ICT investment in Algeria acts more as a **short-term growth driver** than a **structural long-term driver**. While ICT spending increases individual growth immediately, this effect does not persist in the long run. Therefore, policymakers should not only increase investment levels but also improve the **quality of ICT utilization** and link it to productive sectors to ensure sustainable growth.

Main Findings:

- **Cointegration confirmed:** There is a long-run equilibrium relationship between ICT investment and GDP per capita growth. This is confirmed by the significance of the error correction term CointEq(-1) = (-0.6366) at a 1% significance level.
- **Short-run effectiveness:** ICT investment has a positive and statistically significant effect on GDP per capita growth in the short run. The coefficient of D(ITC) is approximately 1.658, meaning a 1% increase in ICT investment raises GDP per capita growth by about 1.66% in the short term.

- **Long-run limitation:** Although the long-run coefficient is positive (0.519), it is statistically insignificant (p-value = 0.1390 > 0.05), indicating that ICT investment has not yet become a sustainable structural growth driver in Algeria.
- **Error correction speed:** The coefficient (-0.636) indicates that the Algerian economy corrects 63.6% of deviations from equilibrium annually, meaning shocks take about 1 year and 7 months to return to equilibrium.
- **Productivity paradox:** The results suggest a gap between ICT accumulation and productivity gains. Investments may not be fully translated into productive use due to limited human capital development and incomplete digital transformation in productive sectors such as industry and agriculture.
- **Short-term stimulus role:** ICT investment currently acts as a short-term economic stimulus, especially in services and telecommunications, but has not yet reached a “critical mass” to generate long-term external economies of scale.
- **Growth sensitivity:** GDP per capita growth responds quickly to ICT investment spending, making financial policy in this sector an effective tool for short-term economic recovery.

Recommendations:

Based on the findings, the following recommendations are proposed:

- Increase spending on ICT projects and ensure their transfer to industrial and service sectors to improve living standards and support productive growth.
- Establish research centers to acquire modern production technologies that reduce costs and increase productivity.
- Strengthen partnerships between the public and private sectors, encourage foreign direct investment, and support cooperation with national institutions for technology acquisition.
- Shift from a “technological equipment” approach to a “digital empowerment” approach by linking ICT investments with intensive training programs and supporting digital transformation in SMEs to ensure long-term sustainability.
- Activate the productive use of technology by moving beyond infrastructure investment and encouraging firms to integrate ICT into production processes.
- Invest in digital human capital to bridge the productivity gap by aligning technological investment with skill development.
- Promote the digital economy and support startups as engines of innovation-driven growth.
- Improve digital flow quality and reduce internet costs for economic institutions, as high costs may hinder long-term sustainability of ICT impact.

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