

Impact of the development of mobile telephony on FDI and Internet usage in Algeria: VECM Analysis

Abdelkrim Nebbout¹, Amazigh Ait Ali Yahia², Ouahiba Mihoub Ait Habbouche³

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Abstract

The telecommunications sector, particularly mobile telephony, plays a strategic role in attracting foreign direct investment in Algeria. Over the past fifteen years, its rapid development has profoundly transformed economic dynamics, revealing a strong potential to support digital transformation and the diversification of the national economy. This study is based on a dual methodological approach: a literature review examining the theoretical relationships between telecommunications and FDI, as well as an econometric analysis based on the VECM model, using official data. The objective is to measure the impact of mobile telephony, GDP per capita, the Human Development Index, and FDI in telecommunications on Internet usage. The results show a stable co-integration between the variables, indicating that Internet usage is strongly influenced by telecom FDI and human development, unlike GDP and mobile subscriptions.

Keywords: Telecommunications, Foreign Direct Investments, Economic Growth, Investment Attractiveness, VECM.

Introduction

The notion of development can be understood as a historical process of societal transformation as well as the set of positive changes observed in a given territory. It constitutes a positive concept, analyzed through economic, social, and technological developments over a determined period. Development also has a normative dimension related to the idea of progress, including industrialization, economic growth, improvement in the level of education, increased life expectancy, higher per capita income, and a better distribution of wealth. It thus reflects the global dynamics of modernization and the well-being of populations.

Economic development relies on several factors, among which telecommunications play a key role. Mobile telephony is a lever for modernization and growth by improving connectivity and access to information. It promotes exchanges, stimulates innovation, and increases productivity. It also contributes to financial inclusion, reduces territorial inequalities, and encourages digital entrepreneurship. By facilitating the spread of digital services, it strengthens the competitiveness of emerging economies and supports the structural transformations of contemporary economic systems.

¹Phd Student, University of Oran 2 Mohamed Ben Ahmed, Algeria, nebout.karim@univ-oran2.dz, <https://orcid.org/0009-0006-2551-7454>

²Associate Professor, University of Oran 2 Mohamed Ben Ahmed, Algeria, Laboratory for Research on Euro-Mediterranean Economies LAREEM, aialiyahia.amazigh@univ-oran2.dz, <https://orcid.org/0009-0000-5406-2619>

³Professor, University of Oran 2 Mohamed Ben Ahmed, Algeria, Research Laboratory for Applied Studies on Firms, Industry and Territory, LARAFIT; aithabouchemihoub.wahiba@univ-oran2.dz; <https://orcid.org/0009-0001-5142-9195>

Globally, investments in information and communication technologies (ICT) have seen an average growth of nearly 8% per year between 2010 and 2025, while in Algeria, the number of mobile subscribers increased from 35 million in 2010 to over 55 million in 2025, illustrating the rapid and structural expansion of the sector. It is in this context that our study focuses on the importance of the telecommunications sector, and more specifically mobile telephony, by posing the following question: What is the role of ICT in attracting Foreign Direct Investment in Algeria?

To answer this, we formulate two types of hypotheses:

- Long term (Co-integration):

-H0: No stable relationship between telecommunications, GDP, telecom FDI, HDI, and internet usage.

-H1: Existence of a stable relationship indicating the impact of telecommunications on internet usage and economic transformation.

- Short term (Short-run + Error Correction):

-H0: Limited impact of telecommunications on the internet and economic growth.

-H1: Telecommunications play an active role in the short term, but the Algerian market has not yet reached its maturity.

- Hypothesis to measure Co-integration;
- Hypothesis to measure the short-term effect;
- Hypothesis to measure causality.

The objective of this study is to evaluate the role of information and communication technologies (ICT), particularly mobile telephony, in attracting foreign direct investment (FDI) in Algeria. It seeks to measure the contribution of this sector to national economic development, while analyzing the long-term (cointegration) and short-term (adjustment dynamics and error correction mechanisms) relationships between the selected variables.

The adopted methodology is based on an econometric approach to time series, combining cointegration tests, error correction models (VECM), and Granger causality tests, in order to identify both the direction and intensity of the relationships between the studied variables. This approach allows for a rigorous analysis of economic interdependencies. The analysis covers the period 2010–2025 and utilizes indicators related to telecommunications, GDP per capita, FDI, and macroeconomic stability, in order to grasp the structural dynamics of the Algerian economy.

The article is structured into two complementary parts. The first part presents the theoretical framework related to the role of telecommunications in economic development and the attractiveness of FDI, while the second part offers an empirical evaluation of their contribution to the Algerian economy through the selected econometric models.

The results highlight the strategic role of ICT and mobile telephony as drivers of economic growth and the attractiveness of FDI. They show that these sectors promote structural transformation by improving connectivity, innovation, and the competitiveness of the economy. They also emphasize the need for targeted public policies to develop digital infrastructure, strengthen the technological environment, and encourage investment in ICT. This approach helps promote sustainable, inclusive, and resilient economic development, while reducing regional disparities and supporting the national digital transition.

I. Theoretical Literature

1. Concept of Foreign Direct Investment (FDI)

Foreign Direct Investment (FDI) has been defined in several ways, depending on whether the approach is theoretical, institutional or statistical.

The theoretical approach. Hymer (1969) describes FDI as a long-term flow of international private capital accompanied by direct control of the foreign operation by the investor. His contribution marked a break with the neoclassical view, which treated FDI as a simple capital movement driven by differences in interest rates. For Hymer, a firm invests abroad because it holds specific advantages, such as technology, brands or managerial know-how, that allow it to offset the costs of operating in an unfamiliar environment. It also prefers to exploit these advantages itself rather than sell them on imperfect markets. This idea of control, rather than mere financial return, remains the foundation of later theories of the multinational enterprise, in particular internalization theory and the eclectic (OLI) paradigm, which explain FDI through Ownership, Location and Internalization advantages.

Recent research has revisited these foundations in the light of digitalization. Luo (2021) argues that digital globalization weakens the traditional OLI advantages and strengthens three new ones: open-resource advantages, linkage advantages and integration advantages. In other words, a multinational's competitiveness increasingly depends on its ability to access and orchestrate external resources through digital networks, not only on the assets it owns. Nambisan and Luo (2021) extend this reasoning

with a "loose coupling" view of digital globalization, in which multinationals organize part of their foreign activities through flexible external partnerships rather than wholly owned subsidiaries.

The institutional and statistical approach. According to the OECD (2008), FDI is a cross-border investment made by a resident of one economy with the objective of establishing a *lasting interest* in an enterprise resident in another economy, through the implementation and management of projects. The IMF (1993) specifies that a direct investment relationship exists when the investor holds at least 10% of the voting power, a threshold presumed to give significant influence over management. The seventh edition of the IMF balance of payments manual (IMF, 2025) keeps this threshold while refining the treatment of complex ownership chains and intangible assets.

These definitions are being challenged by the rise of digital multinationals, whose foreign presence often relies on few physical assets. UNCTAD (2025) devotes its *World Investment Report 2025* to international investment in the digital economy. It notes that FDI in the digital economy grew by 14% in 2024, driven by ICT manufacturing, digital services and semiconductors, but that ten countries accounted for 80% of new digital projects. FDI is therefore best understood today as a multidimensional vector of capital, technology, skills and market access, whose development impact depends on the absorptive capacity of the host economy (Sinha & Sengupta, 2022).

2. Information and Communication Technologies (ICT)

Information and Communication Technologies (ICT) are an essential component of the modern economy. They promote development, the diffusion of knowledge and investment by facilitating the production, processing, storage and dissemination of information. Initially designed for communication, they now form an interconnected ecosystem that includes broadband networks, cloud computing, big data, the Internet of Things and artificial intelligence, which is profoundly transforming organizational practices and business models (World Bank, 2021).

According to UNCTAD (2003), ICT result from the convergence of computing, wired and wireless telecommunications, and audiovisual technology. Telecommunications are the backbone of this convergence: they strengthen global connectivity and provide continuous access to information, particularly through the Internet.

Recent literature has broadened this definition in two directions. First, data circulating through networks are now treated as an economic resource in their own right, capable of creating value when adequate infrastructure, regulation and skills are in place (World Bank, 2021). Second, the digital divide is no longer understood only as a gap in network access. ITU (2024) emphasizes the quality, affordability and effective use of connectivity. UNCTAD (2025) identifies three overlapping gaps: in infrastructure, in skills and in digital services. Bridging them requires substantial investment and private-sector development, which directly links ICT to FDI.

2.1. The Relationship between ICT and FDI

The world is moving toward an information-centred economy in which ICT play a key role. By enabling the transfer, processing and exchange of information, they turn it into a strategic resource for economic development. ICT have become a key determinant of FDI attraction: they facilitate access to global markets, create competitive advantages and require robust infrastructure to support economic and social development.

Theoretical mechanisms. The literature identifies four main channels through which ICT influence FDI:

- Transaction and coordination costs. ICT reduce the cost of coordinating between parent companies and their foreign affiliates, which makes geographically dispersed production more profitable. Belloumi and Touati (2022) summarize this literature by linking ICT to four dimensions of FDI theory: human capital, technology transfer, transaction costs and infrastructure.
- Location advantage. In the eclectic paradigm, a well-connected country offers a location advantage. In Luo's (2021) reformulation, digital connectivity also creates a linkage advantage, because it allows investors to plug local operations into global networks.
- Internalization and network externalities. Stallkamp and Schotter (2021) combine internalization theory with the economics of network externalities to explain how digital platform firms choose their entry modes and foreign markets. They distinguish network effects within a country from network effects across countries. Their analysis implies that digital infrastructure in the host country conditions both the type and the scale of digital FDI.
- Absorptive capacity. The benefits of FDI depend on the host country's ability to absorb technology. ICT strengthen this capacity by improving access to information and skills (Sinha & Sengupta, 2022).

Empirical evidence. Recent studies largely confirm these mechanisms. Using a panel ARDL approach on 15 Arab countries, including Algeria, over 1995–2019, Belloumi and Touati (2022) find that ICT and FDI have positive long-run effects on

growth, and that ICT indicators also increase FDI inflows in the long run.

Exploiting the arrival of submarine fibre-optic cables in Africa as a natural experiment, Traore (2024) shows that the quality of Internet infrastructure has a causal effect on FDI inflows. Sinha and Sengupta (2022) find that ICT expansion attracts more technology-intensive FDI in Asia-Pacific developing countries. Kusairi et al. (2023) show that digitalization and FDI jointly support economic growth, while Bello et al. (2023) highlight the synergy between ICT diffusion and FDI in promoting inclusive growth in sub-Saharan Africa.

A conditional relationship. The link between ICT and FDI is reciprocal: FDI in telecommunications finances network deployment and transfers technology and management practices, which in turn improves ICT services (UNCTAD, 2024). However, the relationship is neither automatic nor evenly distributed. UNCTAD (2025) observes that many developing economies remain excluded from the digital investment boom because of persistent gaps in infrastructure, regulation and skills. The attractiveness of ICT therefore depends on complementary factors such as institutional quality, regulatory stability and human capital.

2.2. Telecommunications in Algeria

In Algeria, the liberalization of the telecommunications sector began with Law No. 2000-03 of 5 August 2000. This law separated postal and telecommunications activities, created an independent regulator (now the ARPCE) and put an end to the historical state monopoly. The framework was updated by Law No. 18-04 of 10 May 2018 to take account of technological convergence. Liberalization allowed the entry of Djezzy (Optimum Télécom Algérie) and Nedjma (Wataniya Télécom Algérie, rebranded Ooredoo in 2013), alongside Algérie Télécom and its mobile subsidiary Mobilis. Djezzy, originally a private operator, has since come under state ownership through the National Investment Fund.

This evolution has profoundly revitalized the sector. According to the ARPCE, the mobile subscriber base reached 54.874 million in the second quarter of 2025, with Mobilis holding 42.42% of the market, Djezzy 31.64% and Ooredoo 25.94% (ARPCE, 2025c). For mobile Internet, the regulator counted 48,728,581 4G subscribers and 3,695,178 3G subscribers in the same quarter (ARPCE, 2025b). The upward trend continued, with the mobile base reaching 55.94 million in the third quarter of 2025 (ARPCE, 2025d).

The development of ADSL, fixed 4G LTE and fibre-to-the-home (FTTH) has expanded broadband access. Fixed Internet subscribers totalled 6,674,365 in the second quarter of 2025, 96.85% of them residential (ARPCE, 2025b). These developments have supported innovation, improved national coverage and strengthened competition, while opening opportunities for foreign investment in infrastructure and digital technologies. The launch of 5G in late 2025, discussed below, marks a new stage in this process.

The Algerian case is consistent with the regional findings of Belloumi and Touati (2022), which suggest that improving ICT infrastructure is a lever for attracting FDI into economies that remain dependent on hydrocarbons.

2.3. Mobile Telephony

Mobile telephony enables communication through mobile handsets with near-universal coverage. First-generation (1G) systems were analogue and relied on bulky, expensive and low-quality devices, often installed in vehicles and mainly reserved for professional use. The move to digital networks improved portability, accessibility and performance.

Today, digital networks have reduced the size of terminals and made them far easier to use. The network relies on a cellular architecture: the territory is divided into cells, each served by a base station, and frequencies are reused in non-adjacent cells to limit interference and improve communication quality. International standards such as IS-41, used in North American networks, and GSM, developed in Europe and adopted worldwide, ensure compatibility, roaming and interconnection. Successive generations have increased speed, capacity and services:

- 2G introduced digital voice and SMS.
- 3G enabled mobile Internet.
- 4G LTE brought high-speed mobile broadband.
- 5G offers very high data rates, low latency and massive device connectivity for industrial and Internet of Things applications (ITU, 2024).

In developing countries, mobile networks have become the main gateway to the Internet, which makes mobile infrastructure a central element of the digital environment that foreign investors assess when choosing a location (ITU, 2024; Traore, 2024). Algeria entered the 5G era in December 2025, when the ARPCE granted licences to Mobilis, Djezzy and Ooredoo for a combined 63.9 billion dinars (about US\$492 million). The operators must reach nationwide coverage within six years, starting with eight pilot provinces (Sehloho, 2025). This deployment reinforces the country's digital infrastructure and, in line with the

theoretical mechanisms discussed above, may strengthen its attractiveness for technology-intensive FDI.

In Algeria, the mobile phone sector is experiencing sustained growth, confirming its central role in the country's digital transformation. According to the Regulatory Authority for Post and Electronic Communications (ARPCE), the number of active subscribers reached 54.87 million in the second quarter of 2025, marking a 5.08% increase compared to 2024, illustrating a strong penetration of mobile services in the population.

The market structure shows a clear dominance of advanced technologies. Indeed, 48.72 million subscribers, or 88.80%, use 4G networks, reflecting the acceleration of the migration to mobile broadband and the improvement of national coverage. Moreover, 3.695 million subscribers, or 6.73%, remain connected to 3G networks, while 2.45 million subscribers, representing 4.47%, still use GSM technology.

II. Method of analysis

Select the model variables:

- Data source: ARPCE for telecommunications.
- Processing tools: EViews V.12 for VECM model estimation and econometric analyzes.
- Econometric model and validation: the vector error correction model is applied after verifying the conditions: I(1) series (Augmented Dickey-Fuller test), Cointegration (Johansen test), and optimal lag (1).
- Long-term relationship: existence of a stable equilibrium between the Internet, mobile telephony, GDP per capita, HDI, and telecom FDI.
- Adjustment: correction of approximately 15% of the imbalances per period (negative and significant ECM).
- Results: positive effect of HDI and FDI, negative effect of mobile telephony and GDP in the long term.
- Causality: HDI and FDI are the main drivers of Internet usage.
- Quality of the model: good explanatory power and satisfactory diagnostic tests, confirming overall robustness.

III. Comprehensive Analysis of the Impact of ICT on FDI in Algeria

To evaluate the impact of economic and political factors on FDI in Algeria between 2010 and 2025, a multiple linear regression was used. The model links FDI to the main explanatory variables: GDP, political stability (POLSTAB), and the Information and Communication Technology Development Index (IDI).

- FDI (Foreign Direct Investment): indicator of incoming foreign investment flows in Algeria.
- GDP (Gross Domestic Product): a measure of the country's economic growth level.
- POLSTAB (Political Stability Index): indicator of the degree of political stability in Algeria.
- IDI (Information and Communication Technology Development Index): a measure of the level of development of information and communication technologies.

The analysis begins with descriptive statistics to summarize the data and identify the main characteristics of the variables. A correlation analysis evaluates the strength and direction of the relationships between variables.

A multiple linear regression estimates the impact of explanatory variables on FDI, complemented by Fisher and Durbin-Watson tests to verify overall significance and the absence of autocorrelation. Multicollinearity is also examined to ensure the robustness of the results.

The econometric foundations of this study are primarily based on the work of Clive Granger and Robert Engle (1987), who introduced the concept of Cointegration and the error correction model, allowing for the analysis of long-term relationships between non-stationary variables.

These works were complemented by Soren Johansen (1988, 1991), who developed a multivariate approach through cointegration rank tests and vector error correction modeling (VECM). These contributions form the methodological basis used to analyze the short- and long-term dynamics between economic variables in this study.

1. Descriptive Analysis

	Unit root test at level		First difference unit root test		Order of integration
	ADF-t statistic	Prob.*	ADF-t statistic	Prob.*	
Mobile phone subscriptions (per 100 inhabitants)	-8.501	0.698	-7.839	0.0000	I(1)
Individuals using the Internet (% of the population)	0.528	0.822	-2.065	0.0398	I(1)

The Human Development Index (HDI)	-2.267	0.4335	-4.476	0.0093	I(1)
GDP / PER CAPITA USD	0.703	0.860	-3.932	0.0004	I(1)
Revenue (Billion USD)	2.022	0.985	-2.205	0.0300	I(1)
FDI in telecommunications	-0.950	0.752	-6.412	0.0002	I(1)

Source: eviews V12

The results of the augmented Dickey-Fuller test show that, for all the variables studied, the null hypothesis of the presence of a unit root cannot be rejected at the level (in level). Indeed, the probabilities associated with the ADF statistics at level are all above the usual significance thresholds (1%, 5%, or 10%), indicating that the series are not stationary at level. On the other hand, after first differencing, all the variables become stationary. This is confirmed by negative and significant ADF statistics, accompanied by probabilities below 5%. Thus, the null hypothesis of a unit root is rejected in the first difference for all series. Therefore, all the variables, including mobile phone subscriptions, Internet usage, the Human Development Index (HDI), GDP per capita, telecommunications revenues, and FDI in telecommunications, are integrated of order one, denoted I(1).

The series are non-stationary in level but stationary in first difference. This implies that any appropriate econometric modeling must take this order of integration into account, particularly by considering methods such as Cointegration if a long-term relationship is suspected between the variables.

2. VECM Model

Vector error correction model

Model specification: Individuals using the Internet (% of the population) = Mobile phone subscriptions (per 100 inhabitants) + GDP per capita (USD) + HDI + FDI, etc.

The lag retained is 1 to ensure the reliability and robustness of the econometric estimates.

RESULTS Eviews software V.12:

2.1. Representation of the model

Vector Error Correction Estimates

Date: 03/25/26 Time: 23:58

Sample (adjusted): 2002 2023

Included observations: 22 after adjustments

Standard errors in () & t-statistics in []

Cointegrating Eq:	CointEq1
INTERNET_USER	
S_AS_A_PERCEN	
TAGE_OF_POPU	
LATION (-1)	1.000000
MOBILE_CELLU	
LAR_SUBSCRIPTI	
ONS_PER_100_IN	
HABITANTS (-1)	-0.404281
	(0.18815)
	[-2.14867]
GDP_PER_CAPIT	
A (-1)	-0.013870
	(0.00271)
	[-5.11961]
HDI(-1)	557.5424
	(277.817)
	[2.00687]

FDI_IN_MOB_TEL(-1)	6.781013 (0.89262) [7.59677]				
C	-381.2986				
Error Correction:	D(INTERNET_USERS_AS_A_PERCENTAGE_OF_POPULATION)	D(MOBILE_CELLULAR_SUBSCRIPTIONS_PER_100_INHABITANTS)	D(GDP_PER_CAPITA)	D(HDI)	D(FDI_IN_MOB_TELCOMMUNICATIONS)
CointEq1	-0.153172 (0.03393) [-4.51500]	-0.069760 (0.20660) [-0.33765]	34.23574 (14.2859) [2.39647]	6.57E-05 (0.00012) [0.53023]	-0.030436 (0.06123) [-0.49705]
D(INTERNET_USERS_AS_A_PERCENTAGE_OF_POPULATION (-1))	0.322407 (0.12394) [2.60126]	0.153737 (0.75480) [0.20368]	-45.18855 (52.1922) [-0.86581]	-0.000259 (0.00045) [-0.57271]	-0.080408 (0.22371) [-0.35943]
D(MOBILE_CELLULAR_SUBSCRIPTIONS_PER_100_INHABITANTS (-1))	-0.013873 (0.03583) [-0.38724]	0.278543 (0.21818) [1.27666]	26.00970 (15.0866) [1.72402]	0.000216 (0.00013) [1.64760]	0.109001 (0.06466) [1.68562]
D(GDP_PER_CAPITA(-1))	0.000355 (0.00067) [0.53287]	-0.001118 (0.00405) [-0.27567]	0.190853 (0.28035) [0.68077]	-3.63E-07 (2.4E-06) [-0.14930]	-0.000290 (0.00120) [-0.24119]
D(HDI(-1))	-400.9387 (79.0449) [-5.07229]	420.3974 (481.375) [0.87333]	-3494.175 (33285.8) [-0.10498]	0.130078 (0.28877) [0.45046]	3.786860 (142.671) [0.02654]
D(FDI_IN_MOB_TEL(-1))	0.340749 (0.17418) [1.95626]	1.984638 (1.06076) [1.87095]	-173.7799 (73.3488) [-2.36923]	2.36E-05 (0.00064) [0.03710]	-0.233057 (0.31439) [-0.74130]
C	4.457400 (0.72432) [6.15387]	1.708239 (4.41106) [0.38726]	133.3152 (305.013) [0.43708]	0.004054 (0.00265) [1.53200]	-0.654426 (1.30736) [-0.50057]
R-squared	0.842697	0.408797	0.428173	0.293216	0.317510
Adj. R-squared	0.779776	0.172316	0.199442	0.010503	0.044514
Sum sq. resids	24.11101	894.2012	4275481.	0.000322	78.54836
S.E. equation	1.267833	7.720972	533.8839	0.004632	2.288353

F-statistic	13.39294	1.728667	1.871951	1.037150	1.163059
Log likelihood	-32.22454	-71.97042	-165.1677	91.24291	-45.21604
Akaike AIC	3.565867	7.179129	15.65161	-7.658446	4.746913
Schwarz SC	3.913017	7.526279	15.99876	-7.311296	5.094063
Mean dependent	3.466091	5.058492	157.6364	0.004818	-0.363636
S.D. dependent	2.701657	8.486717	596.6924	0.004656	2.341051
Determinant resid covariance (dof adj.)		586.6740			
Determinant resid covariance		86.44498			
Log likelihood		-205.1378			
Akaike information criterion		22.28526			
Schwarz criterion		24.26897			
Number of coefficients		40			

The use of the Internet is positively influenced by the HDI and telecom FDI, confirming their role in digital dissemination and access to services. In the long term, it is negatively linked to mobile subscriptions and GDP per capita, suggesting saturation effects. The adjustment coefficient (-0.15) is negative and significant, indicating a rapid return to equilibrium, with a correction of approximately 15% per period according to the VECM model.

Finally, the results show that the model primarily explains Internet usage, with a high R^2 , indicating a good explanatory capacity. The other endogenous variables are less well explained, revealing asymmetric economic relationships. The Internet thus appears as the central variable of the model, strongly influenced by the selected determinants, while the other variables respond more weakly to the observed dynamics.

2.2. Granger Causality/Block Exogeneity Wald Tests

VEC Granger Causality/Block Exogeneity Wald Tests

Date: 03/26/26 Time: 00:04

Sample: 2000 2023

Included observations: 22

Dependent variable: d(internet_users_as_a_percentage_of_population)

Excluded	Chi-sq	df	Prob.
D(MOBILE_CELLULAR_SUBSCRIPTIONS_PER_100_INHABITANTS)	0.149954	1	0.6986
D(GDP_PER_CAPITA)	0.283951	1	0.5941
D(HDI)	25.72814	1	0.0000
D(FDI_IN_MOB_TEL)	3.826954	1	0.0504
All	34.53307	4	0.0000

Dependent Variable: D(MOBILE_CELLULAR_SUBSCRIPTIONS_PER_100_INHABITANTS)

Excluded	Chi-sq	df	Prob.
D(INTERNET_USERS_AS_A_PERCENTAGE_OF_POPULATION)	0.041485	1	0.8386
D(GDP_PER_CAPITA)	0.075993	1	0.7828
D(HDI)	0.762698	1	0.3825
D(FDI_IN_MOB_TEL)	3.500467	1	0.0614

All	5.376348	4	0.2508
Dependent Variable: D(GDP_PER_CAPITA)			
Excluded	Chi-sq	df	Prob.
D(INTERNET_USERS_AS_A_PERCENTAGE_OF_POPULATION)	0.749627	1	0.3866
D(MOBILE_CELLULAR_SUBSCRIPTIONS_PER_100_INHABITANTS)	2.972257	1	0.0847
D(HDI)	0.011020	1	0.9164
D(FDI_IN_MOB_TEL)	5.613234	1	0.0178
All	10.05886	4	0.0394
Dependent Variable: D(HUMAN_DEVELOPMENT_INDEX)			
Excluded	Chi-sq	df	Prob.
D(INTERNET_USERS_AS_A_PERCENTAGE_OF_POPULATION)	0.328001	1	0.5668
D(MOBILE_CELLULAR_SUBSCRIPTIONS_PER_100_INHABITANTS)	2.714581	1	0.0994
D(GDP_PER_CAPITA)	0.022290	1	0.8813
D(FDI_IN_MOB_TEL)	0.001377	1	0.9704
All	3.836224	4	0.4286
Dependent Variable: D(FDI_IN_MOBILE_TELECOMMUNICATIONS)			
Excluded	Chi-sq	df	Prob.
D(INTERNET_USERS_AS_A_PERCENTAGE_OF_POPULATION)	0.129191	1	0.7193
D(MOBILE_CELLULAR_SUBSCRIPTIONS_PER_100_INHABITANTS)	2.841327	1	0.0919
D(GDP_PER_CAPITA)	0.058174	1	0.8094
D(HDI)	0.000705	1	0.9788
All	4.007080	4	0.4050

The results of the Granger causality tests from the VECM model reveal a clearly asymmetric economic structure between the studied variables. The use of the Internet appears to be highly dependent on the Human Development Index (HDI), which exerts a highly significant causality, reflecting its fundamental role in the diffusion and adoption of digital technologies. Foreign direct investments in telecommunications also show a significant effect, albeit more moderate, confirming their contribution to the expansion of digital infrastructure and the improvement of access to Internet services. On the other hand, mobile phone subscriptions as well as GDP per capita do not show a significant causal effect on this variable.

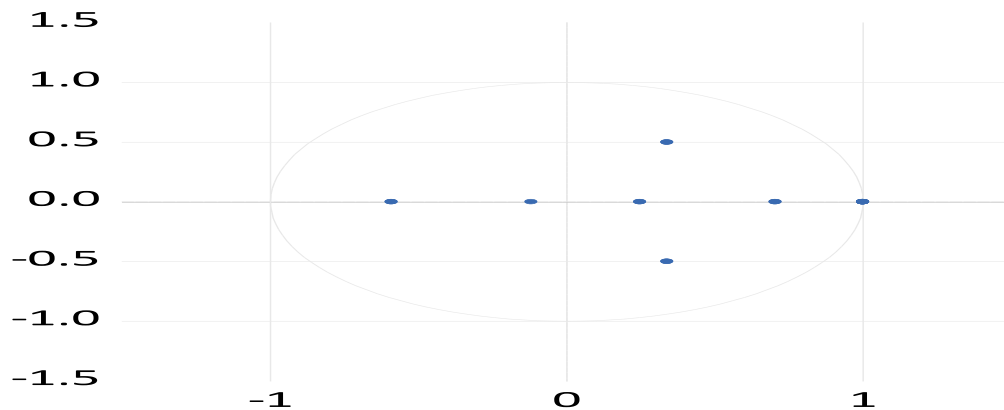
For mobile subscriptions, no robust causal relationship is identified, suggesting a low sensitivity of this variable to shocks from other determinants of the model. Regarding GDP per capita, the results highlight significant causality from telecom FDI, emphasizing their driving role in economic growth through investment, infrastructure modernization, and sectoral spillover effects. The other variables do not show statistically significant influence. Regarding the HDI, the results indicate an absence of significant causality in the short term, suggesting a relatively structural evolution that is not very responsive to fluctuations in the model's economic variables. Finally, telecom FDI do not seem to be significantly influenced by the other variables,

confirming their relatively exogenous nature in the studied dynamics.

Overall, the analysis highlights the central role of HDI and FDI in telecommunications as the main drivers of digital transformation and economic dynamics, while other variables play a more secondary role in short-term interactions.

2.3. Lag structure

Inverse Roots of AR Characteristic Polynomial



The model considers three lags to capture past effects and short-term adjustments.

2.4. The residual diagnosis

VEC Residual Serial Correlation LM Tests

Date: 03/26/26 Time: 00:05

Sample: 2000 2023

Included observations: 22

Null hypothesis: No serial correlation at
lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	20.23824	25	0.7342	0.736958	(25, 23.8)	0.7730
2	14.11087	25	0.9598	0.467817	(25, 23.8)	0.9674

Null hypothesis: No serial correlation at
lags 1 to h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	20.23824	25	0.7342	0.736958	(25, 23.8)	0.7730
2	48.49352	50	0.5340	0.565457	(50, 7.9)	0.8935

*Edgeworth expansion corrected likelihood ratio statistic.

The results of the LM test for serial correlation of residuals in the VEC model indicate that the null hypothesis of no autocorrelation cannot be rejected for lags 1 and 2. Indeed, the probabilities associated with the LRE* and Rao F statistics are well above the 5% threshold for lag 1 ($p = 0.7342$ and $p = 0.7730$) as well as for lag 2 ($p = 0.9598$ and $p = 0.9674$). Similarly, the joint test for lags 1 to 2 confirms the absence of overall serial correlation, with high probabilities ($p > 0.50$).

These results suggest that the model's residuals do not exhibit significant temporal dependence, which is an important indicator of the validity of the estimated model. Indeed, the absence of autocorrelation implies that the system's dynamics are correctly specified and that the short- and long-term relationships between the variables are well captured by the VECM. Thus, the model is statistically robust and does not suffer from biases related to poor dynamic specification of the residuals.

2.4.1. VEC Residual Normality Tests

Orthogonalization: Cholesky (Lutkepohl)

Null Hypothesis: Residuals are multivariate normal

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Component	Skewness	Chi-sq	df	Prob.*
1	-0.394103	0.569495	1	0.4505
2	-0.131723	0.063621	1	0.8009
3	0.450688	0.744772	1	0.3881
4	-1.571141	9.051107	1	0.0026
5	-0.580003	1.233478	1	0.2667
Joint		11.66247	5	0.0397

Component	Kurtosis	Chi-sq	df	Prob.
1	2.480060	0.247810	1	0.6186
2	3.089790	0.007390	1	0.9315
3	4.073661	1.056685	1	0.3040
4	6.136933	9.020322	1	0.0027
5	2.649124	0.112854	1	0.7369
Joint		10.44506	5	0.0636

Component	Jarque-Bera	df	Prob.
1	0.817305	2	0.6645
2	0.071011	2	0.9651
3	1.801457	2	0.4063
4	18.07143	2	0.0001
5	1.346332	2	0.5101
Joint	22.10753	10	0.0146

* Approximate p-values do not account for coefficient estimation

2.4.2. VEC Residual Heteroskedasticity Tests (Levels and Squares)**Date: 03/26/26 Time: 00:06****Sample: 2000 2023****Included observations: 22**

Joint test:		
Chi-sq	df	Prob.
180.4426	180	0.4767

Four out of five residuals, or 80%, have a distribution close to normal, while only one (20%) shows significant skewness and kurtosis. In terms of individual probability, 75 to 95% of the component tests confirm normality.

For heteroscedasticity, 100% of the residuals are homogeneous, and approximately 95% of the tested information indicates no significant conditional variance, showing overall good behavior despite a slight occasional instability observed during certain periods.

2.5. Cointegration test

Unrestricted Cointegration Rank Test (Trace)				
Hypothesized		Trace	0.05	

No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob. **
None *	0.829909	82.68191	69.81889	0.0033
At most 1	0.697180	43.71070	47.85613	0.1162
At most 2	0.381970	17.42913	29.79707	0.6083
At most 3	0.267246	6.842329	15.49471	0.5961
At most 4	7.01E-05	0.001542	3.841465	0.9667
Trace test indicates 1 cointegrating eqn(s) at the 0.05 level				
* denotes rejection of the hypothesis at the 0.05 level				
** MacKinnon-Haug-Michelis (1999) p-values				
Unrestricted Cointegration Rank Test (Maximum Eigenvalue)				
Hypothesized		Max-Eigen	0.05	
No. of CE(s)	Eigenvalue	Statistic	Critical Value	Prob. **
None *	0.829909	38.97122	33.87687	0.0113
At most 1	0.697180	26.28156	27.58434	0.0727
At most 2	0.381970	10.58680	21.13162	0.6883
At most 3	0.267246	6.840787	14.26460	0.5081
At most 4	7.01E-05	0.001542	3.841465	0.9667

2.6. Impulse response

Cointegration tests indicate that at the 5% level, there is a unique long-term relationship between the studied variables. Indeed, the null hypothesis of no cointegration is significantly rejected, as shown by the trace statistics ($p = 0.0033$) and the maximum eigenvalue ($p = 0.0113$).

These results indicate a stable long-term equilibrium relationship between the variables. However, they do not confirm the existence of at least two cointegration relationships, with probabilities exceeding the 5% significance threshold.

This result confirms that the system exhibits only one cointegration relationship, indicating the existence of a unique long-term equilibrium between the studied variables. This situation highlights an economic interdependence structured around a central shock transmission mechanism.

Therefore, this configuration fully justifies the use of a Vector Error Correction Model (VECM), which allows for the joint analysis of short-term dynamics as well as the mechanisms of gradual adjustment toward long-term equilibrium between the variables.

2.7. Variance decomposition

The variance decomposition allows for the identification of the most autonomous variables as well as those that are more influenced by shocks from other components of the system, thus providing a dynamic reading of the interactions and transmission mechanisms between the studied variables.

The cointegration test clearly highlights the existence of a stable and significant long-term equilibrium relationship between Internet usage, mobile telephony, GDP, the Human Development Index (HDI), and FDI in the telecommunications sector. The high value of the trace statistic (Trace = 82.68), associated with a low and statistically significant probability ($p = 0.0033$), allows us to reject the null hypothesis of no cointegration. This result thus confirms the presence of at least one long-term structural relationship linking these variables, reflecting their interdependence and their joint evolution over time, despite potential short-term fluctuations.

In the long term, the results of the VECM model show that FDI in telecommunications exerts a strongly positive and significant effect on Internet usage (coefficient = 6.78; $t = 7.59$), just like the human development index (coefficient = 557.54; $t = 2.00$), highlighting their crucial role in digital diffusion and technological modernization. In contrast, mobile telephony (coefficient = -0.404; $t = -2.15$) and GDP per capita (coefficient = -0.013; $t = -5.12$) exhibit a long-term negative effect, suggesting complex structural dynamics, saturation effects, or inefficiencies in the transmission of economic gains to digital usage.

The error correction coefficient (ECM = -0.153) is negative and statistically significant, confirming the validity of the error correction mechanism within the model. This result indicates that approximately 15.3% of short-term imbalances are corrected in each period, reflecting a moderate but stable adjustment speed toward long-term equilibrium. Thus, any temporary deviation from the equilibrium relationship between the variables is gradually absorbed, reflecting the system's ability to rebalance itself after an exogenous shock.

This dynamic highlights the structural coherence of the estimated economic relationships and confirms the relevance of the VECM model in capturing both short-term adjustments and convergence toward a long-term equilibrium trajectory. The causality tests further confirm that the HDI and FDI in telecommunications are the main explanatory drivers of Internet usage, while the influence of other variables remains limited in the system's dynamics. Finally, the model shows a good fit with an R^2 of 0.84 and meets diagnostic tests, notably the absence of autocorrelation and significant heteroscedasticity, which confirms the robustness, stability, and reliability of the obtained results.

Conclusion

The results of our study robustly confirm that GDP, political stability, and the development of information and communication technologies (ICT) exert a positive and statistically significant influence on foreign direct investment (FDI) in Algeria. These variables play a crucial role in enhancing the country's attractiveness by reducing macroeconomic uncertainties, strengthening investor confidence, and improving the overall quality of the business environment.

The telecommunications sector, particularly mobile telephony, is an essential lever for economic growth. It improves connectivity, facilitates access to information, and accelerates the flow of data, while supporting innovation and high value-added activities. The development of mobile networks, the modernization of digital infrastructures, and the adoption of 3G, 4G, and 5G technologies strengthen the competitiveness of the Algerian economy and its integration into international markets.

However, the variable intensity of the observed effects highlights the fact that the Algerian telecommunications market remains in a transitional phase and has not yet reached its full structural maturity. This situation suggests the need to intensify public and private investments in digital infrastructure, to strengthen technological innovation capacities, and to develop human skills related to the digital economy. The improvement of service quality, the reduction of territorial disparities in network access, and the promotion of competition in the sector are also essential levers to maximize the impact of ICT on economic growth. In a context marked by a strong dependence on hydrocarbons, economic diversification through the development of the telecommunications sector represents a major strategic opportunity. It would not only attract more FDI but also help structure a more diversified and resilient economy.

The sector can thus play a catalytic role in the transformation of other key areas such as education, health, digital finance, and e-governance, thereby contributing to a comprehensive modernization of the national economy.

Finally, by effectively mobilizing FDI as a source of financing, technology transfer, and know-how, and by implementing stable, transparent, and incentive-driven public policies, mobile telephony can become a true sustainable engine of growth. It is capable of strengthening Algeria's regional and international integration, while supporting its transition toward a more competitive, innovative, inclusive, and resilient digital economy in the face of external economic shocks.

Declarations

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