

The Impact of Information and Communication Technology on Human Capital in Algeria: An Econometric Study (2014_2023)

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Abstract: this study aims to examine the impact of information and communication technology on human capital in Algeria from 2014--2023. The research employs multiple linear regression methodology, using the cognitive and technological output indices as independent variables, while the internet user index represents the dependent variable. The findings indicate a statistically significant relationship between the variables in Algeria, confirming the significance of the regression model.

Keywords: information and communication technology, human capital, change, cost.

JEL Classification A12

ملخص: تهدف هذه الدراسة إلى معرفة أثر تكنولوجيا معلومات و الاتصال على رأس المال البشري لجزائر خلال الفترة (2014-2023)، باستخدام منهجية الانحدار الخطي المتعدد اعتمادا على مؤشر مخرجات المعرفة والتكنولوجية كمتغيرات مستقلة، ويمثل مؤشر مستخدمي الشبكة العالمية لمعلومات كمتغير تابع، وقد خلصت الدراسة إلى وجود أثر معنوي بين مستخدمي الشبكة العالمية لمعلومات ومخرجات المعرفة والتكنولوجية في الجزائر، ونموذج الانحدار معنوي.

الكلمات المفتاحية: التكنولوجيا المعلومات و الاتصال، رأس المال البشري، التغير، التكلفة.

1.Introduction

The evolution of realities within human societies has necessitated constant change across various aspects of life. This transformation is driven by the advancement of contemporary technological and scientific paradigms, which render humanity perpetually

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aspiring and progressing. We live in an era characterised by competition across all spheres of life, marked by technological developments and an explosion of knowledge. Consequently, nations strive to enhance the skills of their human workforce, aiming to establish knowledge-based societies capable of employing science, knowledge, and technology to promote comprehensive national development. The information and communication technology sector is of paramount importance because of its significant influence on and contribution to the development of other sectors and activities. Like many nations, Algeria endeavors to keep pace with advancements in information and communication technology, targeting the acquisition of human capital in the digital domain to achieve full integration with the contemporary age.

On this basis, the research problem can be formulated as follows:

What is the impact of information and communication technology on human capital in Algeria during the period of 2014–2023?

To address this research problem, the following hypotheses have been proposed:

- No statistically significant impact exists between cognitive and technological outputs and Internet use in Algeria.
- A statistically significant effect exists between cognitive and technological outputs and Internet use in Algeria.

Significance and objectives of the study

The importance of this study lies in its focus on the impact of information and communication technology on human capital, which is of essential relevance in keeping pace with the contemporary era. This research aims to investigate the impact of information and communication technology on human capital in Algeria from 2014--2023.

Methodology

This research employs a descriptive analytical method to present and analyse developments in the study variables in conjunction with an experimental econometric approach that uses statistical methods to estimate a model measuring the impact of information and communication technology on human capital in Algeria from 2014--2023. This was conducted via the software program SPSS v26.

Structure of the Study

The paper is organised into two principal sections: the first is devoted to the theoretical framework of the study variables, while the second addresses the econometric study, assessing the impact of information and communication technology on human capital in Algeria from 2014–2023.

Previous studies

Study by Miftah Ben Hadia (Hadia & Hechour, 2023, pp. 202–219):

This study confirmed that information technology contributes to achieving total quality and enhancing an institution's competitiveness. The possession of modern information and communication technologies is inevitable, as today's business world is highly complex and characterised by great uncertainty. Institutions are therefore bound by their capacity for intelligent and rapid engagement with technology. Given the challenges arising from the rapid transformation of the global economic system caused by globalisation, which has created a new, widespread mechanism of competition, Algerian institutional leaders have recognised the necessity of employing information and communication technologies to achieve economic and social efficiency.

Study by Lazhar Sahli (Sahli & Bousbaa, 2023, pp. 43–65):

This study examined the impact of information and communication technology on economic growth via a sample of 19 Arab countries from 2005--2018, employing panel data within both static and dynamic analytical frameworks. The static analysis results indicated the suitability of the fixed-effects model, showing that the source of variation among the sample countries lies in the constant term rather than random effects. The dynamic analysis results revealed a positive and significant relationship between economic growth and the number of internet, mobile, and fixed-line subscribers in the short term. In the long term, a positive and significant relationship was identified only with the number of mobile and fixed-line subscribers, as well as the trade openness index, with the error correction coefficient being negative and significant.

Study by Hanan Al-Sadiq Bezan (Bezan, June 2024, pp. 640–661):

This study confirmed that the communications revolution, the information explosion phenomenon, the widespread use of information technology, and its continuous development have led to societal transformations, most notably the emergence of the knowledge economy. The study revealed that the development of this knowledge-based economic pattern primarily stems from the undeniable role of information in all facets of human life. It focused primarily on analysing contemporary events that contributed to the evolution of the knowledge economy, its indicators, and their implications for the need to develop human capital. Consequently, it underscores the necessity of strategic planning to modernise education and learning to produce the human capital required to drive the transition toward a knowledge-based economy.

Study by Raq Zeineb (Zeineb, August 2021, pp. 515–532):

This study confirmed the importance of human capital in enhancing electronic marketing innovation. A questionnaire was developed to collect data from a sample of 35 individuals, and SPSS was used to analyse the data via regression models and other statistical methods. The study concluded that human capital plays a significant role in promoting electronic marketing innovation and recommended the necessity of providing a regulatory environment conducive to human capital to encourage marketing creativity.

Distinguishing the features of the current study from those of previous studies:

In terms of the study environment, previous studies focused on individuals and relied on indicators from Arab countries. With respect to the application sector, previous research employed a descriptive analytical method, which is most suitable for study and analysis. This study, however, differs in its sample composition by combining questionnaires with global indicators from Arab countries. Additionally, prior studies have generally addressed the topic broadly or linked it with other variables related to the independent variable. In contrast, this study relies on global indicators specific to Algeria. It differs in its aim to investigate the relationship between the independent and dependent variables and their statistically significant impact.

2.Theoretical Framework for the Impact of Information and Communication Technology on Human Capital:

2.1 Information and communication technology:

Technology has undergone several denominations. Initially, it was described as new information and communication technology (NICT), but the term "new" was subsequently removed, becoming information and communication technology (ICT), as the novelty faded following its emergence in the mid-1970s with the marketing of the first computer known as ALTAIR and the start of internet use in the 1990s within the same century. Recently, some studies have adopted the abbreviated term information technology. Regardless of the designation, it refers to all technologies involved in processing and transforming information, especially informatics, the internet, long-distance communications, and all technological means used for exchanging, processing, exploiting, and reshaping digital data capable of transmission across networks (Yaqub, 2013/2012, p. 4). It is also defined as a collection of modern methods and techniques used to simplify certain activities and improve their performance. It encompasses devices concerned with processing and circulating information, such as computers, software, storage and retrieval equipment, and wired and wireless electronic transmission through all types of communication, whether written, audible, or visual, with the primary aim of facilitating bilateral and collective communication via closed and open networks (Azayzia, 2020/2019, p. 3).

In conclusion, information and communication technology comprises all modern technical or digital methods that simplify or process information by facilitating communication.

2.2 Basic Components of Information and Communication Technology:

Information has become crucial because of its ability to be collected, stored, shared, published, and retrieved, as well as its adaptability to technological developments, making it the vital nerve and driver of contemporary society. Its components include:

- **Hardware Components:** These components are related to various parts of the data input, output, and information processing.
- **Software:** This comprises all instructions that process information, control, and direct the hardware components in computers.
- **Communications and Computer Networks:** This involves the electronic transmission of data by rapid conversion from analogue to digital, defined as the electronic transfer of data from one location to another.

Data and Information (Databases):

This information represents data that have been processed to be more useful. Useful information possesses characteristics such as relevance to the subject, timeliness, accuracy, conciseness, and completeness. Data and information are often used interchangeably.

Procedures:

These describe the steps required to perform tasks or achieve a specific result. Sometimes procedures are not explicitly stated but are understood through common practice or may be available online.

Human Components:

Individuals constitute a vital and significant part of the information technology system and bear the most tremendous responsibility for the success or failure of information technology systems within the organisation (Al-Khanaq, January 2016, pp. 8–10).

In conclusion, the components of information and communication technology comprise hardware, which includes software and data, and human components, which are crucial to the success or failure of any organisation.

2.3 Classification of Information and Communication Technology Risks:

- **According to their source**, internal risk pertains to company employees, whereas external risk includes hackers, intruders, and natural disasters.
 - **According to their cause**, the risks caused by human factors include poor performance by human resources, such as hazards resulting from negligence or general inadequacy. Other risks involve electronic fraud, exposing information systems to hazards such as fraud, manipulation, and unauthorised access through identity theft. Nonhuman risks are those unrelated to human actions and result from natural disasters or other environmental factors.
 - **According to intent**, risks may arise from deliberate actions, such as the intentional input of incorrect data, or from unintentional or unauthorised actions, such as accidental data entry or destruction due to oversight or error.
 - **On the basis of their consequences**, these risks may cause physical damage to the system and computer hardware or the physical destruction of data storage media, such as tapes and magnetic discs. Additionally, technical and logical risks exist that may affect data stored on computers or magnetic tapes.
- According to their relation to the stages of the utilised technological system, risks are classified as follows:
- **Input Risks:** These involve entering incorrect data, such as creating false or inaccurate data.
 - **Modification or Distortion Risks:** These occur when original documents are manipulated after approval by the responsible person but before being entered into the computer system.
 - **Deletion Risks:** These involve deleting entire documents or excluding specific data before they are entered into the computer system.
 - **Duplication Risks:** These risks arise from entering data multiple times, such as selecting certain documents and inputting their data repeatedly into the system, for example, payment orders or inventory delivery orders.
 - **Data Processing Risks:** These risks primarily affect data stored in computer memory and the programs that operate on such data.

Network Risks:

These risks arise from the use of email in transactions, as it is often relied upon to conclude deals, which facilitates certain types of fraud. Email messages may contain viruses designed to destroy data and information within the system. Therefore, caution is vital when opening attachments to emails, as they are common vectors for hacking by cybercriminals and other malicious actors. Additional risks include security threats from viruses, exposure of the organisation to fraud and deception, network disruption, and risks posed by botnets (Al-Jabli, 2019, pp. 10–14).

In conclusion, information and communication technology risks can be internal or external, depending on their cause, which may include human factors that act with intent or unintentionally. Furthermore, technical and logical risks primarily impact stored data and extend to other risks related to system usage.

2.4 Concept of Human Capital:

The growing attention to the concept of human capital stems from its prioritisation of the qualitative, quantitative, and in-depth development of human resources. In the context of technological advancements that diminish the value of low-skill jobs while creating new knowledge-based positions, the development of human capital, both in quality and quantity, is necessary. Scholars unanimously agree that the challenges of the new era can be addressed only by continuously developing human capital at both the individual and societal levels, especially amid intensely competitive environments. Human capital is fundamentally the source for forming and identifying individuals equipped with the intellectual capacity, skills, and experience necessary to provide practical solutions to customer demands, as it represents the source of innovation and renewal within organisations (Khira & Jennat, 2018/2019, pp. 19–20). Human capital is also recognised as a crucial component of intellectual capital, a term popularised in the 1960s by Scholtz, since human capital has been regarded as an institutional resource contributing to achieving competitive advantage (Bouhdhish & Saidi, 2022/2023, p. 13).

In short, human capital is the core resource of any institution, contributing to its excellence and continual renewal.

2.5 Human Capital and Its Relationship with Technological Capital:

Arab countries and developing nations consume more science and technology than they produce, an issue primarily attributable to the lack of recognition of scientific talent and competencies, as well as the absence of sound policies that assign the right person to the proper role. This prevalence persists within societies that are increasingly dependent on the West.

2.5.1 Modern Technologies: Challenges of Ownership versus Ease of Consumption:

The transfer of technology from developed countries to developing countries leads to several challenges, including the following:

- **Slow Technology Transfer:** Negotiations between technology-exporting and technology-receiving countries often last for years, delaying the anticipated benefits for developing countries.
- **Monopolistic Practices:** Technology exporters frequently exercise monopolistic control, particularly over intellectual property rights or the supply of technology tied to essential skills, information, and capital goods necessary for operating the technology. This control extends to a considerable degree.
- **Randomised Technology Transfers and the Lack of Local Policies:** Developing countries suffer not only from the scarcity of technology transfer but also from uncoordinated transfers that occur without peaceful local policies to establish independent domestic bases across various technological fields. Most bureaucratic institutions responsible for credit policies in less developed countries have yet to grasp the true essence of technology transfer. An indiscriminate focus on importing ready-made technology from industrial countries, coupled with insufficient encouragement and protection of local technological development sources from foreign competition, results in the expansion of existing technology transfer mechanisms, which only deepens technological dependency. Notably, the prevailing approach to technology transfer is closely linked to the significant rise in debt among developing countries, which has reached unsustainable levels.
- **Complex and costly financial and technological deals:** These deals discourage the emergence of independent local institutions capable of assuming responsibility from

foreign consulting firms that provide technical assistance and engineering designs. Moreover, such agreements deplete the scarce foreign exchange reserves of developing countries.

• **Inability to Develop More Autonomous Technology:** In the least developed countries, this deficiency exacerbates technological dependency and frustrates limited local and international efforts to increase domestic technological capacity.

2.5.2 Means of Localising and Producing Technology to Enhance Autonomy:

Allocating a budget to support research and develop education and working towards a qualitative transformation in curricula and teaching methods contributes to preparing new generations of scientists and researchers capable of efficiently engaging with emerging scientific and technological developments.

Preparing an industrial generation that is responsible for its industrial communities through operations, production, maintenance, marketing, development, training, and optimal investment in local human resources is crucial. Utilising highly skilled local cadres of engineers and scientists to seek suitable technologies and adapt them to better fit the importing environment, alongside creating incentives to reduce the brain drain of qualified scientific, technical, and technological talents, is essential (Harshaw & Qariwa, December 2016, pp. 58–59).

In conclusion, the relationship between human capital and technological capital is hindered by the absence of effective policies that assign the right person to the correct position, resulting in delays in achieving the desired outcomes

3. Measuring the Impact of Information and Communication Technology on Human Capital in Algeria: An Econometric Study (2014–2023)

3.1 Study Model and Variables:

To determine the impact of information and communication technology on human capital in Algeria, annual time series data for the period of 2014–2023 were utilised. Data on Algeria's cognitive and technological outputs were sourced from the 16th edition of the Global Innovation Index database, 2023, accessed from (<https://www.wipo.int>). Data on the percentage of individuals using the internet among the population were obtained from the Arab Monetary Fund's key reports database, accessed from (<https://www.amf.org.ae>) for the years 2019, 2020, 2022, and 2023.

The study variables are denoted as follows:

- CERT: Cognitive and technological outputs.
 - LPUWI: Percentage of individuals using the internet (internet users as a percentage of the population).

Table (1): Multiple Regression Results

Predictor Variables	Dependent Variable	R	R ²	F value	F-significance	B	T value	T-significance	VIF
CERT	LPUWI	0.948	0.900	1.332	0.292	0.426	1.154	0.292	1.000

Source: Prepared by researchers from SPSS v26 outputs

3.2 Results Analysis

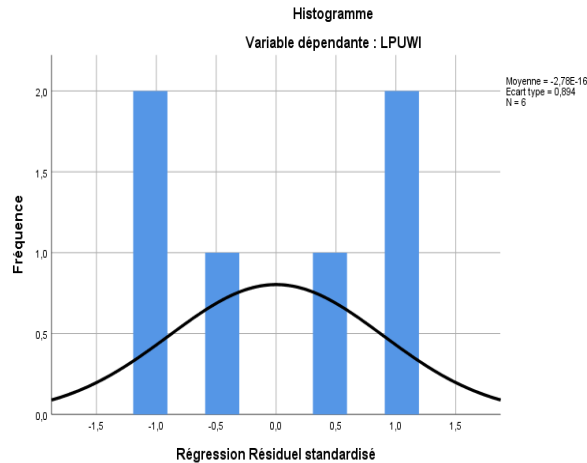
To examine this relationship, the impact of information and communication technology on human capital in Algeria was measured from 2014–2023 via a multiple linear regression model (Table 1). In this model, Algeria’s cognitive and technological output indices were the explanatory variables, whereas the percentage of internet users was the dependent variable. The regression results indicate that the model is statistically significant.

The correlation matrix revealed the highest Pearson correlation coefficient of 0.984, with significance at $p < 0.01$. No variables were excluded from the regression equation. The standard multiple regression method was used, yielding a Pearson correlation coefficient of 0.984 between the dependent and independent variables, an R^2 of 0.900, and an adjusted R^2 of 0.874, indicating that the independent variables explained 87.4% of the variance observed.

ANOVA revealed a significance (Sig) value of 0.004, which is less than 0.01, leading to rejection of the null hypothesis and acceptance of the alternative hypothesis, indicating a significant effect between cognitive and technological outputs and internet users in Algeria. The regression is thus significant, indicating that the independent variables influence the dependent variable, allowing prediction accordingly.

The standardised regression coefficients, standard errors, t test values with corresponding p-values, and variance inflation factor (VIF) values indicate that there are no multicollinearity problems among the variables. The VIF is calculated as the reciprocal of tolerance:

$$VIF = \frac{1}{\text{Tolerance}} = \frac{1}{1} = 1 \text{ Confirming the absence of multicollinearity issues.}$$



Source: Prepared by researchers from SPSS v26 outputs
Figure (1): Distribution of residuals and data clustering results

The previous figures demonstrate the normality of the residual distribution and how the data cluster around the regression line. Consequently, the residuals follow a normal distribution, a condition necessary for the validity of regression analysis.

4. Conclusion

This study was based on a research question concerning the impact of information and communication technology on human capital in Algeria from 2014--2023 and employed a quantitative approach with multiple linear regression methodology. The percentage of internet users among the population was considered the dependent variable, explained by Algeria's cognitive and technological outputs as independent variables.

Before presenting the findings, the study reviewed some previous research and covered theoretical concepts related to the study variables, leading to the following conclusions:

- There is a positive relationship between the study variables.
- The regression model is statistically significant, indicating that the independent variables have a significant effect on the dependent variable.
- A significant effect exists between the independent and dependent variables.
- No multicollinearity exists among the study variables.
- Algeria has made notable progress in its cognitive and technological outputs.

On the basis of these findings, the first hypothesis is rejected, and the alternative hypothesis is accepted.

Recommendations derived from the results:

- Investment in human capital is vital; it is among the key reforms necessary for achieving better levels of productivity in any organisation.
- Technology and communication are considered sources of energy that facilitate human life and work.
- Human capital relies on lifelong wealth and the pursuit of experience.
- Attention should be given to the positive aspects of information technology, and efforts should be made to benefit from them.
- The development of skills and competencies is essential for overcoming difficulties and achieving ongoing improvement.

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Appendices

Régression

NEW FILE.

DATASET NAME Jeu_de_données1 WINDOW=FRONT.

REGRESSION

/DESCRIPTIVES MEAN STDDEV CORR SIG N

/MISSING LISTWISE

/STATISTICS COEFF OUTS R ANOVA COLLIN TOL

/CRITERIA=PIN(.05) POUT(.10)

/NOORIGIN

/DEPENDENT LPUWI

/METHOD=ENTER CERT

/SCATTERPLOT=(*ZRESID,*ZPRED)

/RESIDUALS HISTOGRAM(ZRESID) NORMPROB(ZRESID)

Appendix (I): Variables introduites/éliminées^a

Modèle	Variables introduites	Variables éliminées	Méthode
1	CERT ^b	.	

a. Variable dépendante : LPUWI

. Toutes les variables demandées ont été introduites.

Appendix (II): Récapitulatif des modèles^b

Modèle	R	R-deux	R-deux ajusté	Erreur standard de l'estimation
1	,948 ^a	,900	,874	3,83850

a. Prédicteurs : (Constante), CERT

b. Variable dépendante : LPUWI

Appendix (III): ANOVA^a

	Modèle	Somme des carrés	ddl	Carré moyen	F	Sig.
1	Régression	527,604	1	527,604	35,808	,004 ^b
	de Student	58,936	4	14,734		
	Total	586,540	5			

a. Variable dépendante : LPUWI

Prédicteurs : (Constante), CERT

Appendix (IV): Coefficients^a

Modèle	Coefficients non standardisés		Coefficients standardisés	t	Sig.	Statistiques de colinéarité	
	B	Erreur standard	Bêta			Tolérance	VIF
1 (Constante)	-61,519	19,635		-3,133	,035		
CERT	1,032	,172	,948	5,984	,004	1,000	1,000

a. Variable dépendante : LPUWI